THE BOILER MAKER

VOLUME XXXI

JANUARY TO DECEMBER, 1931

PUBLISHED BY

SIMMONS-BOARDMAN PUBLISHING COMPANY

30 Church Street, New York, N. Y., U. S. A.

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The Boiler Maker

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Annual Index

The annual index of The Boiler Maker for the year 1930 will be mailed without cost to each subscriber whose request for it is received at our New York office on or before February 2, 1931.

As the index will be useful only to those who have kept a complete file of the magazine for the year, only a sufficient number of copies will be printed to meet the requirements of readers who notify us of their desire for a copy.

Boiler Failures

In his annual report to the Interstate Commerce Commission, A. G. Pack, chief inspector, Bureau of Locomotive Inspection, points out that "boiler explosions caused by crown sheet failures continue to be the most prolific source of fatal accidents; 84.6 percent of the fatalities during the year were attributable to this cause as compared with 68 percent in the previous year." This statement characterizing the situation in general is modified by the fact that there was a decrease of 35.3 percent in the number of such accidents, of 15.3 percent in the number of persons killed and of 35 percent in the number injured as compared with the previous year.

The increase in fatalities from boiler explosions undoubtedly is due to the larger boilers and higher pressures carried. This being the case, there can be no avoiding the issue, that absolutely the highest standards of inspection and maintenance must be enforced.

Welding Code for Pressure Vessels

The initial advance in the direction of more liberal rules for fusion welding was made last spring, when the Boiler Code Committee of the American Society of Mechanical Engineers adopted the recommended procedure submitted by the American Welding Society, and on the basis thereof increased the limits on welded pressure vessels to 60 inches diameter, 200 pounds per square inch working pressure, and 8000 pounds per square inch unit stress. The actual revisions of the code were announced and issued in the form of the addenda pages that were sent out on August 12, 1930.

In October, the Specifications for Fusion Welding of Drums or Shells of Power Boilers, which had been prepared in September, 1929, and were first published in the March, 1930, issue of *Mechanical Engineering*, were modified for adaptation to the unfired pressure vessel field, and in this revised form were published in the recent December issue of *Mechanical Engineering*. These specifications included a number of physical tests of the deposited weld metal, and called for stress annealing of the finished vessels in addition. The specifications are fairly rigid and give clear evidence of the intent that they shall apply in general to classes of vessels demanding the highest type of construction.

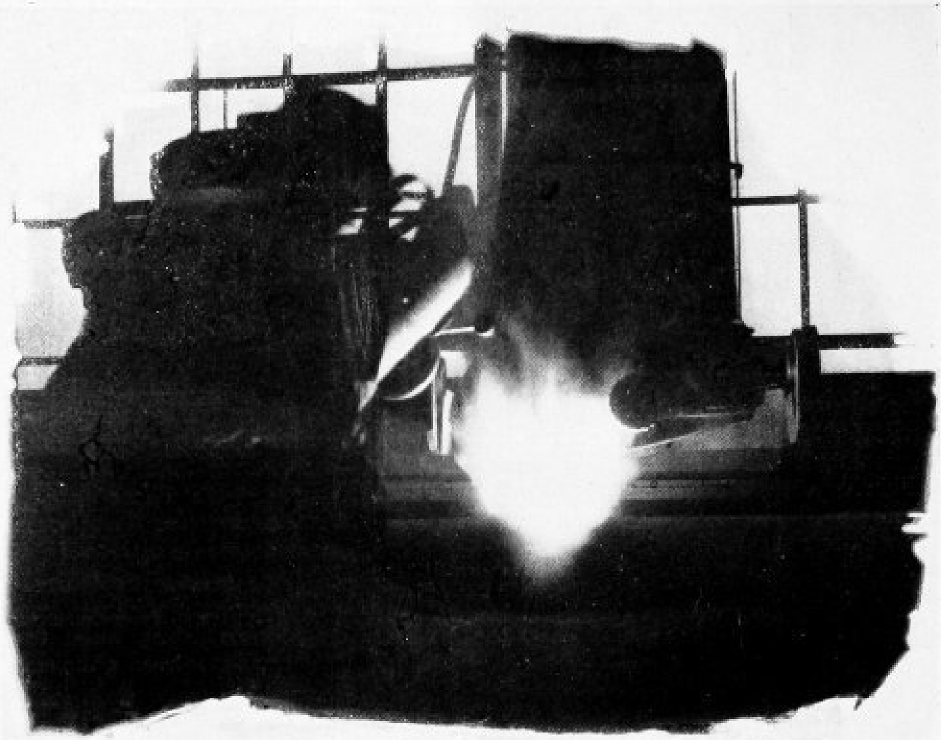
The above developments mean that provisions have been made for fusion welded construction for the smaller and less important vessels at the one end of the range, and the heavy, high-duty vessels at the other end of the range, but as yet nothing has been offered that promises adequately to take care of the range of vessels that come between these two extremes. Some fear has been expressed by certain manufacturers in regard to the adequacy of any provisions which the Boiler Code Committee may make to protect their interests. Others claim that the provisions of the rather rigid set of specifications for the heavy, high-duty vessels will tend to overshadow the rest of the field, and inject the stress-relieving requirement into the construction of all classes of pressure vessels, including medium-duty vessels for moderate pressures. In response to this opinion as expressed, it is the desire of the Boiler Code Committee to provide adequately for these intermediate vessels, and to do this on a practical working basis. Reference is made to this phase of the problem in the introductory statement that precedes the proposed Specifications for Fusion Welding of Unfired Pressure Vessels in the December, 1930, issue of *Mechanical Engineering*.

As to just how this may be done the committee is uncertain as yet; one new suggestion being that there should be imposed a thickness limit above which all vessels must be stress relieved and below which they need not be relieved; while another is that a classification of vessels should be adopted, in which the stress-relieving treatment would or would not be applied according to the use to which the vessel is to be put.

The committee is very anxious to work out a plan that will be practical and effective without injury to the interests of any manufacturer. To that end, suggestions will be welcomed from anyone and everyone interested.

Master Boiler Makers' Convention

In November of last year the executive boards of the Master Boiler Makers' Association and of the Boiler Makers' Supply Men's Association met at Chicago to discuss the possibility of merging the annual convention with other independent railroad association conventions. At that time it was decided for a special committee of the association to meet with committees of these other organizations and of the Mechanical Division, American Railway Association in Chicago on January 10. The results of this meeting will be outlined in an early issue. Communications should be addressed to the secretary of the American Society of Mechanical Engineers, Boiler Code Committee, 29 West 39th street, New York, N. Y.



WELDED BOILER

By J. C. Hodge*

The Bureau of Engineering, United States Navy, has taken an important step in adopting arc-welded construction for the joints of drums for twenty-four boilers now being built by The Babcock & Wilcox Company, for the new scout cruisers *Minneapolis*, *New Orleans* and *Astoria*. This is the first time the bureau has approved the use of fusion-welded seams in boiler drums, and undoubtedly represents the beginning of a new era in boiler construction, in which the welded joint will replace the riveted joint to a great extent if not entirely. Certainly the approval of welding for boiler-drum construction by such a body of engineers will give a great impetus to the widespread movement now being conducted for the approval of welded boiler drums by civilian engineering authorities.

The specifications drawn up by the bureau are based on the Proposed Specifications for Fusion Welding of Drums or Shells of Power Boilers published by the A. S. M. E. Boiler Code Committee in March of this year. These original specifications, while representing the best proposals that had been published governing the testing of welded pressure vessels, were far from being complete. The most important phase of the specifications, namely the non-destructive testing of the welded joint, had been stated in general terms only, as no specific data were at that time available on the non-destructive examination of welded joints. The bureau engineers have revised and amplified the original proposed specifications of The Boiler Code Committee and the new bureau specifications undoubtedly assure the safety and reliability of all welded joints in a boiler drum.

The specifications, quite properly, pay no attention to the process used, since the bureau is not so much concerned with how the welds are made as it is interested in the quality of the welded joints produced. Such a viewpoint may seem altogether too logical to warrant mentioning, but those who are familiar with the past history of welding, with its emphasis upon the minute details of shop practice, realize to what extent the Navy specifications have departed from the usual type of welding specifications. In other words, a welding procedure is not specified, but a definite and rigid testing procedure for determining the physical properties and soundness of the fin-

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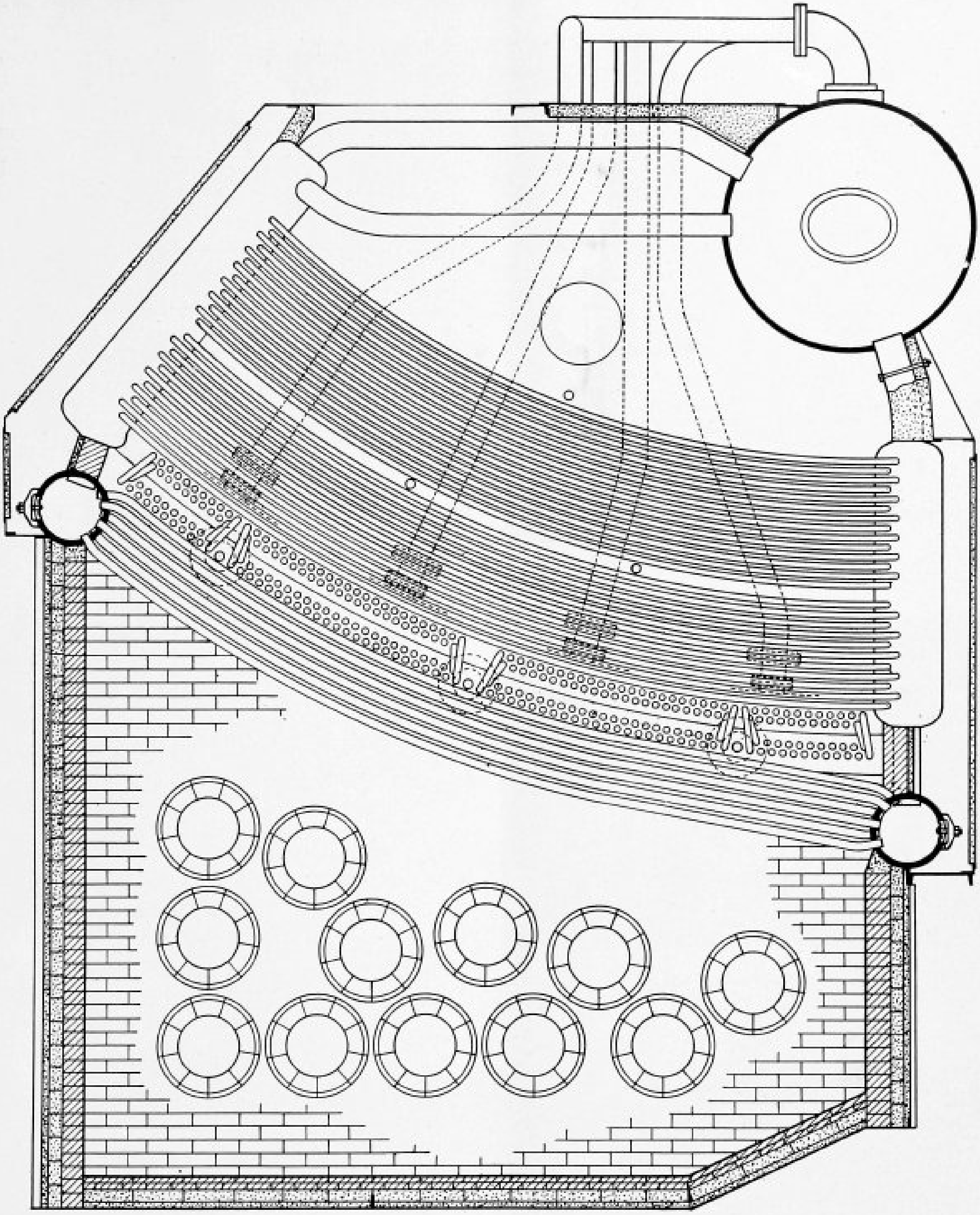


Fig. 1.—New Babcock & Wilcox boiler similar to type developed for the United States Navy to be installed in new scout cruisers

ished welded joint is the basic requirement.

This does not mean that the bureau has paid no attention whatever to the methods and processes used in making welds, but it does mean that, having examined a welding technique and having seen that the technique produces sound welds, the bureau then turns its chief attention to drawing up tests which will definitely prove the quality of the finished weld even though the process used seems to insure uniformly good results.

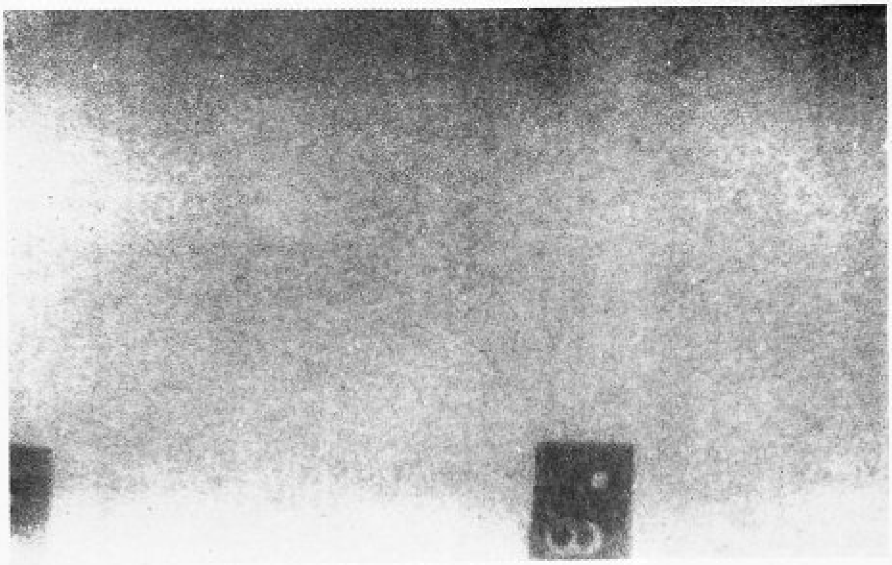
The bureau specifications governing the test procedure of a welded boiler drum are made up of three fundamentals.

(1) Determination of the physical and chemical properties of representative sample welds.

(2) Non-destructive examination of the welded seams by X-ray examination.

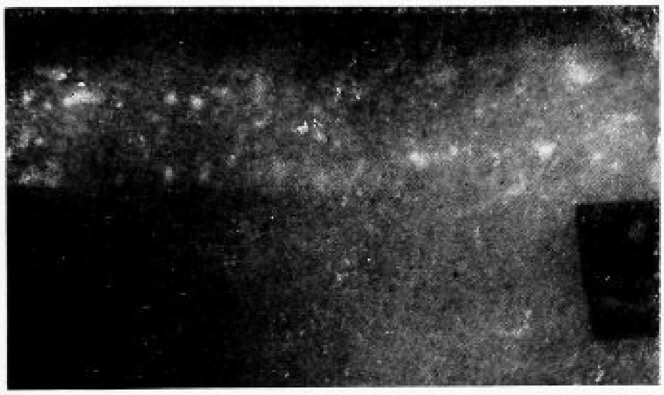
(3) Hydrostatic testing of the finished welded drums.

Representative welded sample plates are obtained by tack welding sample plates to the ends of a longitudinal joint in a drum shell, the arrangement being such that the sample plates are welded at the same time and under the same conditions as the corresponding longitudinal seam of the drum shell. From this representative welded sample, specimens for tension, impact and band test, and for macro-



Radiograph Type 1.—Excellent or ideal weld

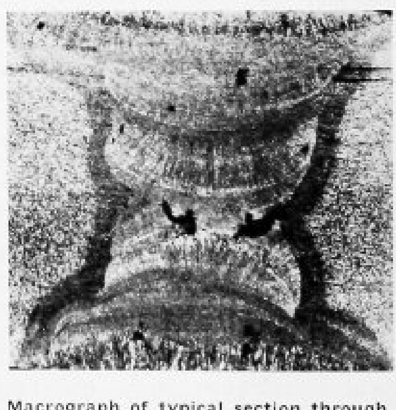
Macrograph of typical section through weld of Type 1



Radiograph Type 2.—Porous but acceptable

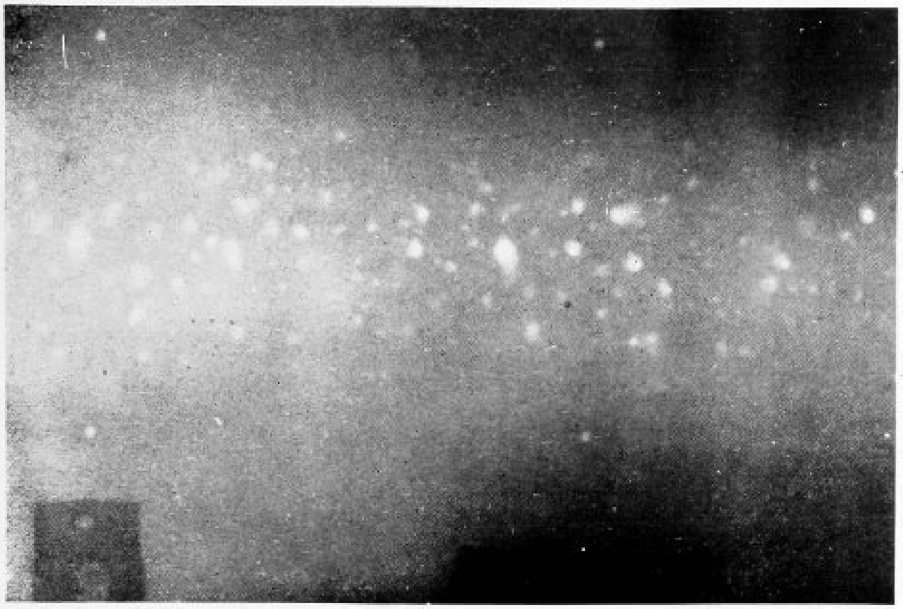
Macrograph of typical section through weld of Type 2

Radiograph Type 2.—Porous but acceptable

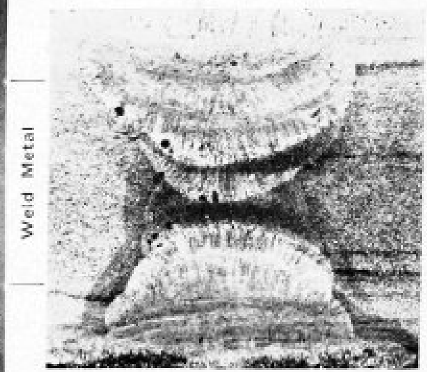


Macrograph of typical section through weld of Type 2

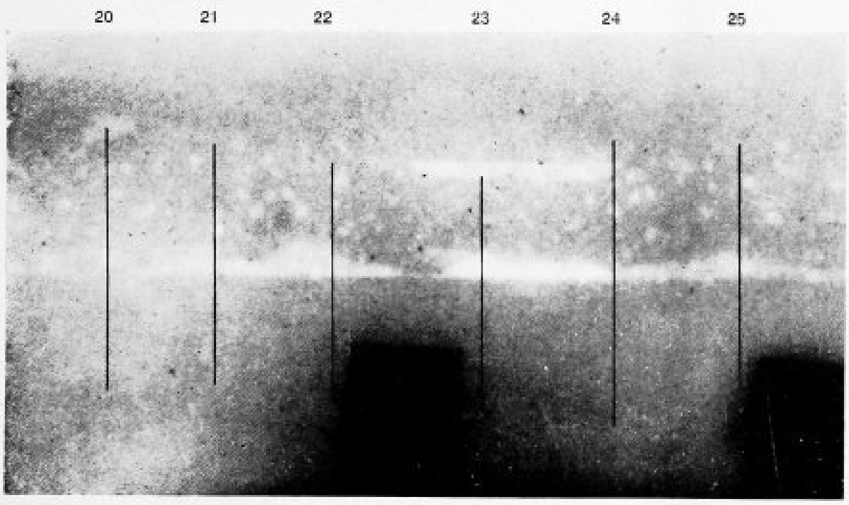
Fig. 2.—Radiographs and macrographs of typical welds



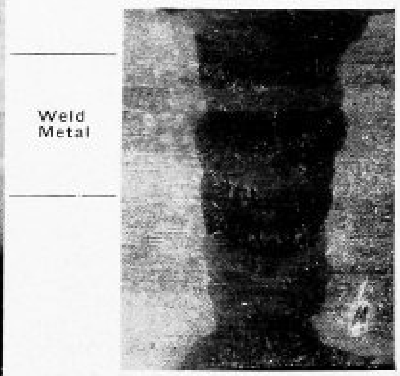
Radiograph Type 3.—Porous and not acceptable

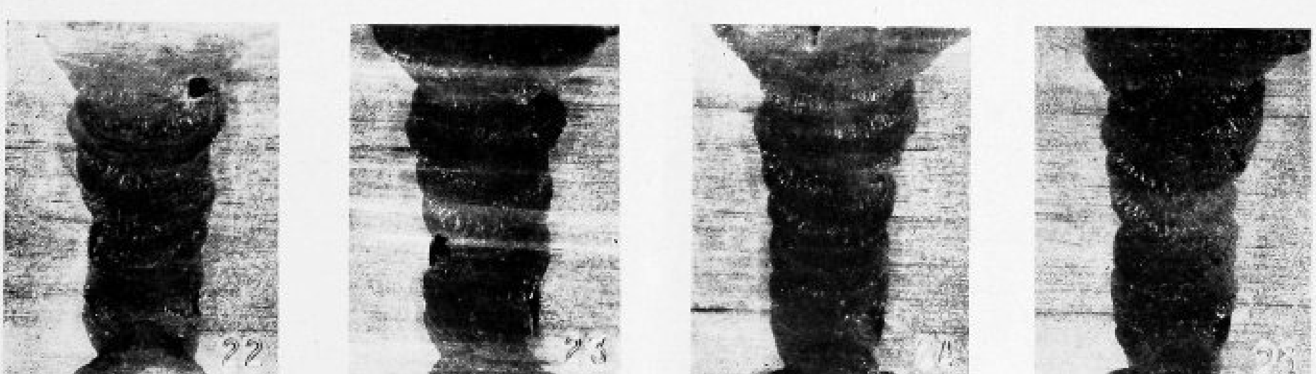


Macrograph of typical section through weld of Type 3



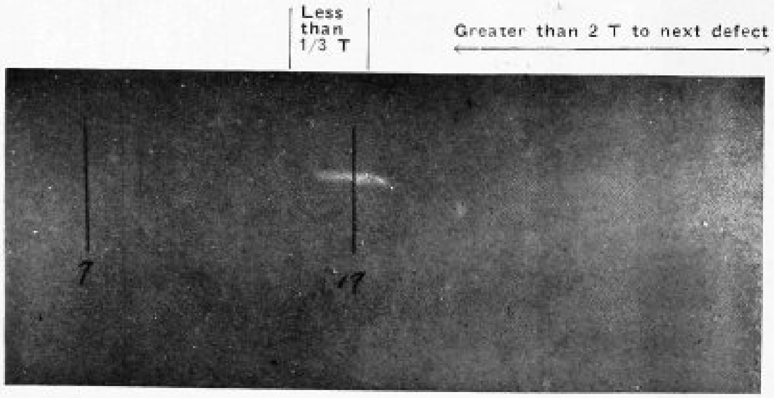
Radiograph Type 4.—Defect along wall of joint; not acceptable





Macrographs of sections 21 to 25 through weld in Radiograph Type 4

Fig. 3.—Radiographs and macrographs of typical welds



Radiograph Type 5.—Defect along wall of joint; acceptable

Macrograph of section 7

Macrograph of section 17

Fig. 4.—Radiograph and macrographs of typical welds

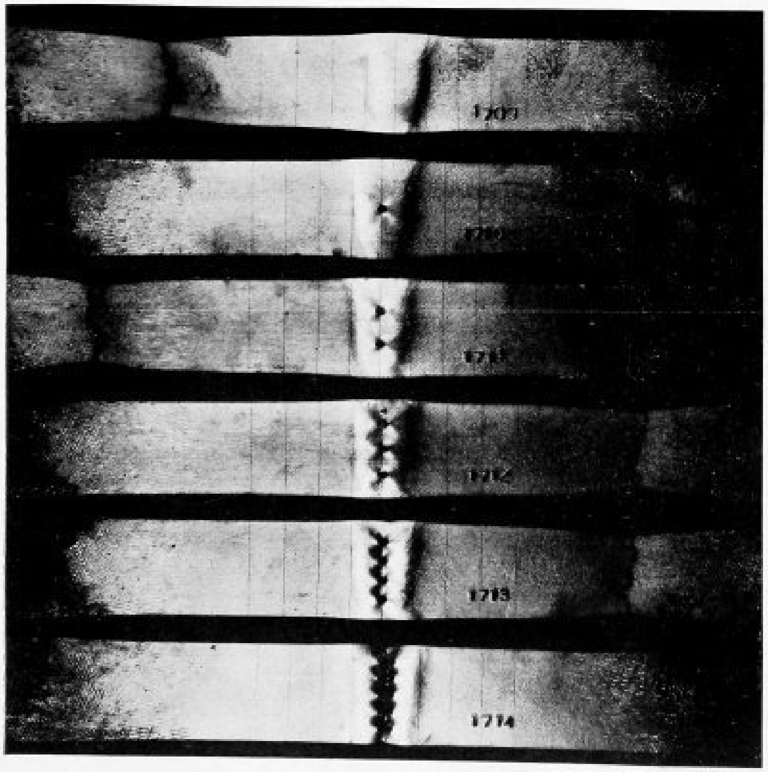


Fig. 5.—Transverse to welded joint

and micro-examination, and drillings for chemical analysis are obtained.

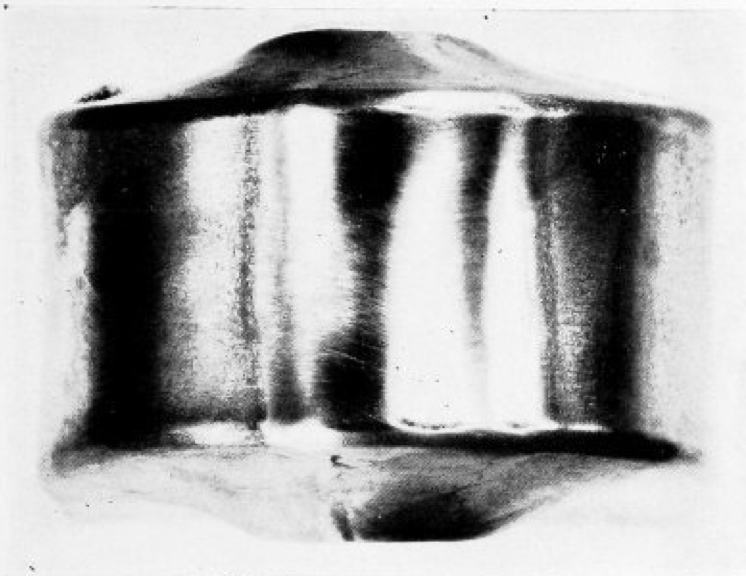
For the tension test, it is specified that the tension specimen be transverse to the welded seam and that on testing this transverse tension specimen failure should occur in the boiler plate. If failure occurs in the weld metal or along the line of fusion between weld metal and plate, then the tensile strength of the specimen shall not be less than the mean of the specified tensile range of the boiler plate used.

For determining the ductility of the weld metal, the bend test is employed. The ductility of the weld metal is expressed as the percent elongation of the outside fibers of the weld metal during bending. The Navy specifications require the bend test specimen to be of the full thickness of the plate and with a width equal to 1½ times the thickness of the plate. The bend test specimen must withstand bending cold under free bending conditions until the least elongation measured across the entire weld on the outside fibers of the specimen is 30 percent.

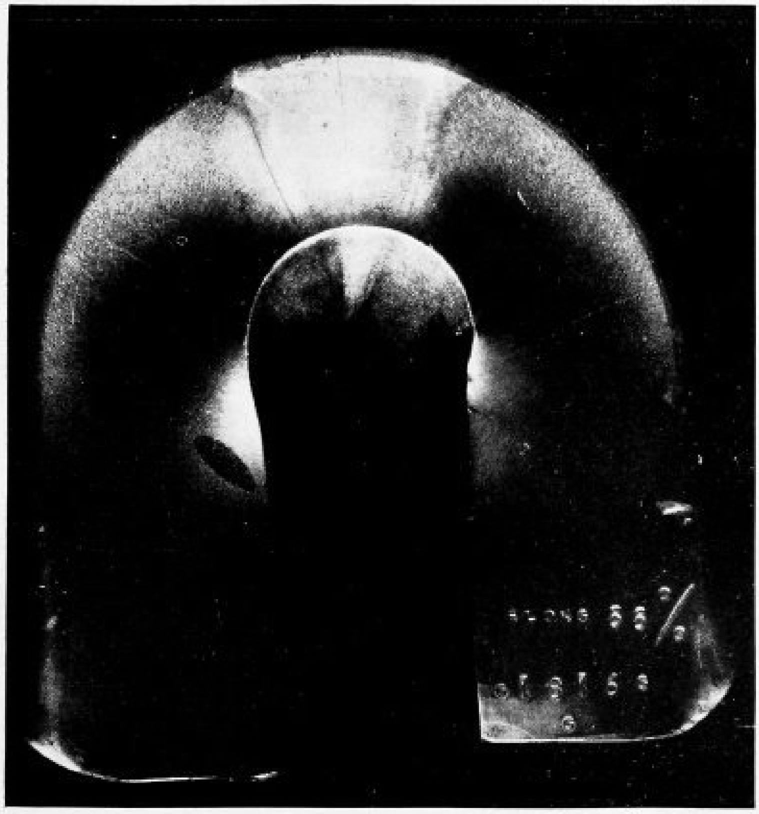
Three impact test specimens are specified, these specimens being removed from the welded joints in such a manner that the impact resistance of the weld metal is obtained for the following locations: (1) the bottom of the welded joint, (2) the middle of the welded joint, and (3) the top of the welded joint. These specimens must show an impact value of at least 20 foot-pounds (standard A. S. S. T. Charpy Impact Specimens with keyhole notch). This value of 20 foot-pounds for the impact or notched-bar impact test should definitely guarantee the satisfactory performance of the weld metal where the service demands a considerable degree of toughness in the weld metal.

The bureau's specifications also cover the chemical analysis of the weld metal, and are written chiefly to insure a low nitrogen content in the weld metal as a check against the brittleness of the weld. Nitrogen in the form of nitrides must not exceed 0.020 percent. This low value for the nitrogen content of the weld metal indicates that the weld metal has been deposited under conditions which give the greatest protection to the molten weld metal from the gases of the atmosphere.

Macro- and microscopic examinations of a section across the welded joint are specified. This section is to be free on macroscopic examination from evidence of incomplete fusion, laps, cracks, blow-holes greater than ⅛ inch in any dimension, and slag inclusions greater than $\frac{1}{16}$ inch in any dimension, and of excessive porosity and excessive coarse grained material. An excessively coarse grained weld metal is defined as a section in which the ratio of coarse grained material in the weld to fine grain material in the weld is greater than 1 to 5. In the event of a question arising as to whether the degree of porosity shown in the section is acceptable, specific gravity determinations of the weld metal are to be made on two all-weld metal specimens. These specific gravity or density specimens shall show a minimum specific gravity of 7.80. For comparison of this value it may be assumed that solid weld metal will possess a specific gravity of 7.85.

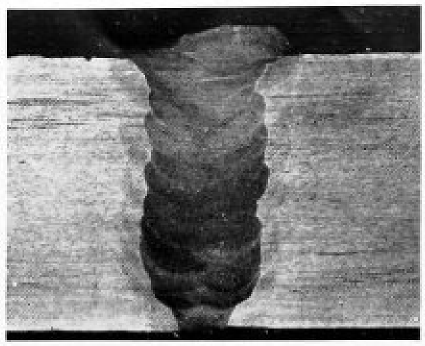


Outer surface of bend specimen

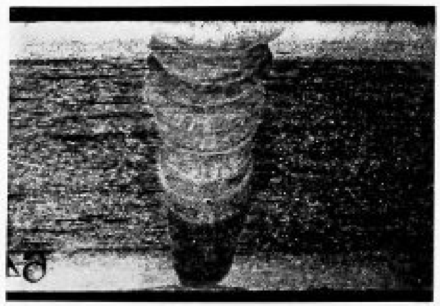


Side view of bend specimen

Fig. 6.—Bend test specimen from 2 inch thick welded plate



Macrograph No. 4



Macrograph No. 5

Fig. 7.—Macrographs of pressure vessel welds; note freedom from major defects

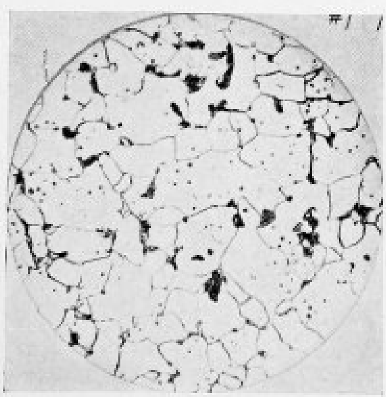
Fig. 8 (Below).—Photomicrographs typical of pressure vessel welded joints of Babcock & Wilcox Company

No. 1.—500 diameters. Weld metal no nitrides nor oxides.

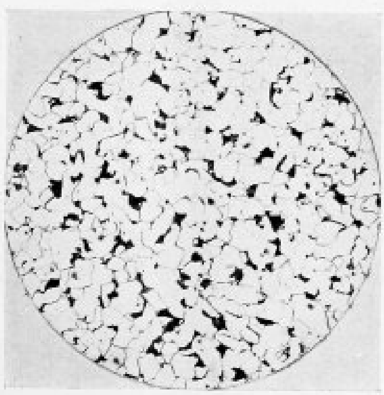
No. 2.—100 diameters. Structure of original, unaffected plate.

No. 3.—100 diameters, Junction of base metal on left and weld metal on right.

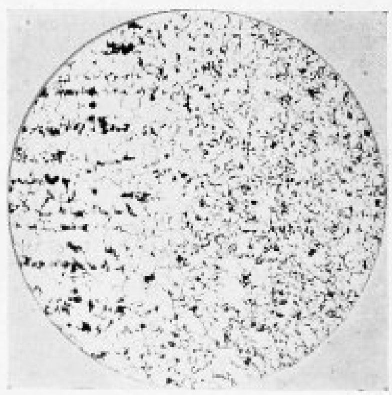
No. 1



No. 2



No. 3



Micro samples are to be removed from the above section, and after polishing and etching, typical photo-micrographs of the section are to be prepared showing (1) the structure of the boiler plate, (2) the structure of the affected zone between the weld metal proper and the plate, (3) the structure of the line of fusion between base metal and weld metal, (4) the structure of the weld metal, (5) the structure at the line of fusion on the other side of the welded joint, (6) the structure of the original unaffected boiler plate on the other side of the welded joint.

Non-Destructive Examination of Welded Seams

In the bureau's specifications the main longitudinal and circumferential welded joints of the welded drum are to be radiographed under an X-ray technique which will determine quantitatively the size of a defect within the weld metal where the thickness of the defect is greater than 2 percent of the thickness of the boiler plate. The radiographic prints obtained by the X-ray examination are to be compared with a set of standard X-ray radiographs which have been selected to show varying degrees of weld metal qualities. Five radiographic prints are used as standards for comparison. These radiographic prints are reproduced in Figs. 2, 3 and 4, the significance of each print being as follows: Radiographic print No. 1 shows the ideal or desired type of print in which the presence of the welded joint can be detected only with great difficulty. Radiographic print No. 2 illustrates a weld which is slightly porous, but nevertheless acceptable. Radiographic print No. 3 represents a welded seam of greater porosity, which is not acceptable. Radiographic print No. 4 is of a weld which has very serious defects and is, of course, not acceptable. The defects represented in this radiographic print are slag inclusions or cavities extending longitudinally along the walls of the joint. Radiographic print No. 5 is used to illustrate the presence of an isolated defect of the elongated slag inclusion type, which under the specifications is limited to a certain size with respect to the thickness of the plate and which must be a minimum distance from any other defects.

A set of standard macrographs accompanying the X-ray radiographs shows the condition of a section through each welded joint corresponding to the five different radiographs.

After a welded drum has passed the X-ray examination and after the various test specimens have been tested or examined to determine whether the quality of the welded joint is within the specifications, the welded drum is subjected to a hydrostatic test pressure equal to twice the working pressure of the drum.

The welding process to be used in manufacturing the boiler drums of the new scout cruisers is based upon a technique developed by the Babcock & Wilcox Company after many years of research into the fundamentals of the subject. Prior to the approval of this welding process for use in the scout cruiser boiler drums, engineers of the bureau inspected both the welding process and the facilities for testing welded drums at the shops of the Babcock & Wilcox Company. The bureau also investigated the results of numerous tests of welded specimens made by this welding process. The following table gives a comparison between the properties called for in the bureau's specification and typical properties of the welded joints produced by the special process.

The specifications apply to weld metal for use with Class B marine steel boiler plates having a minimum tensile strength of 60,000 pounds per square inch. Fig. 5 illustrates a typical set of tensile tests taken transverse from across a welded seam on A. S. M. E. boiler plate.

Comparison of Welding Characteristics

	Navy Specificaions	Babcock and Wilcox Welded Joints
Tension Test		
Ultimate strength (pounds per square inch)		
Minimum	65,000	65,000
Maximum		74,500
Average		67,500
Bend Test		
Percent elongation of outside fibers		
Minimum	30.0	40.0
Maximum		65.0
Average		50.0
Charpy Impact Test (foot-pounds)		
Minimum	20.0	20.0
Maximum		45.0
Average		28.0
Chemical Analysis		
Manganese	0.30 to 0.60 percent	0.30 to 0.60 percent
Phosphorus	Not over 0.04 percent	Not over 0.04 percent
Sulphur	Not over 0.045 percent	Not over 0.045 percent
Carbon	Not over 0.30 percent	0.08 to 0.05 percent
Nitrogen as iron nitride	Not over 0.020 percent	Not over 0.020 percent

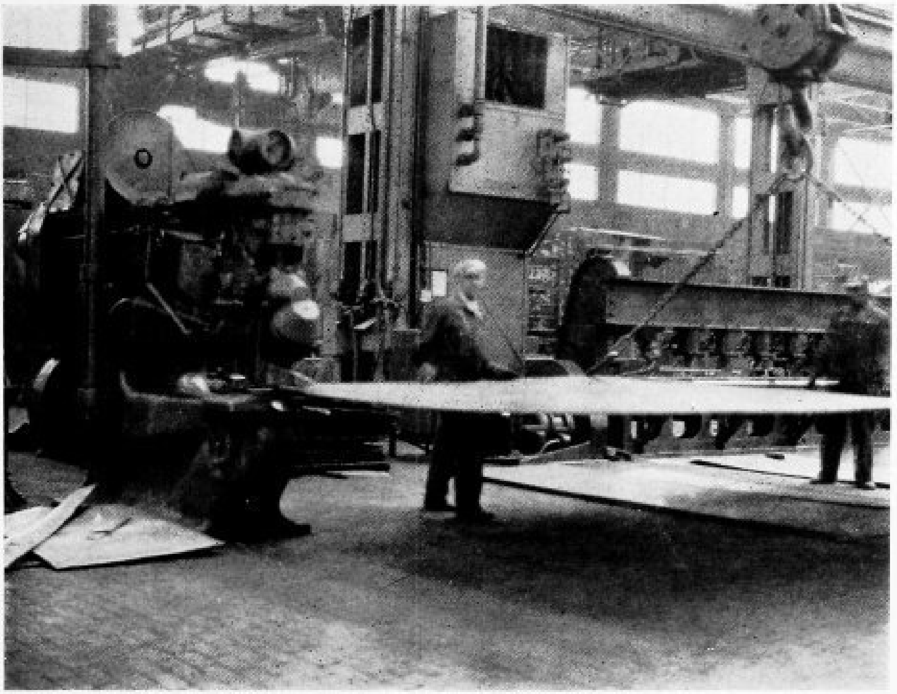
The first specimen showed a tensile strength for the weld metal superior to that of the plate metal, since failure of the specimen occurred in the plate. Succeeding specimens were progressively weakened by drilling holes in the weld metal until failure was made to take place in the weld itself. The maximum stress on the weld in this case was 74,200 pounds per square inch.

Fig. 6 shows a typical bend test specimen in which the elongation of the outside fibers is 55 percent. Typical sections across the welded joints are shown in macrographs Nos. 4 and 5, Fig. 7, both macrographs showing complete freedom from major defects. The protection of the line of fusion between weld metal and base metal should be particularly noted. Photo-micrographs typical of the welded joints which will be present in the boiler drums are shown in Fig. 8. The weld metal possesses a very fine grain structure free from nitrides and oxides and it should be noted that the structure of the affected zone of the boiler plates does not in any way indicate a weakness at this portion of the joints.

Radiographic print, type No. 1, Fig. 2, from the Navy's specifications may be taken as representative or typical of the radiographs obtained on welded joints produced by this process. From the foregoing comparison, it is readily seen that the welding process as developed by the Babcock and Wilcox Company will produce welded joints which will meet all of the tests specified by the Bureau of Engineering.

As mentioned before the specifications placed almost no restrictions upon the process used. The most important exception to this statement is the section which deals with stress relieving, wherein the required heat treatment of finished weld drums is specified in detail. This operation is, however, in no way connected with the actual deposition of the weld metal.

The Bureau of Engineering has certainly taken up this whole subject in its typically scientific and exacting manner, and its adoption of fusion welding together with its specifications point to the fact that welding is no longer a matter of empirical shop practice but a process capable of scientific control with results that are susceptible of being checked and proven by trustworthy tests.



Fabricating sheets at the Paducah boiler shop

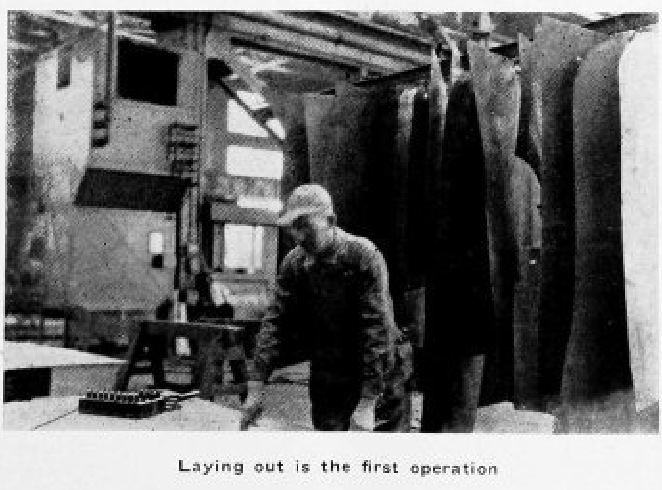
Welding Practice on the Illinois Central System

In the December, 1930, issue, beginning on page 330 general instructions for the cutting and welding practice of the Illinois Central System were given, with specific reference to the oxy-acetylene method. Fusion welding by means of the electric-arc process is discussed in the following paragraphs:

Before the welder starts operations he must be sure that the electrode is connected to the negative side (which is marked —). He must also see that the positive side is connected to the operation as closely as possible in order to avoid any broken joints on the circuits. All connections must be made tight. Before commencing to weld the operator must be sure that he is using the proper welding rod or wire for that particular work. No operation is to be started if it can only be welded part way through. All welds must be made entirely through the plate so that the material is as strong and as solid as it is possible to make it. All arc welds should be reinforced at least 20 per cent.

All work should be free from grease or dirt and must be kept clean at all times. Each layer of metal is to be brushed after it is applied. This is important, as the oxide which lies on the surface of the weld will interfere with making a good weld. If not kept clean, slag forms on the top which must be penetrated before the arc will bring the metal to the fusion point. If the welder sees that the current is fluctuating he should report the condition at once to the foreman or electrician in charge and should not resume the operation until the current is steady again.

When the operator starts making his weld he must hold a very close arc (approximately ⅛ inch away from the work); by so doing the metal is deposited in place in solid form. All welds should be started from the lowest point, the finishing weld being made at the highest point. After each electrode is used the weld must be thoroughly brushed with a steel brush in order to remove all oxide which might have formed on the weld. The electrode holder should be held in a manner not to obstruct a clear view of the work or weld. Under no circumstances should the electrode be moved swiftly. If this is done the weld metal



Laying out is the first operation

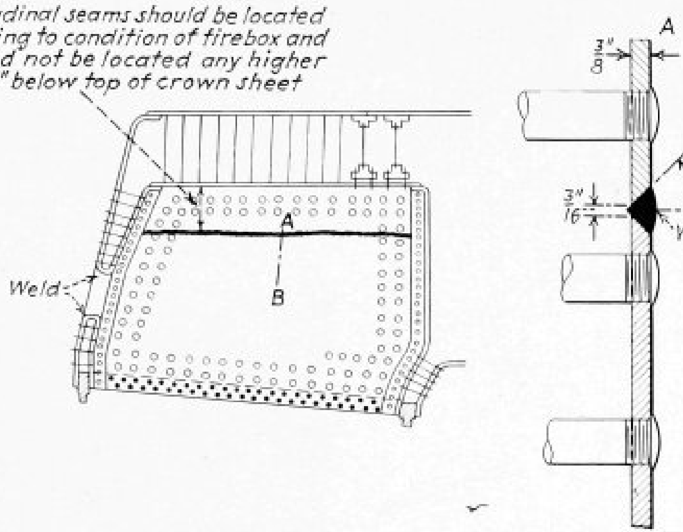


Fig. 1- Full or Half Side Sheets

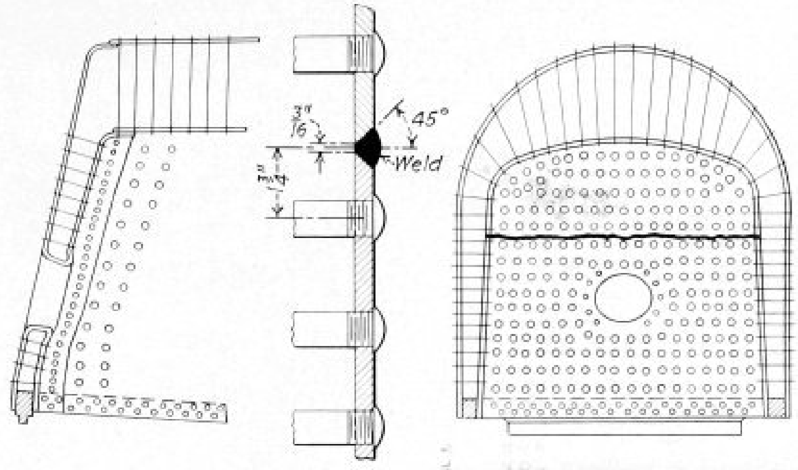
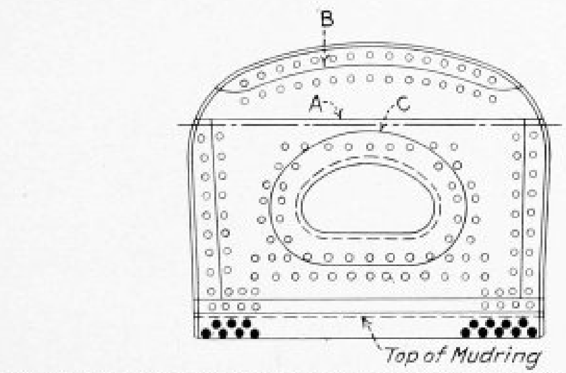
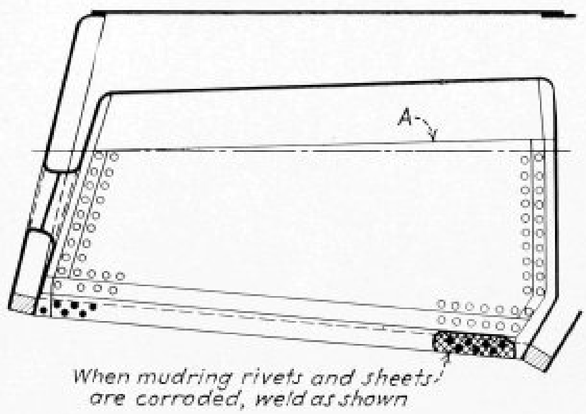


Fig. 2- Door Sheets



A-When necessary to replace portion of door sheet cut at line "A"
B-When necessary to replace portion of door sheet flange, cut between 1st. and 2nd. row of staybolts
C-When necessary to replace door collar, cut outside of 1st. row of staybolts

Fig. 3- Method of Removing Back End



A- When necessary to replace crown sheet, cut at "A"

Fig. 4- Method of Removing Side, Flue and Door Sheets

Methods for welding side sheets and door sheets, and removing back ends and firebox sheets

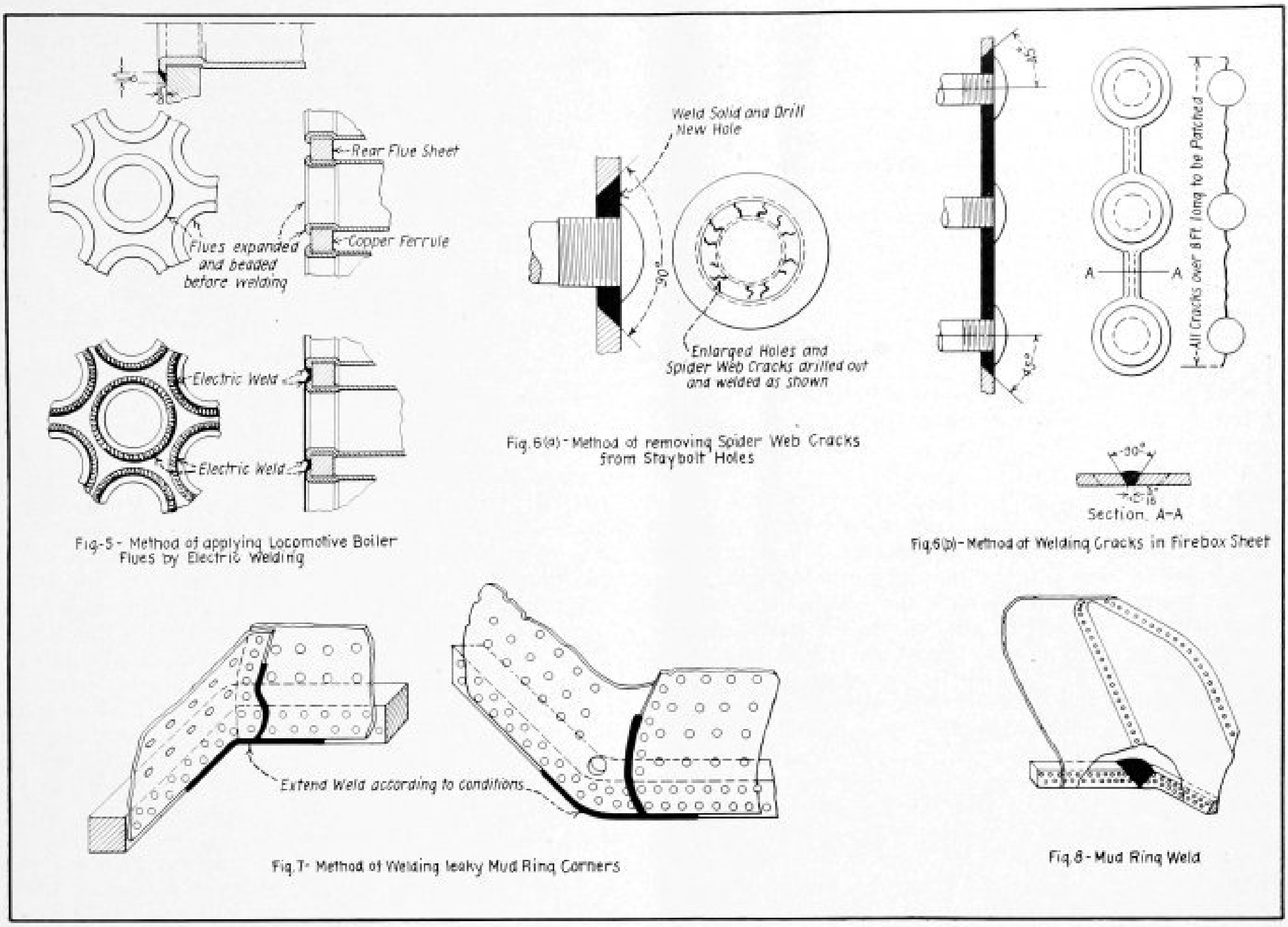


Fig. 5 - Method of applying Locomotive Boiler Flues by Electric Welding

Fig. 6(a) - Method of removing Spider Web Cracks from Staybolt Holes

Fig. 6(b) - Method of Welding Cracks in Firebox Sheet

Fig. 7 - Method of Welding leaky Mud Ring Corners

Fig. 8 - Mud Ring Weld

Methods of welding flues, staybolt hole cracks and mud ring corners

has a burned appearance, caused by oxygen in the air coming in contact with the metal while it is at a high temperature. By holding the electrode close and working slowly the metal is given time to cool to a lower temperature while the arc is passing over the weld. A simple method of determining the quality of the metal in a weld made by the electric-arc process is to chip a section of the weld with a suitable chipping tool. When the chips are tough and curl without breaking, the weld is good. When the welded metal chips like cast iron and is brittle, the weld is poor.

A list of the amperage and correct wire for use in electric welding follows:

Fireboxes	⅛-inch wire	90-100 amperes	⅜-inch sheet
Fireboxes	5/32-inch wire	95-105 amperes	⅜-inch sheet
Fireboxes	⅛-inch wire	95-105 amperes	½-inch sheet
Fireboxes	5/32-inch wire	100-110 amperes	½-inch sheet
Flues	⅛-inch wire	120-135 amperes	Water in boiler
Flues	5/32-inch wire	125-135 amperes	Water in boiler

If grates become broken or burned they should be reclaimed as follows: When the grate has one or two burned fingers the grate should be removed from the frame. By turning it into the vertical position the ends of the fingers may be built up preferably by means of the oxy-acetylene process. When a finger of the grate has been broken it may be repaired by welding the finger in position. If the finger has been lost, remove one from a scrap grate then place it in position and weld with the fusion process. The welding is to be performed from both sides of the finger when possible. When the grate has more than three fingers broken at one time it may not be advisable to repair it as the cost may exceed the price of a new grate.

The methods for replacing full or half side sheets and door sheets are shown in Figs. 1 and 2 while Figs. 3 and 4 show the method of removing the back end and side, flue, and door sheets respectively.

The instructions for welding flues in sheets are as follows: After the flues are set in the regular way the engine should be placed in service before welding the flues in order to overcome any unnatural strain. The flues to be welded should be thoroughly worked with the expander and beading tool. Flues must be sand blasted or the roughing tool used around the flue beads in order to remove any scale or foreign matter. Under no circumstances should the copper ferrules be allowed to project out under the flue beads. Before welding, be sure that the flue sheet is free from grease. Begin welding operations at the top row of flues. Weld across the top row then the next row and so on until finished. The welding machine should be set to operate at 125 to 135 amperes. For this work the Wannamaker welding wire No. 3, ⅛-inch should be used or 5/32-inch on superheater flues. This operation is shown in Fig. 5.

When flues which are welded to the back sheet begin to leak the old welds of the leaky flues should be entirely removed, the flues thoroughly worked with the expander and beading tool and then rewelded. It is not good practice to bead a weld on a flue. All the old welds should be removed.

When welding flues that have not previously been welded but have been in service for some time the flues should be thoroughly expanded and beaded and the beads and sheets sand blasted or the roughing tool used.

On Illinois Central power the standard installation of F. B. C. welded sleeves consists of the UW sleeve except where it is necessary to apply flush sleeves, in which case the FW type is used. The sleeves must be clamped solidly in place with the applicator furnished for that purpose, after which the sleeve should be tack welded on three sides. The applicator is then removed and used for the next sleeve. The sleeves are then welded using Wannamaker No. 3, 5/32-inch diameter electrode. Not over three layers of welding material should be applied to each sleeve.

In preparing half, side and door sheets for welding by the electric-arc process the sheet should first be bolted to the mud ring. The staybolts may all be applied except the rows adjacent to the seam which is to be welded. When plates are in their proper place they should be tack welded for 12 inches. Intermediate spaces alternating from the center space out should first be welded. Vertical seams should be tacked in a manner similar to horizontal seams. Welding such seams is started at the bottom and finished at the top. When welding overhead with the electric-arc process, it is necessary to add 10 amperes to the current of the machine and hold a very close arc. This applies to firebox work only. The method of welding cracks and checks around staybolt holes is shown in Figs. 6(a) and 6(b).

When trouble is experienced from leaky side sheet seams, door collars, flanges or old patches on which the rivets or patch bolts are bad, remove the rivets or patch bolts and cut around the sheet on a line with the center of the holes by means of the cutting blow-pipe. Bevel the edge of the sheet to 45 degrees and lap-weld, filling the holes on the inside sheet. This practice should be followed in preference to a patch when side sheets are grooved due to excessive calking adjacent to the lap. Sleeves should be thoroughly cleaned before welding.

Welding of transverse or vertical flue sheet knuckle cracks will not be permitted. A patch should be applied as shown in Fig. 1, December, 1930, issue. All flue holes should be put in the patch, then it should be cut to size and properly beveled. Weld the center bridge first then the next bridge on either side and continue alternating from side to side as each weld is completed, finally, weld the flanges. Welding is to be done on the fire side. Flanges should be cut at a 45-degree angle.

Door collars should be applied in accordance with Fig. 2 in the December, 1930, issue. When a new collar has been properly secured in place it should be tack welded to the door sheet after which the welding to the door sheet should be completed. The flange must be butt welded to the door hole flange of the back head after the inside weld has been completed.

When mud ring corner patches are to be applied as shown in Fig. 3, December, 1930, issue, be sure all defective parts are removed. The sheet must then be beveled to 45 degrees with a feather edge at the water side of the sheet. The patch may then be applied leaving ⅛-inch opening between the patch and the sheet. Staybolts should be applied in the patch to hold it in place. Patches must be well laid up in mud ring corners and electric welded to the mud ring along the calking edge, after the rivets have been applied. When sheets become thin at mud ring corners, due to corrosion, they may be built up with bronze, the sheets to be sand blasted before welding. When engines are shopped for general repairs all mud ring corners must be welded inside and outside, as shown in Fig. 7.

When mud ring corners become leaky they must be welded with the electric-arc process but must also be properly calked and cleaned off thoroughly with the roughing tool and beveled to 45 degrees whenever possible. Bevels must never be allowed to reach into rivet holes or the heads of rivets. Wannamaker coated wire No. 3 should be used for this operation, the machine being set at 125 to 135 amperes. Welding should be started at the lowest point of the mud ring, the operator proceeding along the lower edge until it is completed. Next the upright seam should be welded to above the grate frame. When the mud ring seams are welded the amperage should be lowered to 100; then weld above the mud ring as in Fig. 7.

To weld broken mud rings between shoppings, first remove a sufficient amount from the bottom of the firebox plates to permit movement of welding tools; vee out the mud ring to 45 degrees on the top side of the crack, leaving ⅛-inch opening at the bottom, as in Fig. 8; parts must be sand blasted or thoroughly cleaned free from all scale and rust. Wannamaker coated welding wire No. 3 should be used with 130 to 145 amperes.

Patches of an elliptical or circular shape should be applied as shown in Figs. 4(a) and 4(b), December, 1930, issue, where the cracks or checked part of the sheet do not cover an area greater than three staybolt rows in width. Patches do not require dishing when electrically welded. Where the defective part does not require the removal of a large area of plate and yet necessitates a patch larger than shown on Fig. 4(a) of the December, 1930, issue, a patch as shown in Fig. 4(c) of the same issue may be applied, the edges to be prepared as shown. When welding patches, start the weld at the bottom and continue on around to end on the opposite side. For general repairs, half side sheets must be applied in preference to these patches.

Work of the Boiler Code Committee

Case No. 663. *Inquiry: a* Could not Par. P-261 of the code be arranged to provide for the corrosion allowance to be subtracted from the actual shell thickness when using the formula in the case of vessels with extra shell thickness?

b Could not a paragraph be inserted in the code permitting the replacement area to be calculated in accordance with section *a* of Par. P-261 when the area computed according to section *b* is larger?

Reply: a In case a shell is made thicker than called for by the code formula in order to allow for corrosion, the rules in Par. P-261 shall be based on the thickness of the shell plate less the amount added for corrosion.

b The required strength of the rivets in shear in the flange of a nozzle may be computed by both sections *a* and *b* of Par. P-261 and the lesser of the two values used.

Case No. 664. *Inquiry:* Is it necessary, in inserting minus dished heads (convex side to pressure) in the shells of pressure vessels, to reduce the thickness of the head flange as required by Par. U-75 of the code, by turning it in the lathe as shown in Fig. U-3½*B*, or may this reduction be made by chipping or grinding?

Reply: The code is not mandatory in its requirement for reduction of thickness of head flanges to the exact form shown in illustrations in Fig. U-3½. It is the opinion of the committee that if the edge of the head flange at the point of weld is reduced to approximately the same thickness as the shell by either chipping or grinding, the intent of this requirement will be met. In case of such chipping or grinding, it is merely necessary to effect the reduction within the distance $1\frac{1}{2}T$. It is the opinion of the committee that a variation of thickness between the edge of the head and the shell plate of 20 percent of the shell plate thickness should be construed as complying with the code requirements provided the head is of the thickness required by the code.

Case No. 667. *Inquiry:* Is it the intent of the code that the reference in section *a* of Par. P-261, which requires double riveting for manhole frames on drums 48 inches or larger, shall apply on nozzles which may be used as nozzles or manholes?

Reply: The committee points out that if the rules given in Par. P-268 for attachment of nozzles are met with a single row of rivets, a double row is not required.

Case No. 668. *Inquiry:* Will the thermit pressure method of welding be considered under the rules of the code as the equivalent of the forge or hammer welding process for welding together ends of pipe or tubing, where the thermit reaction is utilized only for heating up the ends prior to pressing them together as is done in the pressure electric welding method?

Reply: If the application of the thermit is solely for the purpose of heating the surfaces to be joined and no extraneous metal is added at the joint, it is the opinion of the committee that the method may be considered as the equivalent of the forge welding process.

Case No. 669. *Inquiry:* Is it to be understood from the revision of Par. H-74 of the code, that the use of the regular flange and firebox classes of boiler plate steel are no longer permitted for the construction of low-pressure steel heating boilers?

Reply: In revising Par. H-74 to eliminate the carbon limit, the provisions for flange and firebox steel of the type given in the specifications in Pars. S-5 to S-17 were inadvertently omitted, as well as the provision for the use of steel of a lower tensile strength It is therefore proposed to add the following to Par. H-74:

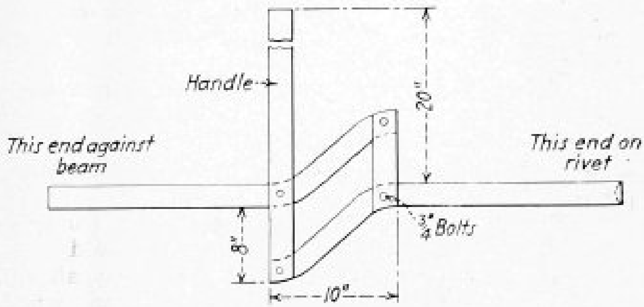
"or of Pars. S-5 to S-17 of Section II of the Code. If desired, steel of lower tensile strength than specified may be used, the desired tensile limits to be specified with a range of 10,000 pounds per square inch."

Bucking Bar For Rivets

In the illustration is shown a bucking bar designed as a pantograph in order to be more effective in cinching rivets tightly and in speeding up production riveting. The bar gives the operator a leverage which is not obtainable in a straight type of bucking bar. It prevents vibration and enables the operator to keep the bar in line with the rivet.

The bar illustrated is made of 2-inch round steel, the ends being of any desirable length necessary for the particular conditions surrounding the work which is to be performed. As shown, it is designed to buck ⅝-inch rivets, the dimensions of the pantograph being correct for the 2-inch bar. A bar of this style can be used effectively on construction and repair work by placing the back end against a beam or block and the other end over the head of the rivet, manipulation being effected by operating the handle. The pressure which can be exerted with the handle by the operator is sufficient to hold a rivet securely while it is being driven. It has been found to be exceptionally well adapted to the bucking of rivets in steel cars, as well as in boilers and in tender tanks.

The bar as shown allows for a considerable amount of variation in the distance from the rivet to the support.



Pantograph bucking bar for production riveting

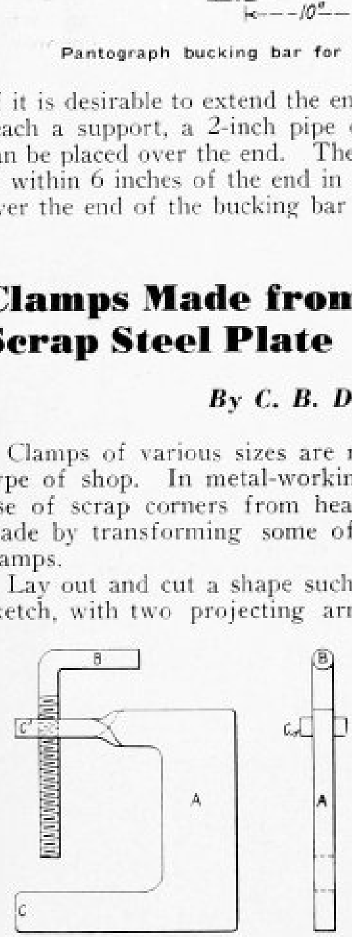
If it is desirable to extend the end of the bar in order to reach a support, a 2-inch pipe of the necessary length can be placed over the end. The pipe should be plugged to within 6 inches of the end in order to allow it to slip over the end of the bucking bar that distance.

Clamps Made from Scrap Steel Plate

By C. B. Dean

Clamps of various sizes are most convenient in any type of shop. In metal-working shops an economical use of scrap corners from heavy-steel plates may be made by transforming some of such scrap into "C" clamps.

Lay out and cut a shape such as shown by *A* in the sketch, with two projecting arms similar to *C*. The

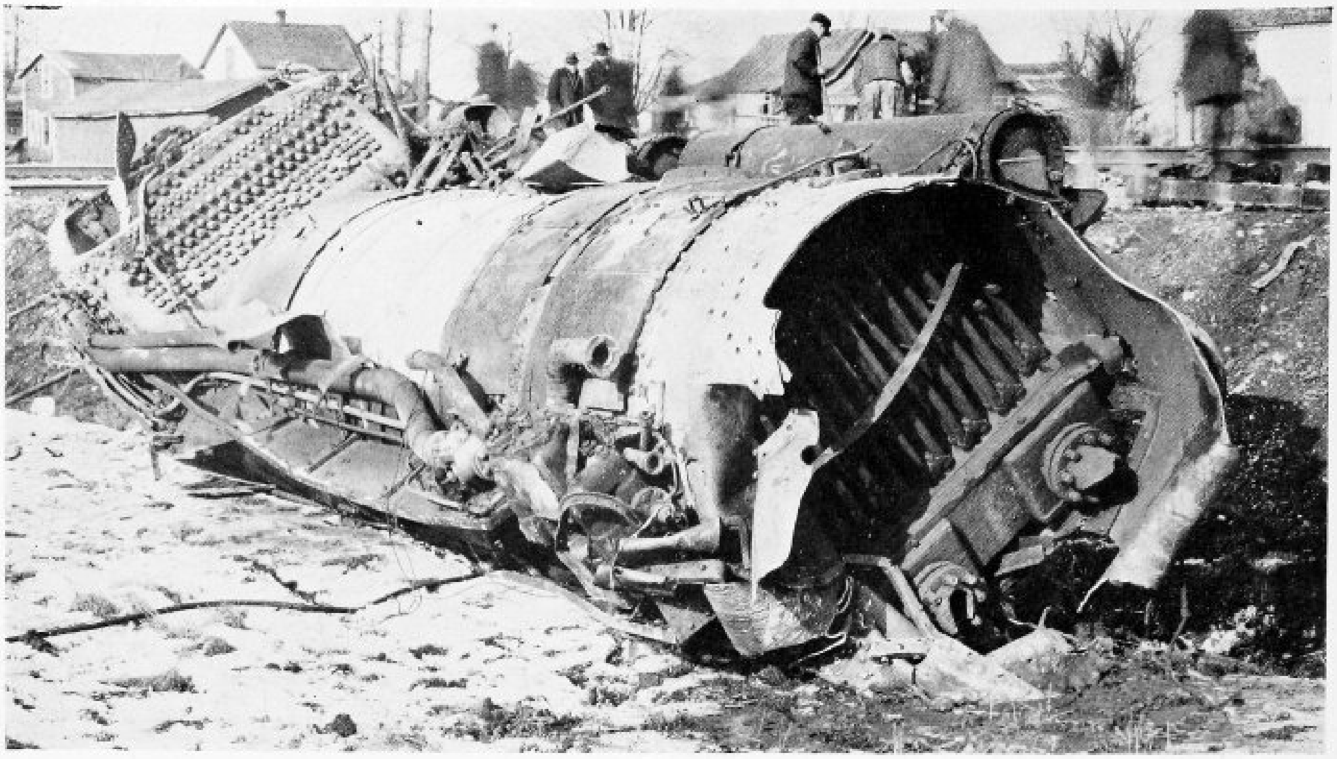


Type-C clamp made from scrap material

upper arm *C'* is given a half twist. In this arm drill and tap a bolt hole of the desired size. An ordinary bolt with a 90-degree bend as shown at *B* completes the clamp.

$1,000,000 Boiler Order

The London County Council has recently placed with Yarrow & Co., Ltd., one of the largest contracts for watertube boilers that has been granted in the United Kingdom. The order is for ten watertube boilers for the London County Council Tramways Department Power Station at Greenwich and it represents a value of over £200,000 ($1,000,000). The contract is a noteworthy indication of the growing prominence of the Yarrow watertube boiler for land work in Great Britain.



Chief Inspector Reports Locomotive Accidents for 1930

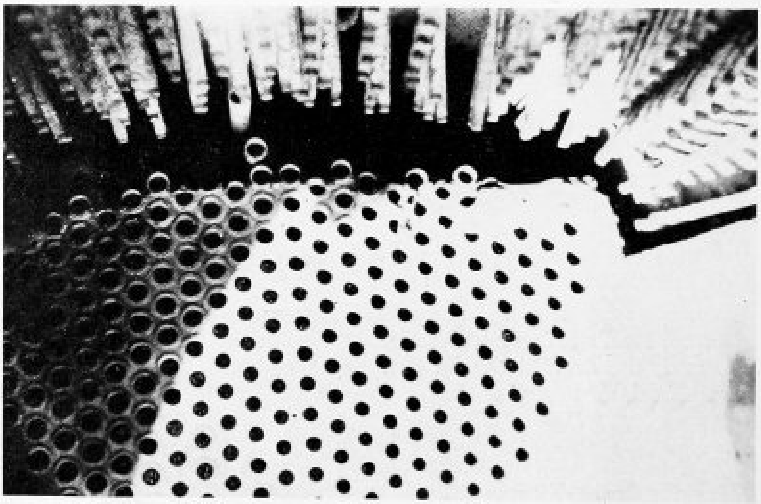


Fig. 1.—(At top) Boiler after low water explosion
Fig. 2.—(Below) Result of a crown sheet failure

Only 16 percent of the locomotives inspected during the fiscal year ending June 30, 1930, were found defective according to the nineteenth annual report of A. G. Pack, chief inspector, Bureau of Locomotive Inspection, to the Interstate Commerce Commission. In addition, the report showed a decrease in the number of accidents and the number of persons killed or injured. Only 16 percent of the locomotives inspected were found defective. There were 295 accidents which resulted in 333 casualties. This is the best record ever attained by the railroads since 1916, when the Bureau of Locomotive Inspection first began the compilation of statistics pertaining to the inspection of locomotives as they are now reported. There has been a steady decline in the number of defective locomotives, accidents and casualties since 1923, when 65 percent of the locomotives inspected by federal inspectors were found defective, and there were 1348 accidents which resulted in 1632 casualties. Following is an abstract of Mr. Pack's report:

During the year 16 percent of the locomotives inspected were found with defects or errors in inspection that should have been corrected before being put into use as compared with 21 percent for the previous year. A summary of all accidents and casualties to persons occurring in connection with steam locomotives compared with the previous year shows a decrease of 17.1 percent in the number of accidents, a decrease of 31.6 percent in the number of persons killed, and a decrease of 17.9 percent in the number injured during the year.

The decrease in accidents and casualties brought about by the decrease in defective locomotives, and the converse, are illustrated graphically by the curves on the chart, page 17.

Some of the carriers are maintaining their locomotives in condition approaching perfection while others are delinquent in this respect. The average percentage of locomotives on all railroads found defective has steadily decreased over a period of years reaching the low point of 16 percent for the year ended June 30, 1930. Improved standards of maintenance reflected by the reduced percentage of defective locomotives have brought about the greatest degree of safety of locomotive operation ever attained.

Boiler explosions caused by crown-sheet failures continue to be the most prolific source of fatal accidents; 84.6 percent of the fatalities during the year were attributable to this cause as compared with 68 percent in the previous year. However, there was a decrease of 35.3 percent in the number of such accidents, a decrease of 15.3 percent in the number of persons killed, and a decrease of 35 percent in the number of persons injured as compared with the previous year.

The increasing size of locomotive boilers and the high pressures carried therein tend to increase the violence of explosions and cause increase in the fatalities per accident and increase in the seriousness of injury to those who are exposed and survive. Attention is directed to the necessity for the use of the safest and strongest practicable firebox construction, including the use of reliable boiler-feeding and water-level indicating devices. These questions have been referred to in my former annual reports in order that the number of this class of accidents and the effects thereof might be minimized.

Two hundred and eighty-two applications were filed for extensions of time for removal of flues, as provided in Rule 10. Our investigations disclosed that in 12 of these cases the condition of the locomotives was such that extensions could not properly be granted. Nineteen were in such condition that the full extensions requested could not be authorized, but extensions for shorter periods of time were allowed. Forty-four extensions were granted after defects disclosed by our investigations had been repaired. Twenty-seven applications were canceled for various reasons. One hundred and eighty applications were granted for the full periods requested.

Under Rule 54 of the Rules and Instructions for Inspection and Testing of Steam Locomotives, 1242 specification cards and 7500 alteration reports were filed, checked, and analyzed. These reports are necessary in order to determine whether or not the boilers represented were so constructed or repaired as to render safe and proper service and whether the stresses were within the allowed limits. Corrective measures were taken with respect to numerous discrepancies found.

Under Rules 328 and 329 of the Rules and Instructions for Inspection and Testing of Locomotives Other Than Steam, 70 specifications and 123 alteration reports were filed for locomotive units and 23 specifications and 6 alteration reports were filed for boilers mounted on locomotives other than steam. These were checked and analyzed and corrective measures taken with respect to discrepancies found.

Eleven suits for penalties, involving 241 counts for

Fig. 3.—Failure due to overheated crown sheet

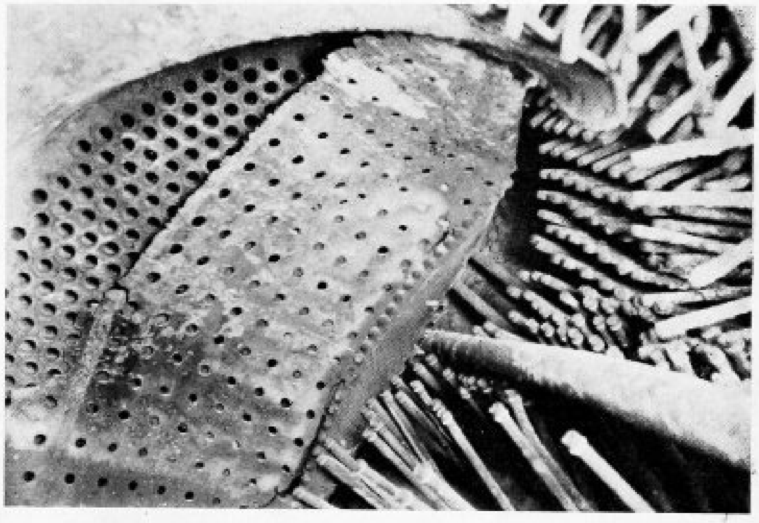
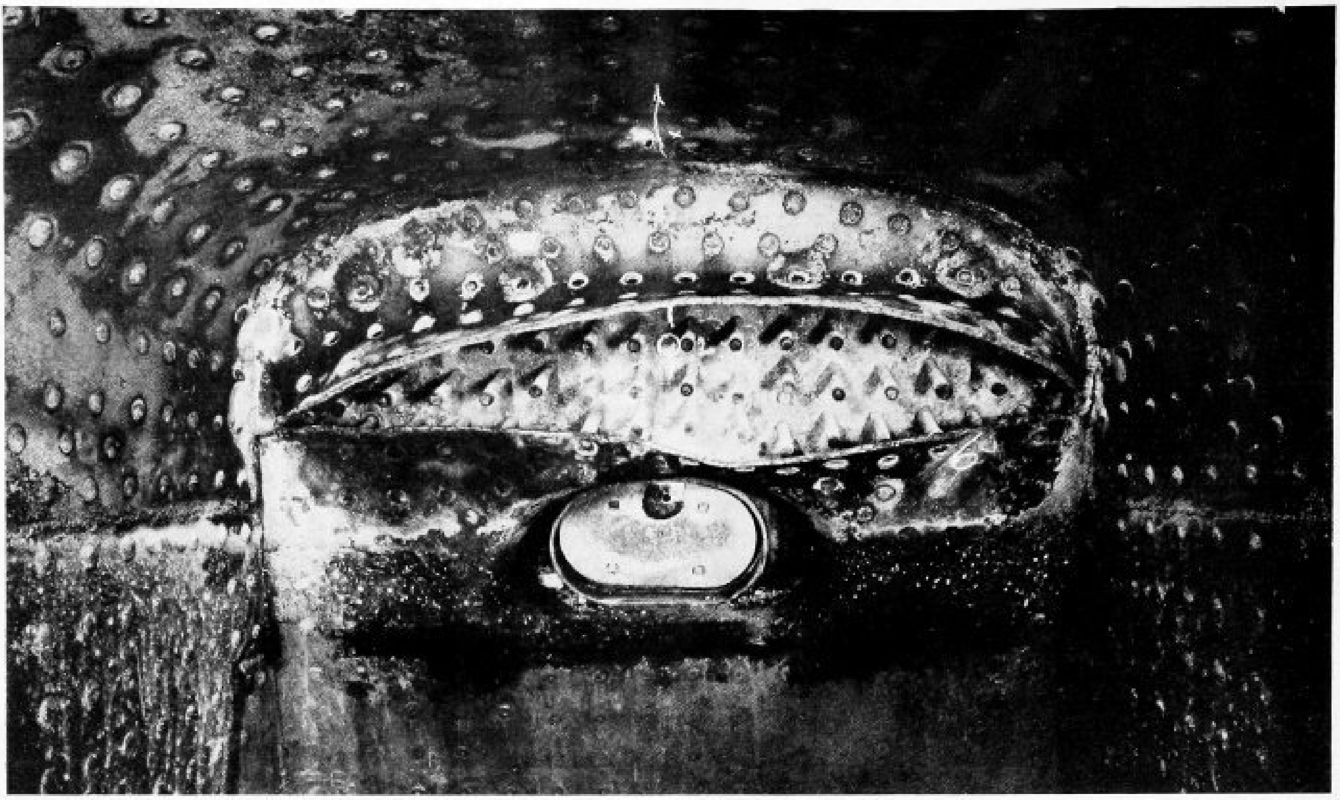


Fig. 4.—This boiler was thrown 660 feet



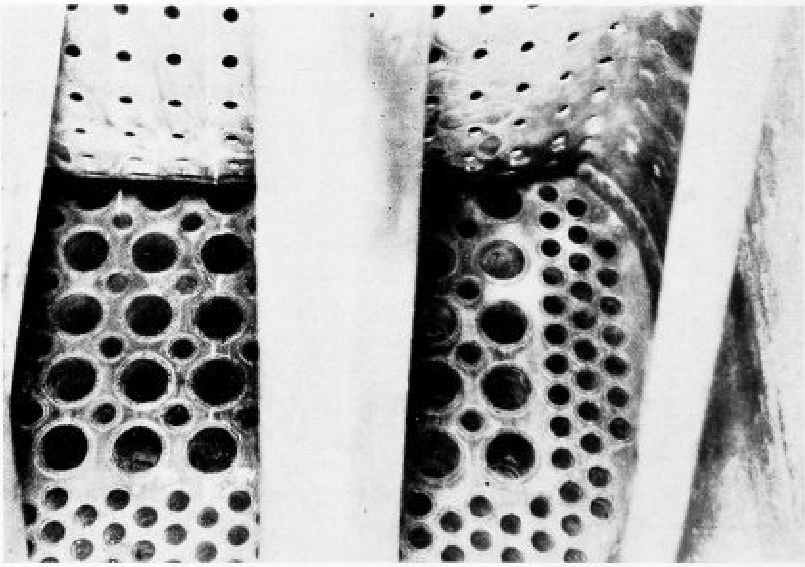


Fig. 5.—(At top). Transverse seam in door sheet which failed. Fig. 6. —(At right). Crown sheet failure resulting from low water. Fig. 7.— (Above). Water column connection which was plugged with scale

alleged violations of the Locomotive Inspection Law and Rules, were pending in the various district courts at the beginning of the year. Information of violations was lodged with the proper United States attorneys in three cases, involving 39 counts. Judgments in favor of the Government were obtained in 11 cases, involving 236 counts; 107 counts were dismissed by stipulation or agreement and penalties imposed on 129 counts in the sum of $12,900. Three cases, involving 44 counts, were pending in the district courts at the end of the year ending June 30.

The part of the commission's order dated February 21, 1929, promulgating Rule 118, applying to equipment of new locomotives with mechanically operated fire doors, together with the provision applicable to maintenance of fire doors became fully effective on April 1, 1929, and the part of the order applying to equipment of existing locomotives with mechanically operated fire doors when receiving classified repairs became fully effective on July 1, 1929. The terms of the order are being generally complied with. However, some of the mechanically operated fire doors that were at first applied as a result of the order contained inherent defects that precluded proper operation; these are now being replaced by fire doors that are apparently satisfactory.

No formal appeal by any carrier was taken from the decisions of any inspector during the year.

Typical examples of locomotive accidents due to the failure of some part or appurtenance of the boiler are given below.

Fig. 1 shows the result of a crown-sheet failure caused by overheating due to low water; the line of demarca-

TABLE 1.—ACCIDENTS AND CASUALTIES CAUSED BY FAILURE OF SOME PART OF THE STEAM LOCOMOTIVE, INCLUDING BOILER OR TENDER

	Year ended June 30					
	1930	1929	1928	1927	1926	1925
Number of accidents	295	356	419	488	574	690
Percent increase or decrease from previous year	17.1	15	14.1	14.9	16.8	31.3
Number of persons killed	13	19	30	28	22	20
Percent increase or decrease from previous year	31.6	36.6	[1] 7.1	[1] 27.3	[1] 10	69.7
Number of persons injured	320	390	463	517	660	764
Percent increase or decrease from previous year	17.9	15.8	10.4	21.6	13.6	33.9

[1] Increase.

TABLE 2.—ACCIDENTS AND CASUALTIES CAUSED BY FAILURE OF SOME PART OR APPURTENANCE OF THE STEAM LOCOMOTIVE BOILER[1]

	Year ended June 30							
	1930	1929	1928	1927	1926	1925	1915	1912
Number of accidents	105	119	150	185	247	274	424	856
Number of persons killed	12	14	26	20	18	13	13	91
Number of persons injured	113	133	174	205	287	315	467	1,005

[1] The original act applied only to the locomotive boiler.

TABLE 3.—NUMBER OF STEAM LOCOMOTIVES REPORTED, INSPECTED, FOUND DEFECTIVE AND ORDERED FROM SERVICE

Parts defective, inoperative or missing, or in violation of rules	Year ended June 30					
	1930	1929	1928	1927	1926	1925
1. Air compressors	873	1,202	1,282	1,679	2,151	1,574
2. Arch tubes	87	104	103	127	204	198
3. Ash pans and mechanism	76	132	133	192	211	216
4. Axles	12	20	7	13	8	14
5. Blow-off cocks	325	442	469	650	780	825
6. Boiler checks	521	761	914	1,043	1,200	991
7. Boiler shell	579	841	954	1,422	1,888	1,597
8. Brake equipment	2,706	3,894	5,214	6,572	7,062	6,497
9. Cabs, cab windows, and curtains	3,066	2,140	1,670	2,055	2,666	2,541
10. Cab aprons and decks	710	1,005	852	1,086	1,307	1,165
11. Cab cards	226	305	378	575	696	665
12. Coupling and uncoupling devices	122	154	179	289	394	447
13. Crossheads, guides, pistons, and piston rods	1,421	1,887	2,088	2,602	3,018	2,922
14. Crown bolts	95	129	164	235	334	283
15. Cylinders, saddles, and steam chests	2,311	3,210	3,264	4,526	5,080	4,352
16. Cylinder cocks and rigging	848	967	1,007	1,634	1,904	1,801
17. Domes and dome caps	154	227	281	388	463	371
18. Draft gear	950	1,310	1,453	2,037	2,634	2,283
19. Draw gear	1,003	1,367	1,650	2,210	3,140	3,273
20. Driving boxes, shoes, wedges, pedestals, and braces	1,359	1,993	1,990	2,710	3,342	3,241
21. Fire-box sheets	471	657	730	796	1,129	1,152
22. Flues	254	334	464	465	556	524
23. Frames, tailpieces, and braces, locomotive	1,271	1,377	1,354	1,682	1,973	2,036
24. Frames, tender	177	297	256	264	373	391
25. Gauges and gauge fittings, air	290	309	461	721	886	694
26. Gauges and gauge fittings, steam	553	678	969	1,425	2,038	1,809
27. Gauge cocks	783	1,114	1,413	2,024	3,068	3,081
28. Grate shakers and fire doors	767	295	377	613	720	832
29. Handholds	865	1,125	1,373	2,285	3,100	2,831
30. Injectors, inoperative	103	86	93	84	78	70
31. Injectors and connections	3,275	4,484	5,563	7,188	8,303	8,064
32. Inspections and tests not made as required	7,456	9,246	6,623	8,889	10,646	10,436
33. Lateral motion	372	618	699	673	758	659
34. Lights, cab and classification	119	121	118	107	106	86
35. Lights, headlights	373	488	571	835	946	928
36. Lubricators and shields	312	423	500	746	883	704
37. Mud rings	445	636	822	1,073	1,458	1,384
38. Packing nuts	828	991	1,265	1,851	2,772	2,761
39. Packing, piston rod and valve stem	1,429	1,708	1,904	2,214	2,489	2,411
40. Pilot and pilot beams	272	371	386	507	638	832
41. Plugs and studs	348	482	619	740	1,087	849
42. Reversing gear	579	788	967	1,247	1,539	1,274
43. Rods, main and side, crank pins, and collars	2,488	3,465	4,152	5,137	5,683	4,813
44. Safety valves	116	170	172	212	270	234
45. Sanders	804	1,008	1,031	1,268	1,769	2,004
46. Springs and spring rigging	3,311	4,557	4,939	5,956	6,826	5,532
47. Squirt hose	313	387	478	644	975	1,008
48. Stay bolts	395	542	590	631	905	741
49. Stay bolts, broken	1,098	1,197	1,867	2,373	3,582	3,745
50. Steam pipes	730	925	1,020	1,308	1,587	1,590
51. Steam valves	399	471	708	774	962	869
52. Steps	1,021	1,394	1,817	2,440	3,227	2,867
53. Tanks and tank valves	1,426	1,717	1,941	2,747	3,430	3,352
54. Telltale holes	183	174	241	377	487	451
55. Throttle and throttle rigging	1,175	1,554	1,889	2,233	2,618	2,403
56. Trucks, engine and trailing	1,141	1,605	1,914	2,363	2,860	2,966
57. Trucks, tender	1,531	2,144	2,610	4,114	4,929	5,372
58. Valve motion	827	1,067	1,262	1,368	1,576	1,250
59. Washout plugs	1,283	1,871	2,211	2,786	3,649	3,588
60. Train control equipment	48	60	112	....	....	....
61. Water glasses, fittings, and shields	1,501	1,816	2,115	2,973	3,621	3,713
62. Wheels	1,025	1,325	1,609	2,119	2,243	2,148
63. Miscellaneous—Signal appliances, badge plates, brakes (hand)	691	1,101	1,273	1,511	1,746	1,529
Total number of defects	60,292	77,268	85,530	112,008	136,973	129,239
Locomotives reported	61,947	63,562	65,940	67,835	69,173	70,361
Locomotives inspected	100,794	96,465	100,415	97,227	90,475	72,279
Locomotives defective	16,300	20,185	24,051	29,995	36,354	32,989
Percentage of inspected found defective	16	21	24	31	40	46
Locomotives ordered out of service	1,200	1,490	1,725	2,539	3,281	3,637

Relation of defective locomotives to accidents and casualties resulting from locomotive failures

tion being approximately 12¾ inches below the highest part of the crown sheet. This accident caused the death of three employees. The boiler was thrown upward and forward, coming to rest 175 feet ahead of the point of explosion and turned in the opposite direction from which the train was moving.

Fig. 2 shows the result of an explosion causing the death of two employees due to the crown sheet having become overheated as a result of low water. The force of the explosion tore the boiler from the frame, hurling it forward 328 feet and 16 feet from the track where it indented the earth to a depth of 6 feet and rebounded to a point 80 feet farther and 35 feet from the track. The crown sheet, with parts of the back flue sheet and door sheet attached, was blown down and out of the firebox.

In this explosion the fusion-welded side sheet seam failed on the right side. The left fusion-welded side sheet seam failed for its entire length in a similar manner. A total of 347 inches of fusion-welded seams failed.

Figs. 3 and 4 show the result of an explosion causing the death of two employees, the serious injury of two others and the injury of eighteen non-employees, due to the crown sheet having become slightly overheated as a result of low water, the line being approximately 4 inches below the highest part of the crown sheet. The force of the explosion tore the boiler from the frame, hurling it forward 660 feet.

This accident occurred while the locomotive was double-heading a passenger train running at an estimated speed of 38 miles per hour on an ascending grade. Running gear of this locomotive was derailed as was the locomotive which it was helping and which turned on its side at an angle of approximately 45 degrees.

This boiler carried 200 pounds steam pressure. The combustion-chamber crown sheet, 36 inches in length, was joined to the firebox crown sheet by a transverse fusion-welded seam which failed for a distance of 35 inches where the initial rupture evidently took place.

The force of any explosion depends upon the size and suddenness of the initial rupture and the temperature and volume of water in the boiler at the time of the rupture. Therefore, it has been frequently recommended by this bureau that welded seams in crown sheets of conventional type be avoided because of their almost universal failure under such circumstances and the serious results which follow such accidents.

Evidence brought out at the investigation of this accident shows that just prior to the accident the right injector was wasting water and steam at the overflow, and that trouble was being experienced with the injector.

Fig. 5 shows a failed fusion-welded transverse seam in door sheet, the accident resulting in the serious injury of one employee. Shop records show this locomotive received classified repairs and made ready for service in February, 1926, at which time the patch in the door sheet was applied.

The estimated mileage since the patch was applied was approximately 100,000 miles. So far as could be determined, there was nothing in the appearance of the welded seam prior to the failure that would indicate an unusual condition, and the appearance of the fractured area was typical of failed fusion welds.

The failure occurred with 3 gages of water and about 100 pounds of steam pressure in the boiler while the locomotive was being made ready for service. There were no indications of low water, and no cause found that would produce overheating.

Fig. 6 shows a crown-sheet failure as a result of low water, the line of demarcation being 6¾ inches below the highest part of the crown sheet, which resulted in the injury of two employees. The entire surface of the crown sheet of the combustion chamber in front of the thermic syphons showed a very distinct blue color, and the line of demarcation was well defined in this area. The combustion-chamber crown sheet pulled away from 153 radial stays and pocketed to a depth of 13½ inches at the deepest place.

After reviewing and giving deep study to the cause and effect of many boiler explosions over a number of years it is believed that every known precaution should be taken to guard against such accidents or to reduce, as far as possible, their fatal and disastrous consequences. The right injector with which this boiler was equipped had been reported as "not supplying the boiler" 13 times prior to the accident, which would indicate that proper attention had not been given to this injector at the times it was reported.

Fig. 7 shows the vertical member of the boiler connection to bottom of water column filled practically solid with hard scale. The condition illustrated was found by our inspector on a locomotive that was about to be placed in service. Defective and improper water-level-indicating appliances have been the cause of many overheated crown sheets and much damage to property and serious injury and loss of life to persons. Extreme care should be exercised in seeing that these appliances are maintained in good condition at all times. Water columns and connections should be blown out and tested before each trip, and parts where scale or sediment is liable to accumulate should be thoroughly cleaned each time gage cocks and water glass cocks are required to be cleaned.

New Welding Electrodes

The Flex-Arc welding electrode, a general purpose steel-welding electrode evolved by extensive experimental and development work conducted in acutal welding practice, is announced by the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.

To insure absolute uniformity, each coil of wire is arc tested prior to straightening and cutting; and all processes, from steel to bundled wire, are under proper supervision to assure sustained quality and uniformity.

The reduced metal spattering effected by the use of these electrodes assures a quiet, stable, and flexible arc at both extreme low and high current values; and the easy arc manipulation gives the operator a more flexible tool for vertical and overhead welding. These electrodes have a uniform melting rate which assures quick penetration and a perfectly fused bead that blends with the general appearance of the completed product.

Welds made by these electrodes are easily machined and are free from slag, oxidation, and gas inclusions. Tensile strengths ranging from 55,000 to 60,000 pounds per square inch are consistently obtained without any special skill on the part of the operator.

Flex-Arc sulcoat and bright finish electrodes are manufactured from steel made by the basic open-hearth process. They meet the American Welding Society specifications E-No. 1-B.

Process for Welding High-Carbon Steel

A new process for electrically welding high-carbon structural steel tubing has been announced by officials of Steel & Tubes, Inc., Cleveland, O., a subsidiary of the Republic Steel Corporation. The new equipment is located at the Elyria, Ohio plant and it is an adaptation of the patented Johnston process of electric welding owned and developed by Steel & Tubes, Inc.

The new style of electrically welded high-carbon tubing differs from ordinary steel tubing in its much greater strength and rigidity. The process is the result of over two years experimental work by company engineers. In the old-style of forming, the tubing was rolled into an open seam or butted tube. In the brazed form, the seams were united by spelter, consisting of a combination of soft metal. The new electric welding process forms a union of the metal itself at the seam making the tube much stronger than brazed tubing.

The tube is homogeneous, has a smooth finish with the welding seam rolled down so as to become almost imperceptible. According to company engineers, tests have shown that it will withstand severe mechanical bending and forming operations. It can also be hot galvanized which was not commercially possible with brazed tubing.

High-Pressure Steam for Locomotives

By C. F. Hirshfeld*

"Looking at the steam locomotive through the eyes of an engineer who has concentrated his efforts in the stationary field, I am struck by the fact that it appears to have improved little during the period in which my own field of endeavor has made such rapid progress. To be sure, it has been made bigger, superheaters have been adopted, feedwater heaters have been added, and so on, but the locomotive that I viewed with wonder as a small boy and the locomotive that I view now more understandingly as a middle-aged man are essentially the same."

When the locomotive designer begins to study recent stationary-plant development he discovers marked increases of steam pressure during a comparatively short period, and latterly an evident tendency toward radical increases of steam temperature. It is but natural to ask whether these are proper items for serious consideration in his field of endeavor.

There is a popular belief that thermal economy increases indefinitely with increasing steam pressure and this belief has been responsible for quite a bit of loose thinking. Comparatively simple calculations suffice to show that it is erroneous. It is at once apparent that the great improvement with increasing pressure occurs in the lower ranges of pressure, and that there is a reversal, that is, an actual loss if the pressure is carried high enough.

A great part of the saving that is achieved through the use of high-pressure steam in condensing stationary practice is achieved through the use of regenerative feedwater heating. The higher the pressure, the greater the effect of this process. However, even with regenerative feedwater heating, the gains obtainable with like pressure increments become increasingly smaller as the pressure increases and ultimately reverses.

Inspection indicates that at 700 degrees F. there is probably little justification in exceeding about 600 pounds without regenerative heating and something like 800 to 900 pounds with four-stage regeneration, unless reheating be resorted to. In practice the limits are set in both cases close to 500 pounds because of the serious effect of condensate in the steam. The situation is naturally improved by increasing the initial temperature. If 1000-degrees F. steam could be used, the practical or commercial upper-pressure limit without reheating would probably be in the neighborhood of 1000 pounds.

There are, however, other considerations which may also be weighty, particularly in the case of locomotives. Thus, for example, high-pressure steam occupies much less space per unit of weight than does saturated steam. One pound of steam at 200 pounds absolute and 700 degrees F. occupies a space of 3.4 cubic feet, whereas the same weight at the same temperature, but at a pressure of 1400 pounds, occupies only 0.4 cubic foot. As a result of this fact, pipes and other parts for high-pressure steam may in fact weigh less than for the equivalent amount of low-pressure steam.

It is at least conceivable that the combination of decreased fuel consumption per unit of output and decreased volume might be used in locomotive practice in either one of two ways. One would be the increase of capacity without increase of grate area or its equivalent; the other would be decreased size of parts for present output.

Experience with steam superheated above a temperature of 750 degrees F. is still too meager to make it safe to draw final conclusions with respect to higher temperatures. At present it looks as though carbon-steel tubes can be used safely to produce steam with a temperature of 800 to 850 degrees F., provided the metal temperature does not rise too high. The limit in this respect is taken at present at about 950 degrees F. provided the steam is practically free of oxygen when it reaches the superheater tubes. It is also necessary to design so that the unit stresses in the metal do not exceed something of the order of 4000 pounds per square inch.

The importance of oxygen-free steam cannot be ignored as experience indicates that very rapid attack upon the metal may be expected at such metal temperatures if any appreciable quantity of oxygen is present in the steam.

This is also the temperature at which reaction between iron and steam begins to become noticeable. As a matter of fact, this reaction does not occur to a sufficient extent at 950 degrees F. to be at all significant, but it becomes of great importance at between 1000 and 1050 degrees F. The reaction is such that a very closely adherent magnetic-oxide scale is formed on the steam side of the tube and hydrogen passes off with the steam.

Higher temperatures may be used with alloy steels such as the nickel-chromium alloys and others which show higher creep strengths than the carbon steels. Such metals have been used in experimental equipment delivering steam at 1100 degrees F., and there is no indication of short life due to creep, simple oxidation, or reaction with steam. Unfortunately the available alloys are all very high priced, and their metallurgy and physical behavior are not yet well understood.

These facts would seem to indicate that we are limited to steam temperatures of the order of 800 to 850 degrees F. if restricted to carbon-steel tubing, and that we can probably extend this temperature to 1000 or 1100 degrees F. if the cost of the more expensive alloys can be justified. These figures immediately enable us to de-

* Mr. Hirshfeld is chief of the research department, The Detroit Edison Company, Detroit, Mich. He contributed this paper, of which an abstract is given here, at the invitation of the Railroad Division, A. S. M. E., during the annual meeting of the society, which was held in New York, December 1 to 5, 1930, inclusive.

termine the highest steam pressures that show thermal advantages under any selected set of conditions. It must be realized, however, that the thermal considerations alone are not completely determinative. There are many others of operating and economic character which are equally important, and much more difficult to evaluate with respect to any particular field.

If one choose about 800 degrees F. as the highest temperature which now seems reasonably possible under locomotive conditions, it would appear from thermal considerations as though a pressure in the neighborhood of about 800 pounds might be usable for non-condensing operation. It becomes pertinent to inquire into boiler characteristics at such pressures. Stationary experience with the higher pressures has been obtained with watertube boilers exclusively, and with comparatively clean and pure boiler water. It is a long cry from such conditions to those found in average locomotive practice.

With properly designed watertube boilers there has been no evidence of any intrinsic limitations to adequate natural circulation at pressures in the neighborhood of 600 to 700 pounds, and there is no reason to expect such trouble at 800 pounds. On the other hand, when pressures of 1200 to 1400 pounds are reached, the forces causing natural circulation appear to be approaching such magnitudes that very small changes of design or condition may lead to serious trouble.

In this country we have succeeded in obtaining commercially satisfactory operation at such pressures with watertube boilers of what one may call conventional design, but it has required careful design and careful operation. European engineers, on the other hand, calculated in advance the forces that should be available for creating natural circulation, and concluded that somewhere in the neighborhood of 1200 to 1400 pounds one entered the questionable region. It is possible that this is responsible for some or all of the radically new types of high-pressure steam-producing equipment now being experimented with in Europe.

Two things of interest have been uncovered. An almost unbelievably small amount of scale on the water side in 1200 to 1400-pound pressure boilers is fatal to those surfaces subjected to high rates of heat transfer. And it is possible to show by calculation that, with heat-transfer rates which may be regarded as possible of achievement, the metal of exposed tubes in a 1400-pound pressure boiler may reach temperatures at which the existing stresses will cause fairly rapid creep.

If one may judge from such meager evidence, it would seem that even if the locomotive boiler were modified structurally so as to adapt it to use with pressures of this order of magnitude, the feedwater conditions now characteristic of locomotive practice would make operation at such pressures impossible. In fact, I greatly doubt whether operation at a pressure as low as 400 pounds could be conducted commercially without great improvement over present feedwater practice as it exists throughout the country.

I have endeavored to picture just what sort of boiler I would design for a high-pressure locomotive if that problem were put up to me. That it must have a water-cooled firebox is almost self-evident. That the water-cooled surfaces should take the form of tubes for high pressure instead of plates is almost equally obvious. I conceive first of a rather large reservoir which shall be adapted to hold a volume of water substantially at boiler temperature and which shall serve as a source of steam supply to meet sudden short-time demands. Associated with this reservoir is a system of water tubes serving as a watertube boiler. These form the firebox and, besides, give such added surface as is required to reduce the products of combustion to an acceptable temperature. Circulation through these tubes is produced by a pump which draws from the hot-water reservoir, and the tubular surface is so arranged as to discharge to that reservoir. The water tubes simply serve as a collection of heating paths starting at the pump discharge and ending at the pump suction, i.e., the reservoir from which the pump draws. Steam made is tapped off this heating system as required. I imagine that the pump speed would be regulated with respect to steam demand so that it will always circulate a large excess of water.

One familiar with locomotive design will undoubtedly view with alarm the steam temperatures that have been suggested as desirable with higher pressures. Even a temperature of 800 to 850 degrees F. is not a pleasant thought in connection with locomotive engines of present design. Assuming, however, that we retain the reciprocating engine, is the present design a necessary result? I think not.

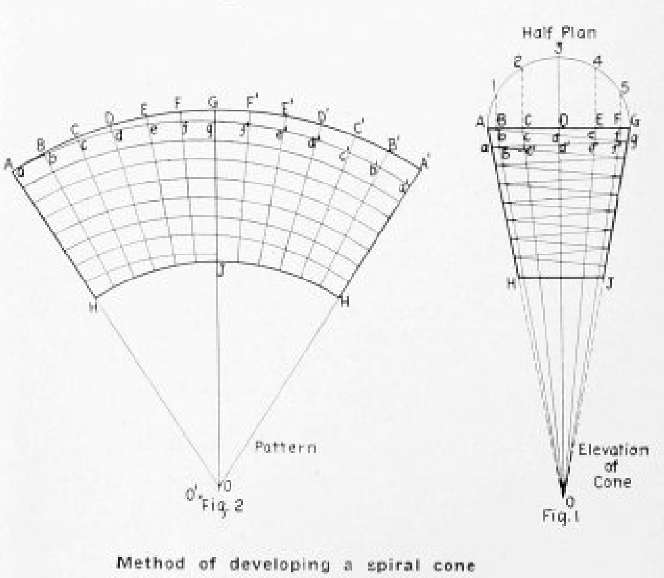
It is almost certain that some type of poppet-valve mechanism will have to be substituted for the present types in which metal slides on metal. But I cannot see that this necessarily offers insurmountable difficulties. Cylinder lubrication, as we now understand it, will also have to be abandoned. It is at least possible to conceive of a design of piston reciprocating in a cylinder which does away with actual metallic contact.

If we cut loose from present designs and adopt the condensing turbine solution, many of these problems disappear, but others of equal or greater magnitude make their appearance. However, they do not seem to be more difficult than many that have been solved successfully in other fields in recent years by the simple method of breaking completely from the conventional and considering all possibilities without too great reference to past convictions.

Developing a Spiral on a Blast Furnace

By James Wilson

In Fig. 1, *A-G-J-H* is the elevation of a cone, and an elevation of the center of holes required to rivet a spiral of $1\frac{1}{4}$-inch by 2-inch material to the cone, as a trough around the boshing of a blast furnace, where water



Method of developing a spiral cone

travels to keep the cone plates cool. To obtain the construction lines for the spiral proceed as follows: With center *D* on top of the elevation and *DA* as a radius describe a semicircle to represent a half plan of the large end; divide this into any number of equal parts, as *1, 2, 3, 4* and *5;* drop perpendiculars from these points to the line *A-G* to get the points *B, C, D, E* and *F* and from the latter points draw lines to the center *O*, which is obtained by producing *A-H* and *G-J*. Now draw an elevation of the flat iron spiral; but to save confusion, it is better to have only one line which will be the center or rivet line of the flat bar. Fill in all the required spiral lines, as in Fig. 1, which shows 8 revolutions from the top to the bottom of the cone.

To draw the pattern for the cone, and the position that the spiral will occupy on it, proceed as follows: With *O*, Fig. 2, as a center, and *O-G*, Fig. 1, as a radius, describe an arc, *A-G-A'*. With the same center, and *O-J*, Fig. 1, as radius, describe *H-J-H*. Make the distances *A, B, C, D*, etc., Fig. 2, equal to *A, 1, 2, 3*, etc., Fig. 1, and from the former points draw lines to meet at *O*, Fig. 2. This will give *A-A'-H-H*, the pattern for the cone in one piece, its seam on the line *A-H*, Fig. 1. It will also give a series of slant lines, corresponding to those on the elevation by means of which the points on the spiral in elevation can be transferred to the pattern. Thus *A-g-a*, Fig. 1, represents one revolution of the spiral; therefore, make *A-a, B-b, C-c, D-d, E-e*, etc., Fig. 2, equal to those marked in Fig. 1. Join the points in the pattern, thus obtained, by drawing an arc to touch them, a center for which will be found somewhere near *O'*. This arc will represent a development on the cone in the flat, of the position of one revolution of the spiral. Repeat this construction to draw in the other spirals.

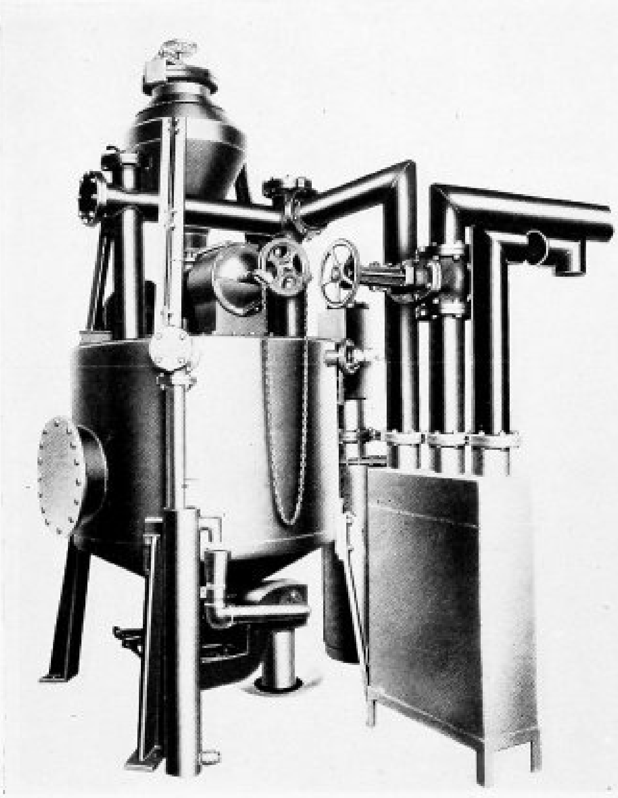
No matter how many plates the cone is to contain, the method of working can be easily understood by referring carefully to the illustrations.

Acetylene Generators

The Oxweld Acetylene Company, 30 East 42nd street, New York, has placed on the market two improved types of non-automatic stationary acetylene generators for supplying large volumes of acetylene. These generators are each made in two sizes having 500-pounds and 1000-pounds carbide capacity. They are designed for large industrial plants where oxwelding and cutting are used extensively and where oxygen and acetylene are piped to stations convenient to operators.

The type NA-3 acetylene generator, shown in the illustration, is for plants using low-pressure welding and cutting apparatus and delivers to a storage holder which is weighted to supply acetylene to the shop piping system at a pressure of 20 inches water column. In operation, the carbide is conveyed from the hopper to the generating chamber by a rotary feed screw driven by a slow speed reciprocating water motor. From the generator the gas enters the wash box where it passes through a water seal which acts as a scrubber to remove any particles of residue which might have been carried over.

When residue is being drawn off from the generator the wash box acts as a vacuum release and permits a reverse flow of gas which allows acetylene to return from the holder to the generating chamber to displace the drained water. When the generator is refilled with water, the gas passes from the generating chamber to the holder through this same wash box.



The Oxweld type NA-3 acetylene generator

The gas holder of suitable size may be located either inside or outside the generator house as best meets the needs of the particular installation. On the holder is mounted an automatic water holder shut-off which stops the carbide feed mechanism. When the gas bell approaches its upper limit, this shut-off must be opened by the attendant before the generator will again produce acetylene.

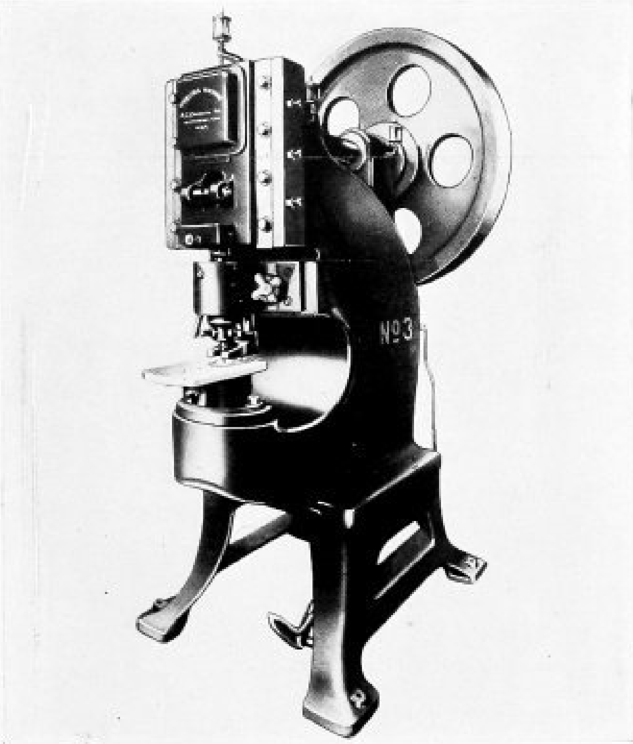
The type NA-4 generator is similar to the type NA-3 with the addition of an Oxweld automatic booster system to deliver acetylene to the shop piping system at pressures not to exceed the permissible limit of 15 pounds per square inch.

Campbell Nibbling Machine

The Campbell No. 3 nibbling machine has been brought out by A. C. Campbell, Inc., Bridgeport, Conn., to fulfill the need for a machine for cutting all kinds of shapes from sheet metal 3⁄8 inch to 3⁄4 inch in thickness. It is designed not only for cutting original pieces, but also for production work where the making of punches and dies is not desirable.

The machine cuts at a speed of approximately 20 linear inches per minute in any direction. Like the smaller nibbling machines it works on the circular punch and die principle with a pilot to prevent the work from slipping and the punch from taking too large bites. The cutting is clean without burr and very little finishing is necessary when a smooth edge is required.

It is designed to handle a large variety of work. Circles can be cut with a circle-cutting attachment which is furnished with the machine. For making original cuts the use of a straight edge and the French curve is recommended to insure close cutting to the line. The



The Campbell No. 3 nibbling machine

original piece may be used as a template for cutting duplicate pieces since the punch is designed to follow the template accurately. The machine has three strokes —1 inch, $\frac{13}{16}$ inch and ½ inch—with a capacity for handling all thicknesses of sheets from ⅜ inch to ¾ inch. A ⅞-inch punch can be set in the die by turning the stroke adjustment collar. The stripper plate is set in correct position by releasing the locking lever and turning the handwheel.

The following are the specifications for the machine: Floor space required without motor, 5 feet by 4 feet 2 inches; height over wheel, 8 feet 6 inches; pulley size, 50 inches diameter by 7½ inches face; pulley speed, 105 revolutions per minute; depth of throat, 15 inches; power required, 7½ horsepower; net weight, belt drive, 9000 pounds; shipping weight, belt drive 9500 pounds; maximum cutting capacity, ¾ inch; punch diameter, ⅞ inch.

Lukens Rolls Largest and Heaviest Plate

On its 206-inch four-high reversing type plate mill, the largest plate-rolling mill in the world, the Lukens Steel Company, Coatesville, Pa., recently produced the largest and heaviest steel plate ever rolled up to the present time.

The plate was reduced from a carbon-steel ingot weighing approximately 92,130 pounds, produced in the open hearth furnace. The sheared dimensions of the large plate are 195 inches in width, 360¾ inches in length and 2⅜ inches in thickness. It weighs approximately 48,200 pounds.

Rolling mill operations were in charge of R. W. Simpson, superintendent of mills, supervised by J. H. McElhinney and W. H. Warren, respectively general superintendent, and vice-president and general manager, of the Lukens Steel Company.

Arc-Welded Factory

The Wilson Welder & Metals Company, Inc., 38th street, North Bergen, N. J., has built a new plant which is not only a scientifically laid-out factory, from the standpoint of production, but the structural steel, in which electric welding was used exclusively, was erected by themselves. The building is of brick and steel.

Electric welding effected a saving of about 10 percent in the tonnage of steel used. In addition, the boiler, tanks, tracks and supporting hangers for the portable crane monorails were arc welded.

Business Notes

Owen H. Persons, assistant manager of sales of the American Steel & Wire Co., with headquarters at Philadelphia, Pa., has resigned to become general manager of sales of the Edgecomb Steel Company, offices at Philadelphia.

Paul Llewellyn, formerly president of the Interstate Iron & Steel Company, Chicago, has recently been elected to serve as the chairman of the board of the Empire Steel Corporation, Mansfield, Ohio.

James K. Aimer has been appointed assistant general manager of sales in charge of railroad, locomotive and car equipment sales, also bar iron and billet sales for Reading Iron Company; Mr. Aimer is located at 230 Park Avenue, New York, N. Y. He will assume complete supervision and direction of all sales to railroads, and in addition will direct the sales of Reading charcoal iron boiler tubes, formerly under the direction of G. H. Woodroffe, metallurgical engineer. Mr. Woodroffe will now handle all complaints and serve in an advisory capacity to the general sales organization.

Changes in personnel of the Pacific Coast offices of The Lincoln Electric Company, Cleveland, O., manufacturers of "Stable-Arc" welders and "Linc-Weld" motors include the appointment of S. H. Taylor, Jr., to succeed W. S. Stewart in charge of the coast with headquarters at 812 Mateo St., Los Angeles, Cal. Mr. Stewart has recently been appointed district manager of the Cleveland territory. Appointment of L. P. Henderson as manager of the San Francisco office of this company is also announced, as well as the appointment of E. J. Pfister formerly of the Philadelphia and Allentown offices, to district manager of the Kansas City District with offices at 405 R. A. Long Bldg., 10th and Grand streets, in that city. The Philadelphia office has also been moved to the Commerce Building in that city.

Correction

In the December issue of THE BOILER MAKER, there appeared an article on pages 337 and 338 entitled "Layout of Branch Pipe at an Angle to Both Planes" by I. J. Haddon. The last sentence of the next to the last paragraph reads: "This is the practical method, although it is out of date." This should read "This is the practical method; it is out of date to lay out the hole in the pipe *D*, although it is easy to do."

The Boiler Maker

VOLUME XXXI NUMBER 1

PUBLISHED Monthly by the Simmons-Boardman Publishing Company, 34 North Crystal Street, East Stroudsburg, Pa., with Executive Offices at 30 Church Street, New York City.

Edward A. Simmons, President. Henry Lee, Vice-President. C. R. Mills, Vice-President. L. B. Sherman, Vice-President. Samuel O. Dunn, Vice-President. F. H. Thompson, Vice-President. Roy V. Wright, Secretary. John T. De Mott, Treasurer. George Slate, Business Manager.

Chicago: 105 W. Adams Street. Washington, D. C.: 17th and H Streets, N. W. Cleveland: Terminal Tower. San Francisco, Cal.: 215 Market Street.

Subscription Price: United States, Canada and Mexico, $3.00; Foreign Countries, $4.00 a Year. Single Copies, 35 Cents.

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THE BOILER MAKER is a member of the Associated Business Papers, Inc. (A. B. P.), and the Audit Bureau of Circulation (A. B. C.)

EDITORIAL STAFF: H. H. Brown, Editor. L. S. Blodgett, Managing Editor. W. Lumbard, Associate Editor.

Contents

Eliminating Scale on Rivets

By D. J. Champion

An ever-present difficulty in performing well-finished work in the boiler shop is the elimination of scale and pit marks from the heads of rivets. In the normal heating of a rivet for driving, some scale is almost sure to be formed from the oxygen in the air. This condition is greatly aggravated if the rivet is overheated. Experience has shown a very simple way in which the difficulty may be overcome and a perfectly smooth rivet head obtained when the set is removed.

This may be accomplished by using a different shaped head when driving rather than one which conforms exactly to the style head originally found on the rivet. In other words, if the rivet is hot enough to produce scale on the head, the reforming or reshaping of the head in driving by using a rivet set entirely different in contour than the original head will break the scale and cause it to fall off leaving the head perfectly smooth. For example, if a gothic-shaped head or a bull head, as it is more familiarly called, be used, and formed into a regular button head, any scale that might be formed on the head in heating will be broken away, and in falling off will leave an absolute metal-to-metal contact and a clean-surfaced head free from scale.

It is easy enough to say that rivets are overheated but, in the last analysis, a great many rivets are actually hotter than is absolutely necessary for driving. When this happens a good workman is able to handle the situation if he will apply himself intelligently to the work in hand. The suggestion given above is one way to accomplish this.

The Mercury Boiler

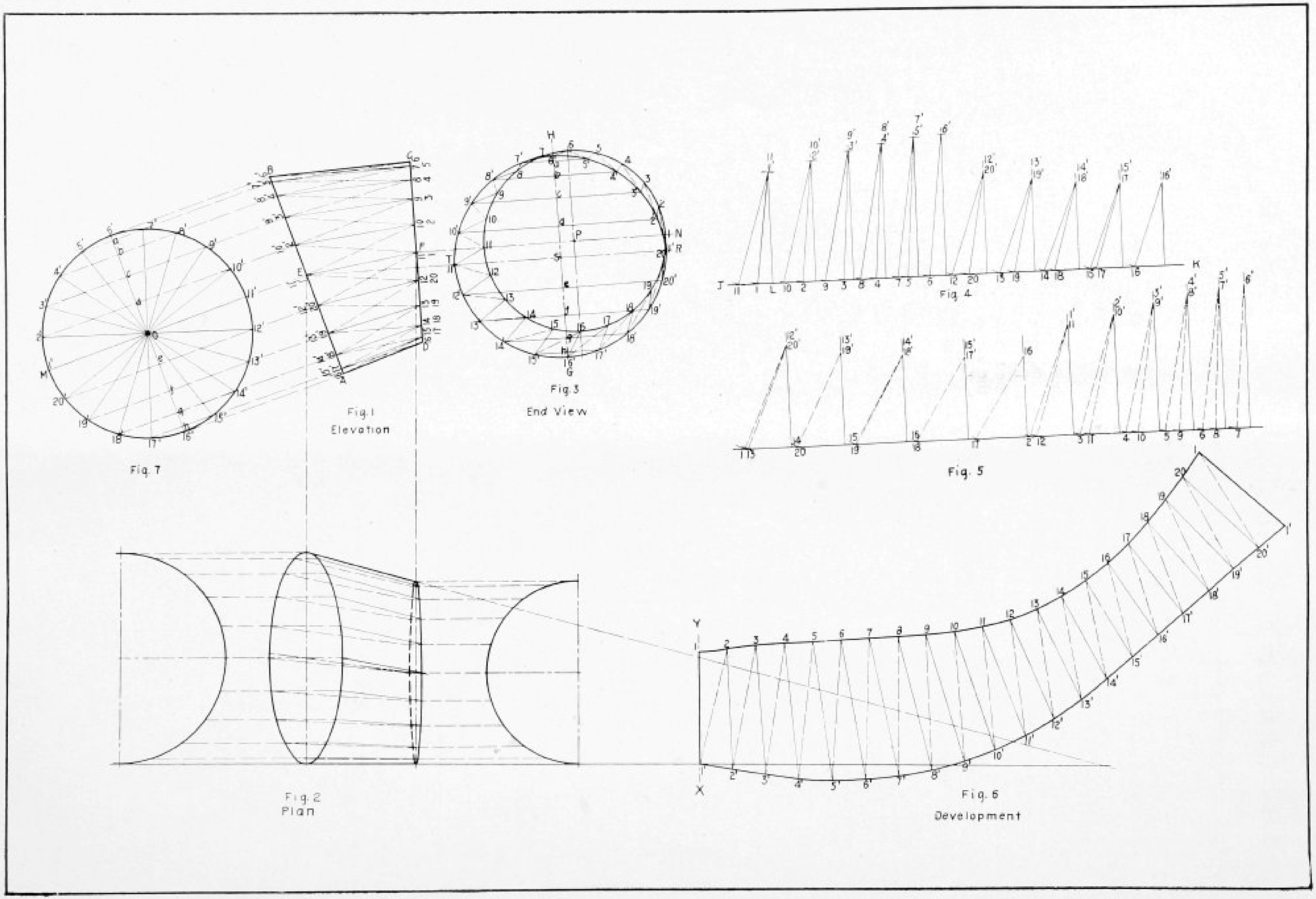
While the development and use of the mercury boiler is still in the experimental stage, the Dutch Point Station of the Hartford Electric Light Company has obtained an indicated economy of 12,000 British thermal units per kilowatt hour and it is estimated that further development along these lines will give an economy of approximately 10,000 British thermal units per kilowatt hour. Where, in 1924 the heat units per kilowatt hour for the most efficient power station in France is given as 22,400 British thermal units, in England as 20,150 British thermal units and in the United States as 18,030 British thermal units, some idea of the efficiency of this type of boiler may be obtained.

The mercury vapor-steam cycle is different from any previous practice and represents an attempt to work in the field of wide temperature differences without resorting to high pressure and superheat. The physical characteristics of mercury, which boils at 800 degrees F. at a pressure of 70 pounds per square inch, contributes to the success of the boiler.

In actual practice the mercury is evaporated at a very high temperature in a low-pressure watertube boiler. The vapor is then expanded through a specially designed turbine and exhausts into a condenser which in reality is a medium-pressure boiler. The condenser's circulating water is transformed into steam at a pressure of 250 pounds per square inch by the heat of the mercury vapor at exhaust. The steam so generated is then led to the steam mains of the plant and is used to run ordinary steam turbines.

Because of the great temperature difference between mercury at 800 degrees F. and the steam at exhaust, accomplished at low pressures, the thermal efficiency of the boiler is necessarily high. Because of the low pressure at which the mercury is generated the velocity of the gas is low and and therefore the mercury turbine operates at about one-third the speed of a steam turbine. Of greatest importance to the boiler maker, however, is the fact that mercury carries nothing in solution and therefore there is no problem of corrosion or scale formation in the boiler tubes. Higher heat transfer rate and higher boiler efficiency result.

Present economies in the use of steam boilers is obtained by the reduction of losses in the boilers, turbines, condensers and auxiliaries as well as in improvement in the steam cycle by the use of higher temperatures, superheat, and higher pressures. However, the advantages of the mercury-vapor cycle, or other vapor cycle for that matter, are evident and indicate that greater economies can be obtained through the use of such combinations.



Method of developing a radius elbow

Questions and Answers Pertaining to Boilers

This department is maintained for the purpose of helping those who desire assistance on practical boiler shop problems. Inquiries should bear the name and address of the writer. Anonymous communications will not be considered. The identity of the writer, however, will not be disclosed unless the editor is given special permission to do so.

Development of Radius Elbow

Q.—Is it possible that this taper elbow sheet, 84 inches diameter to 72 inches diameter, can be figured as a cone or does it have to be triangulated? With these cuts on this sheet it makes these joints slightly elliptical figured as a tangent elbow 65 degrees 25 minutes as the angle with a 30-foot radius using 16 cuts. F. G.

A.—The development of the end section of a 30-foot radius elbow, having the end section tapered from 84 inches, the diameter of the elbow, down to 72 inches diameter, is more readily done by triangulation on account of the size of the development.

Figs. 1, 2 and 3 show the elevation, plan and end views of the tapered section of the elbow as outlined in the question.

To construct the end view, first draw a perpendicular to the line *A-B* of the elevation at *E* as *E-M*, then with *O*, any point on the line *E-M*, as a center draw a circle, the diameter of the circle being taken equal to *A-B* of the elevation. Divide the circle into any number of equal parts, 20 being taken in this case, the greater the number of equal parts taken the more accurate the final development. Number these points *1′* to *20′* as shown. Parallel to the line *E-M* draw lines passing through points *1′* to *20′* cutting the line *A-B* of the elevation. Number these points *1′* to *20′* as shown. Next erect a perpendicular to the line *C-D* at *F* as *F-N*, then with *P*, any point on *F-N*, as a center draw a circle, the diameter of the circle being taken equal to *C-D* of the elevation. Divide this circle into the same number of equal parts as taken before and number the divisions *1* to *20* as shown. Parallel to the line *F-N* draw line *C-D* of the elevation; number these points *1* to *20* as shown.

Then parallel to the line *F-N* draw a line passing through the point *E* of the elevation as *E-R*, the point *R* being on a perpendicular to the line *F-N* at *N*. From *R* lay off *R-T* equal to *A-B* of the elevation, *R-S* being taken as one-half *R-T*. At *S* erect a perpendicular to the line *R-T* as *G-H*. Parallel to the line *E-R* draw lines through the points *1′* to *20′* of the elevation, cutting the line *G-H* of the end view, extend these lines and number these intersections *a*, *b*, *c*, *d*, etc., as shown.

At *a*, Fig. 3, step off each side of the line *G-H* the distances *a-7′* and *a-5′* being taken equal to *a-7′*, *a-5′* of Fig. 7, locating the points *5′* and *7′*, Fig. 3. At *b*, Fig. 3, step off each side of the line *G-H* the distances *b-4′* and *b-8′* being taken equal to *B-4′* and *b-8′* of Fig. 7, locating the points *4′* and *8′*, Fig. 3. In the same manner locate all points *1′* to *20′* of Fig. 3. Connect these points with a curved line.

Connect the points *1* and *1′*, *2* and *2′*, *3* and *3′*, etc., of the elevation with full lines, these lines will be the surface lines of the object; also connect the points *1′* and *2*, *2′* and *3*, *3′* and *4*, *4′* and *5*, etc., with dotted lines.

By George M. Davies

Connect the points *1* and *1′*, *2* and *2′*, *3* and *3′*, etc., of the end view with full lines and the points *1′* and *2*, *2′* and *3*, *3′* and *4*, etc., with dotted lines.

The right-angled triangles used to find the true length of the surface lines *1-1′*, *2-2′*, *3-3′* etc., and the lines *1′-2*, *2′-3*, *3′-4*, etc., of the elevation can now be constructed. Draw the horizontal lines *J-K*, Fig. 4, and at *L* erect a perpendicular with *L* as a center, and with the dividers set equal to the perpendicular distance between the line *C-D* and the point *1′* in the elevation, scribe an arc cutting the perpendicular and locating the point *1′*, Fig. 4. Then with *L* as a center and with the dividers set equal to the distance *1-1′*, Fig. 3, scribe an arc cutting the line *J-K* locating the point *1*. Connect *1* and *1′*, Fig. 4. This distance is the true length of the surface line *1-1′* of the elevation. In like manner locate the true lengths of all the surface lines of the elevation, using the perpendicular distances from the line *C-D* to the points *1′* to *20′* as the altitudes and the corresponding distances *1-1′*, *2-2′* *3-3′*, etc., of the end view, Fig. 3, as the bases of the right-angled triangles.

In the same manner construct the right-angled triangles to find the true length of the surface lines indicated by the dotted lines *1′-2*, *2′-3*, *3′-4*, etc., of the elevation and end views. This is done in Fig. 5. The true length of all the surface lines having been found we are now ready to make the development, Fig. 6.

Draw the vertical line *X-Y*, Fig. 6, and with the point *1′* as a center and the dividers set equal to the distance *1-1′*, Fig. 4, scribe an arc cutting the line *X-Y* and locating the point *1*. With *1* as a center and the dividers set equal to the distance *1-2*, Fig. 3, scribe an arc. Then with *1′* as a center and with the dividers set equal to the distance *1′-2*, Fig. 5, scribe an arc cutting the arc just made locating the point *2*, Fig. 6.

With *1′* as a center and the dividers set equal to the distance *1′-2′*, Fig. 7, scribe an arc; then with *2* as a center and the dividers set equal to the distance *2-2′*, Fig. 4, scribe an arc cutting the arc just made locating the point *2′*, Fig. 6. Continue in the same manner, taking the lengths of the solid lines from Fig. 4, the lengths of the dotted lines from Fig. 5, the lengths of the short arcs *1-2*, *2-3*, *3-4*, etc., from Fig. 3 and the lengths of the long arcs *1′-2*, *2′-3*, *3′-4*, etc., from Fig. 7 until the development is completed.

Boilers for Burning Gas

Q.—We have a horizontal return tubular boiler that is equipped for burning either gas or fuel oil. At present it is fired with gas altogether, but it uses an excessive amount of gas and I would like to have some information for the use of natural gas. I am not able to make a drawing of the boiler but will try to explain it to you.

This boiler is used for heating purposes in a large building. The shell part of the boiler proper is approximately 6 feet in diameter and about 12 feet long. The floor of this boiler or firebox is straight from front to back with a target wall about 4 or 4½ feet from the burner. There is no air inlet into the firebox or combustion chamber except around the gas jets. This boiler has two burners, both of which have 7¼-inch pieces of pipe for the gas flow. Each pipe sets ⅝-inch back of a 2-inch pipe, 9 inches long, through which the gas reaches the combustion chamber. The only draft control is a damper in the stack. It is about 20 inches from the floor of the combustion chamber to the belly of the boiler and the target wall extends to within about 8 inches of the belly of the boiler. H. S. R.

A.—The essential feature in burning gas is ample space, in which the combustion of gases may be practically completed before striking the heating surfaces.

This feature is not obtained in the setting as outlined in the question, the target wall should be removed so that the combustion of the gas will be completed before striking the boiler.

The gases have the power of burning out completely after striking the heating surface, provided the initial temperature is sufficiently high, but where the combustion is completed before such time, the results are more satisfactory. Another objection to the target wall is that it directs the flame upward where it can impinge on the metal of the shell and injure it.

A furnace volume of approximately 0.75 to 1.25 cubic feet per rated horsepower will give a combustion space that is ample.

Whatever the design of the burner, provision should be made for the regulation of both the air and the gas supply independently. A gas opening of 0.8 square inch per rated horsepower will enable a boiler to develop its normal rating with a gas pressure in the main of about 2 inches. The pressure is ordinarily from 6 to 8 inches and in this way openings of the above size will be good for ordinary overloads.

The air opening should be 0.75 to 0.85 square inch per rated horsepower. Good results are secured by inclining the gas burners slightly downward toward the rear of the furnace.

Strength of Dished Heads

The answer to the question on the strength of dished heads in the November, 1930, issue was based on the rules for construction of unfired pressure vessels, Section VIII of the 1927 A.S.M.E. Boiler Code.

This was in error as the revised 1930 Code has modified the formulae given in the answer. Paragraphs *U-36, U-37, U-38* of the 1930 code are as follows.

U-36. The thickness of a blank unstayed dished head with the pressure on the concave side, when it is a segment of a sphere shall be calculated by the following formula:

$$t = \frac{8.33 \times P \times L}{2 \times TS}$$

where t = thickness of plate, inches
P = maximum allowable working pressure, pounds per square inch
TS = tensile strength, pounds per square inch
L = radius to which the head is dished, measured on the concave side of the head, inches

Where two radii are used, the longer shall be taken as the value of L in the formula.

When a dished head has a manhole or access opening that exceeds 6 inches in any dimension, the thickness shall be increased by not less than 15 percent of the required thickness for a blank head computed by the above formula, but in no case less than ⅛ inch additional thickness over that for a blank head. Where a dished head has a flanged opening supported by an attached flue, an increase in thickness over that for a blank head is not required. If more than one manhole is inserted in a head, the thickness of which is calculated by this rule, the minimum distance between the openings shall be not less than one-fourth of the outside diameter of the head.

The radius to which the head is dished shall not be greater than the diameter of the shell to which the head is attached.

Where the radius L to which the head is dished is less than 80 percent of the diameter of the shell the thickness of a head with a manhole opening shall be at least that found by making L equal to 80 percent of the diameter of the shell. This thickness shall be the minimum thickness of a head with a manhole opening for any form of head.

A blank head of a semi-elliptical form in which the minor axis of the elipse is at least one-half the diameter of the shell shall be at least as thick as the required thickness of a seamless shell of the same diameter. If a flanged-in manhole, which meets the code requirements, is placed in an elliptical head the thickness shall be the same as for an ordinary dished head with a radius equal to 0.8 the diameter of the shell and with the added thickness for the manhole.

The diameter of the shell to be used in applying these rules shall be the inner diameter of the shell for a head fitted to the inside of the shell, and the outer diameter of the shell for a head fitted to the outside of the shell.

Unstayed dished heads with the pressure on the convex side shall have a maximum allowable working pressure equal to 60 percent of that for heads of the same dimensions with the pressure on the concave side.

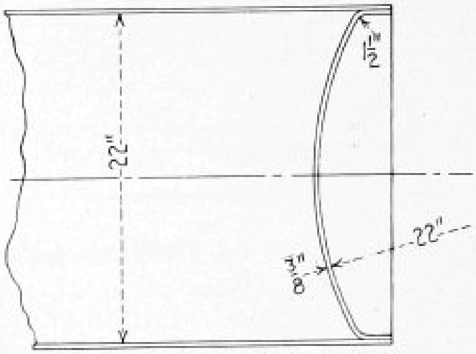


Fig. 1.—Standard dished tank head

If a nozzle-type manhole which meets the code requirements is placed on an elliptical head, the thickness of the head shall be the same as for an ordinary elliptical head providing in the case of saddle-type riveted flanged manholes, the provisions of Par. *U-55* are complied with. In the case of nozzle-typed manholes forge-welded to the head, a reinforcing collar of the thickness required in Par. *U-55* shall be drawn simultaneously with the drawing of the flange in the head.

U-37. When dished heads are of a less thickness than called for by Par. *U-36*, they shall be stayed as flat surfaces, no allowance being made in such staying for the holding power due to the spherical form unless all of the following conditions are met:

a. That they be at least two-thirds as thick as called for by the rules for unstayed dished heads.

b. That they be at least ⅞ inch thick.

c. That through stays be used attached to the dished head by outside and inside nuts.

d. That the maximum allowable working pressure shall not exceed that calculated by the rules for an unstayed dished head plus the pressure corresponding to the strength of the stays or braces secured by the formula for braced or stayed surfaces given in Par. *U-40* using 70 for the value of C.

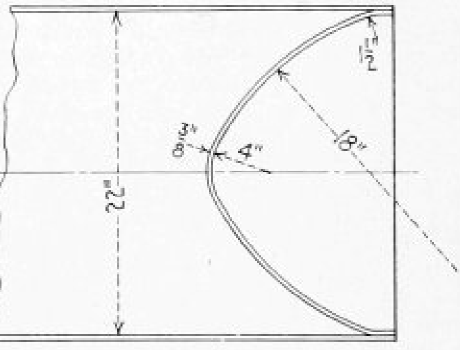


Fig. 2.—Extreme case of dished tank head

If a dished head is formed with a flattened spot or surface, the diameter of the flat spot shall not exceed that allowable for flat heads as given by the formula in Par. *U-36*.

U-38. The corner-radius of an unstayed dished head measured on the concave side of the head shall not be less than 3 times the thickness of the material in the head; but in no case less than 6 percent of the diameter of the shell.

Substituting this formula in the same problem, using 55,000 pounds tensile strength we find the permissible working pressure reduced to 135 pounds for a 22-inch diameter tank with 22-inch radius of head, as shown in Fig. 1, and 168.6 pounds for 22-inch diameter tank with 18 inches and 4 inches radii of head, as shown in Fig. 2.

Associations

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Assistant International President—William Atkinson, suite 522, Brotherhood Block, Kansas City, Kansas.
International Secretary-Treasurer—Chas. F. Scott, suite 506, Brotherhood Block, Kansas City, Kansas.
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States and Cities That Have Adopted the A.S.M.E. Boiler Code

States

Arkansas	Missouri	Rhode Island
California	New Jersey	Utah
Delaware	New York	Washington
Indiana	Ohio	Wisconsin
Maryland	Oklahoma	District of Columbia
Michigan	Oregon	Panama Canal Zone
Minnesota	Pennsylvania	Territory of Hawaii

Cities

Chicago, Ill.	St. Joseph, Mo.	Memphis, Tenn.
Detroit, Mich.	St. Louis, Mo.	Nashville, Tenn.
Erie, Pa.	Scranton, Pa.	Omaha, Neb.
Kansas City, Mo.	Seattle, Wash.	Parkersburg, W. Va.
Los Angeles, Cal.	Tampa, Fla.	Philadelphia, Pa.
	Evanston, Ill.	

States and Cities Accepting Stamp of the National Board of Boiler and Pressure Vessel Inspectors

States

Arkansas	Missouri	Pennsylvania
California	New Jersey	Rhode Island
Delaware	New York	Utah
Indiana	Ohio	Washington
Maryland	Oklahoma	Wisconsin
Minnesota	Oregon	

Cities

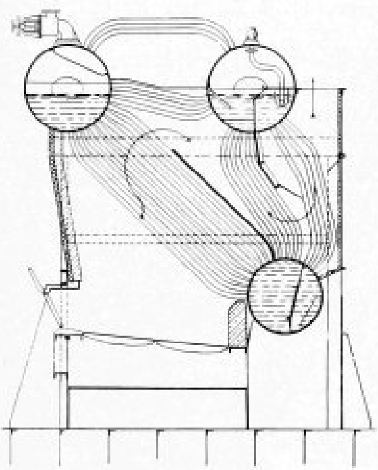
Chicago, Ill.	St. Louis, Mo.	Nashville, Tenn.
Kansas City, Mo.	Scranton, Pa.	Omaha, Neb.
Memphis, Tenn.	Seattle, Wash.	Parkersburg, W. Va.
Erie, Pa.	Tampa, Fla.	Philadelphia, Pa.

Selected Boiler Patents

Compiled by Dwight B. Galt, Patent Attorney, Washington Loan and Trust Building, Washington, D. C. Readers wishing copies of patents or any further information regarding any patent described, should correspond directly with Mr. Galt.

1,726,112. WATERTUBE BOILER. HENRY JOHN SUTHERLAND MacKAY, OF RYDE, ENGLAND, ASSIGNOR TO THE BABCOCK & WILCOX COMPANY, OF BAYONNE, N. J., A CORPORATION OF NEW JERSEY.

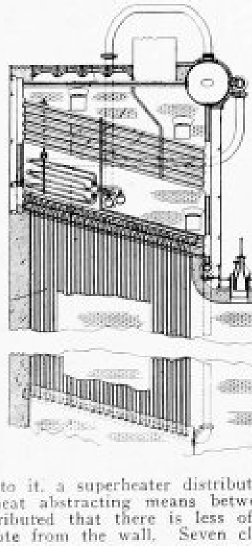
Claim.—In a steam boiler, front and rear upper drums connected by watertubes, a lower drum connected to the front upper drum by a bank of tubes and to the rear upper drum by two banks of tubes, a baffle extending transversely of the boiler and extending downwardly from said rear drum between the two said banks of tubes to define a front bank and a rear bank, the rear upper drum being provided with an upper compartment shorter than the associated drum to which compartment the feed



water is introduced, part of the tubes of the rear bank being connected to said compartment, and the remainder to said rear upper drum outside of said compartment, the lower drum being divided by a longitudinally extending imperforate diaphragm into two lower compartments, to one of which the tubes of said bank are connected, a circulatory system comprising the other lower compartment and the portion of the rear upper drum outside of said upper compartment, and means for passing gases over said circulatory system and then over said rear bank, the gases passing over all of the tubes of said bank in the same general direction. Eight claims.

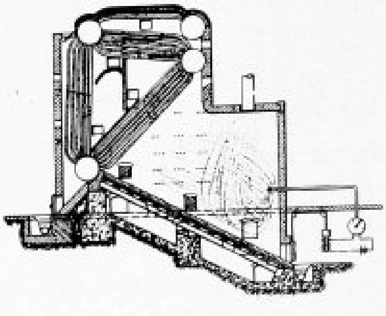
1,722,073. WATERTUBE BOILER WITH SUPERHEATERS. BENJAMIN BROIDO, OF NEW YORK, N. Y., ASSIGNOR TO THE SUPERHEATER COMPANY, OF NEW YORK, N. Y.

Claim.—In apparatus of the watertube class, the combination of a boiler setting comprising a wall cooling the hot gases in the furnace coming into proximity to it, a superheater distributed through a space from the wall inward, heat abstracting means between the furnace and the superheater so distributed that there is less of it adjacent to the wall than at points remote from the wall. Seven claims.



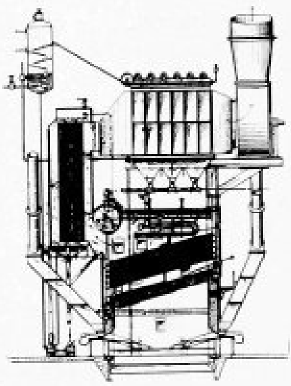
1,721,440. FURNACE. ERNST H. ELZEMEYER AND PAUL S. KNITTEL, OF ST. LOUIS, MISSOURI; MINNIE ELZEMEYER EXECUTRIX OF SAID ERNEST H. ELZEMEYER, DECEASED.

Claim.—A furnace comprising side and end walls, a roof, a burner projecting through said roof, a sloping floor, said walls and floor being of porous material to permit air to filter therethrough and being otherwise free from draft openings, and an ash gate at the bottom of the end wall and sloping floor. Four claims.



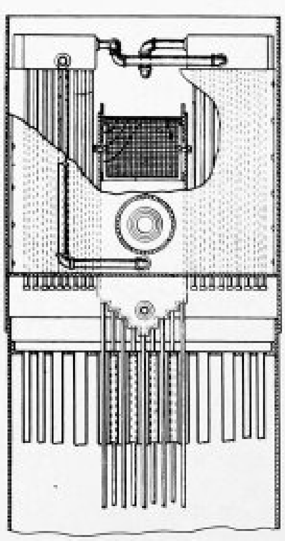
1,729,259. STEAM-BOILER ECONOMIZER. DAVID S. JACOBUS, OF JERSEY CITY, NEW JERSEY, ASSIGNOR TO THE BABCOCK & WILCOX COMPANY, OF BAYONNE, NEW JERSEY, A CORPORATION OF NEW JERSEY.

Claim.—In a steam-boiler-economizer set in the waste flue of the boiler, a plurality of sets of tubes spaced along the length of the flue, each set of tubes having a series of longitudinal header boxes arranged in parallel across the flue and extending longitudinally of the flow of the gases with spaces between them to allow dropping of soot and connections between the several sets of tubes and boxes to direct the water successively through the several sets of tubes. Thirty claims.



1,721,212. SMOKEBOX OF LOCOMOTIVES. GUY T. FOSTER, OF DAYTON, OHIO, ASSIGNOR TO LOCOMOTIVE ECONOMIZER CORPORATION, OF NEW YORK, N. Y., A CORPORATION OF DELAWARE.

Claim.—In a locomotive structure, a smokebox and a smokestack opening from the smokebox, a passageway formed within the smokebox and leading to the smokestack, a stop stationary in the passageway, and a screen extending transversely across the passageway and freely movable to and from abutment upon said stop. Two claims.



The Boiler Maker

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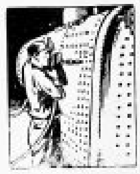


Boiler Expansion

A careful study of the explanation given by H. L. Miller of the expansion and contraction strains that occur in the sheets of a locomotive boiler firebox, published in this issue, will make very clear to our readers the necessity of utilizing the best possible materials and the most careful workmanship. The description of the action of sheets and staybolts under widely varying boiler temperatures is the most practical that has been made available for publication in this magazine. The second article on this subject, dealing with the effect of expansion and contraction on boiler materials will be published next month.

Boiler Welding

As G. H. Koch points out in an article in this issue on automatic-arc welding in boiler work, there undoubtedly is a bright future for the application of the several fusion welding processes. It is only with the continuance of the extremely careful advance which has been made in the development of welding that the ultimate possibilities of the process may be realized, particularly in boiler construction. The procedure being followed by the American Society of Mechanical Engineers Boiler Code Committee, the American Welding Society and the Interstate Commerce Commission, Bureau of Locomotive Inspection in developing regulative measures for the use of welding in the construction of boilers and pressure vessels assures a sound future for fusion welding.

The Boiler Industry

Annual statistics covering the construction of steel boilers in the United States for the year ending December 31, 1930, have been issued recently by the Department of Commerce. New orders for 814 steel boilers were placed in December, 1930, according to reports submitted to the Bureau of the Census by eighty-one manufacturers, comprising most of the leading establishments in the industry, as compared with 777 boilers in November, 1930 and 1029 boilers in December, 1929. For the year, 13,166 boilers of all types, including steel heating boilers, were built, having a total heating surface of 13,470,390 square feet as compared with 18,526 boilers for the year 1929, having a total heating surface of 19,468,534 square feet. This represents a decrease of approximately 29 percent in production and about 31 percent decrease in the rating of these boilers. This curtailment of production has caused the suspension of operations in a number of boiler manufacturing plants, a shortening of working hours in others and the cutting of wage scales in some few cases. A general curtailment by practically all boiler manufacturing concerns has been noted. It is believed that this condition will continue until the revival of building construction occurs, especially in the field of public works, power plants, institutional building programs and similar lines.

In the field of railway locomotive maintenance, conditions are somewhat better than those in the power boiler field, although they are far from normal. Recent wage statistics compiled by the Department of Commerce, Interstate Commerce Commission show a decrease of about 11.5 percent in the number of boiler makers employed, as compared with the same period of 1929, and a decrease of service hours of 19.5 percent. In this field curtailment in general has been in the reduction of working hours, in short lay-off periods, elimination of overtime and similar means, without cutting the hourly rate of compensation. Modern production methods and machines in the railway shops during a normal period would have accounted partially for the decrease in gainful employment in this field. When railroad operation, along with industry in general, returns to a more normal level, the demand for men in the shops will have a corresponding increase.

Pin Riveting

As described in this issue, the system of pin riveting developed by the Skoda Works may suggest a solution to some of the difficulties experienced in the construction of boilers and other vessels required to operate at high pressures. Caustic embrittlement unquestionably has its beginning in seams and rivet holes that are not entirely tight. The slightest leakage between plates or around rivets in boilers operating in districts subject to embrittlement promotes the disastrous action which finally becomes apparent, at an advanced stage, in minute cracks around the rivet holes.

From the claims advanced by the originators of the pin-riveting process absolutely tight joints and the elimination of oxide scale on rivets are assured. Further, rivet holes are completely filled. The photographs of test sections of seams joined by this means would indicate that these claims were satisfied.

Available information on the process does not mention any tests of pin riveting that may have been made in this country. It would be interesting to learn if any of our readers have had experience with pin riveting or whether manufacturers of rivets or of riveting machines have investigated its possibilities. If work of this nature has been done, The Boiler Maker will welcome information on the subject. Such data will be published for the benefit of our readers.

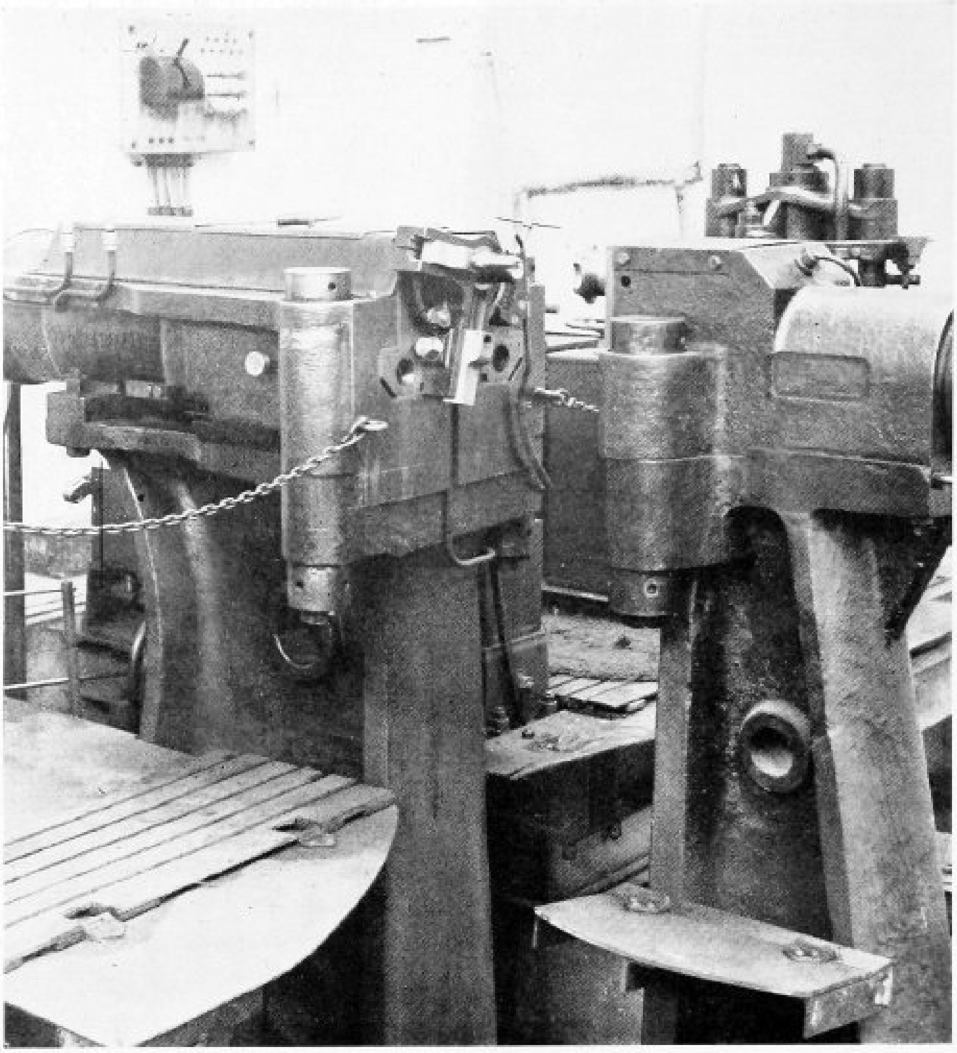


Fig. 1.—Rotary head with centering pin ready for riveting oblique seams, mounted on pressure head of hydraulic riveter. Pin riveting device is on holding-on tool

Pin Riveting in Boiler Work

Most of our readers undoubtedly are unfamiliar with the term "pin riveting" which is descriptive of a new method of joining sheets that has been developed by the Limited Company, formerly the Skoda Works in Plzen, Czecho Slovakia. The following information has been supplied by representatives of the Skoda Works in this country and is presented as an interesting development in a field which too often is considered fixed and productive of few changes. Should our readers desire further information upon the subject of pin riveting or wish to comment on the process, as explained in the following paragraphs, such communications will be given prompt attention. The details of the device and its operation are as follows:

High technical progress imposes exacting conditions on the manufacturer of steam boilers in general and of high pressure boilers in particular. It need hardly be mentioned that the high pressures now used in boilers, and the requirements for absolute safety in their operation, demand almost faultless work in the boiler shops. It is, therefore, necessary, in addition to highly skilled mechanics, for shops to be equipped with up-to-date machine tools which produce precision work at a comparatively low cost. Among the manufacturing problems which during the last few years have been the object of thorough investigation and special attention, the matter of riveting has been of the utmost importance.

This operation has not as yet attained that degree of perfection which insures absolute tightness of the riveted joint even when the riveting be done with the help of modern hydraulic or pneumatic riveting machines. It is necessary, therefore, to calk a large number of rivets which means additional work to be done after the formation of the rivet heads. This is due to the fact that the problem of the rivet head proper has not as yet been definitely solved.

The ordinary rivet of the type having one head ready-made has not given entire satisfaction for the reason that the oxide layer which forms during the heating of the rivet cannot be removed from under the die head before the second head is formed. This layer forms between the plate and the rivet head a sort of isolating coat which is not affected by the riveting pressure and later gives rise to leakage.

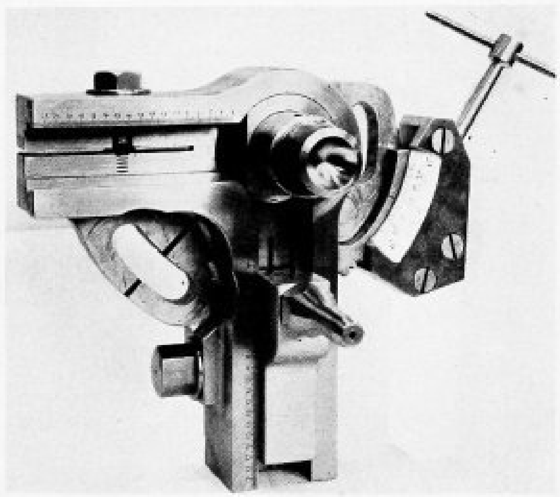
Another difficulty is that the part of the rivet shank below the head cannot be upset to perfection, as the rivet head formed by the snap tool does not allow a further deformation of the shank to a depth sufficient completely to fill up the rivet hole below the head of the rivet. This form of riveting leaves much to be desired so far as high-pressure work is concerned.

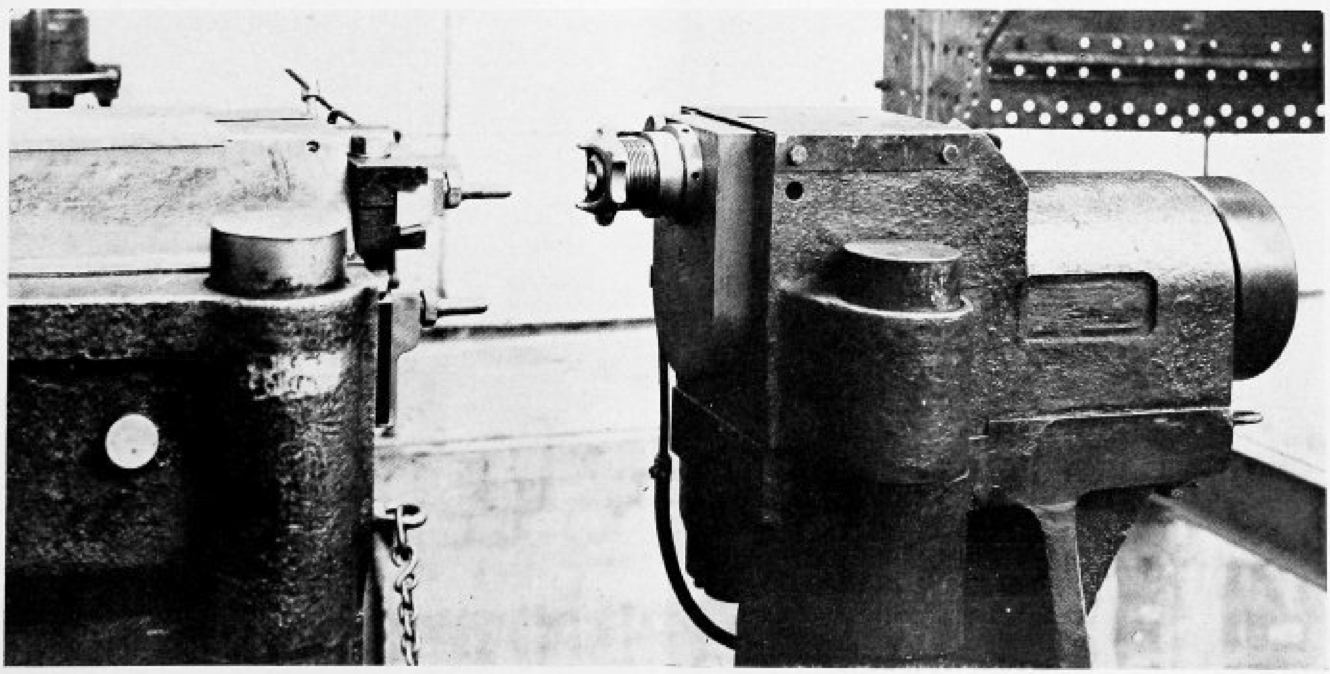
In Europe, the Schönbach method of riveting, which was adopted some years ago, has not given complete satisfaction since it does not insure a uniform distribution of the rivet material on the two sides of the plates, the effect being that one of the rivet heads is too small when completed, with the consequence that plates are damaged. The other head is too large with an oversize border. Furthermore, the rivet heads are not concentric with the shank axis, and finally the whole method renders the riveting mechanism complicated, and the implements and tools needed therewith are costly.

Not even did the pin-riveting system known as the Schüch method with a pre-forged conical head, bring about any essential change in riveting; for although technically an improvement it was not economical because the manufacturing process of the rivet proper remained the same as before. In addition the finishing of the rivet head had to be done in the same way as in the case of the ordinary method of riveting.

It is claimed by the Skoda Works that the riveting method which this concern developed, which is exclusively pin riveting, in which rivet iron bars cut to size are used, has solved the problem in a satisfactory manner. The method enables the formation of perfectly symmetrical rivet heads simultaneously on both sides of a seam with the help of a mechanical device fitted to the hydraulic riveting machine, the general arrangement as installed being shown in Figs. 1 and 11. The three methods of driving rivets, including the ordinary rivet, the Schüch type and the Skoda method, are shown in Figs. 5, 6, 7, 8, 9 and 10. The illustration, Fig. 11 shows a longitudinal section of the device with the snap tool in the inactive initial position. A second view in this illustration represents the position of the snap tool when the rivet head has been formed, while the final view is a plan of the ad-

Fig. 2.—(Right) Assembled device for pin riveting. Fig. 3.—(Extreme right) Assembled universal rotary head for vertical pin riveting. Fig. 4.—(Below) Device for pin riveting, fitted in holding on tool of riveter





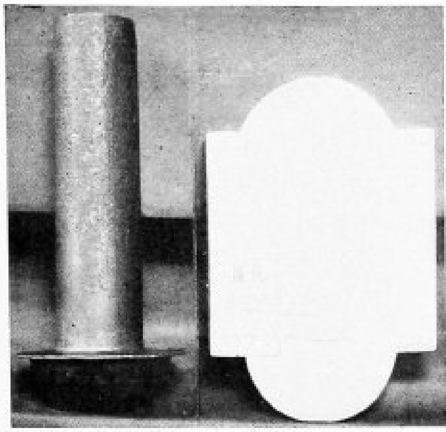


Fig. 5.—Ordinary rivet, and section, when hand driven

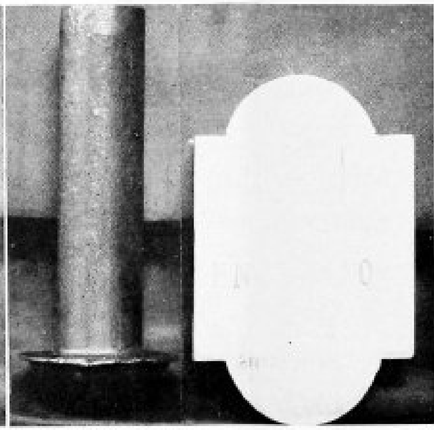


Fig. 6.—Rivet and section after driving on hydraulic bull riveter

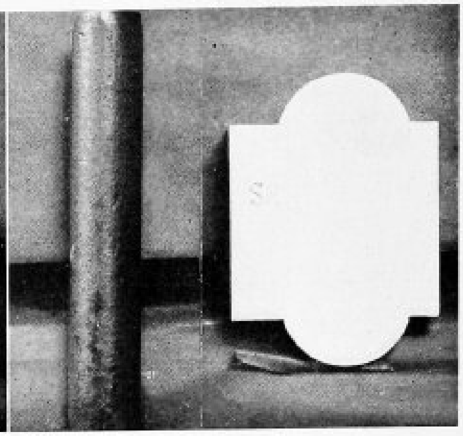


Fig. 7.—Pin rivet and section after driving on bull riveter fitted with rotary head

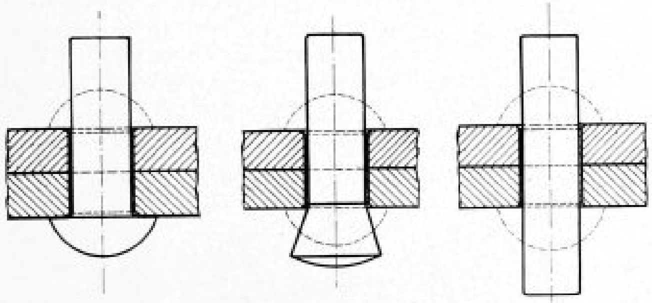


Fig. 8.—(Left) Ordinary rivet with head. Fig. 9.—(Center) Schüch method of riveting. Fig. 10.—(Right) Pin rivet

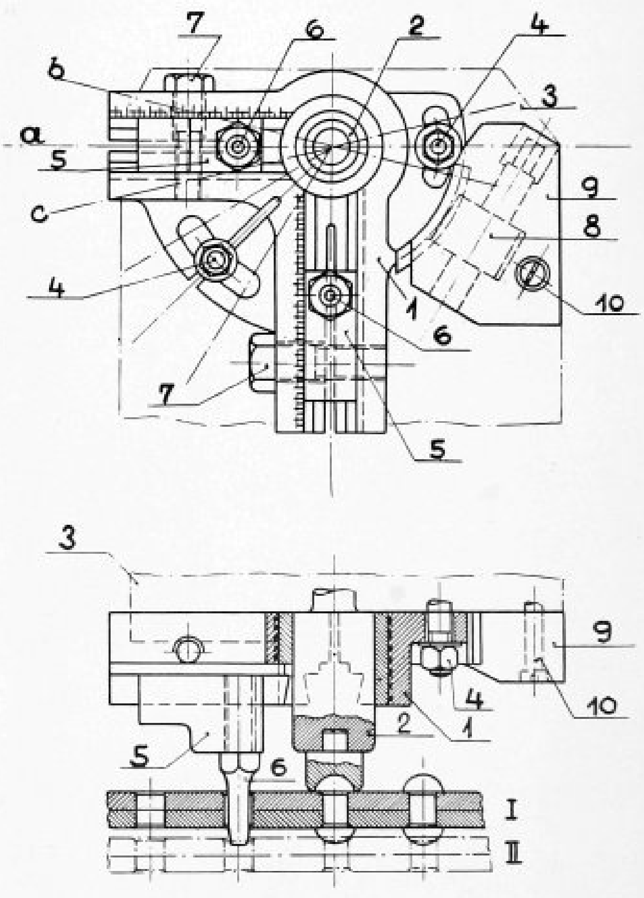


Fig. 12.—Universal rotary head for pin riveting

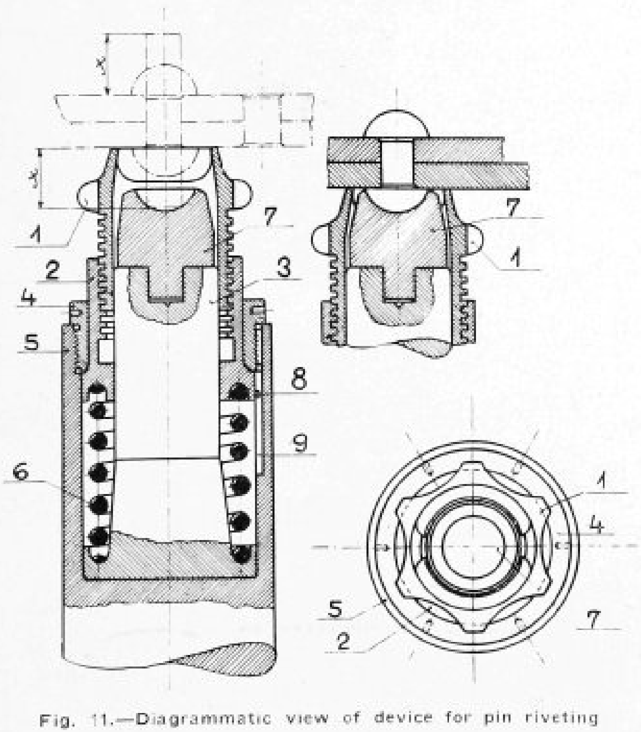


Fig. 11.—Diagrammatic view of device for pin riveting

justing-screw sleeve and of the end with its openings for the spanner.

The adjusting-screw sleeve *1* is screwed into the loose nut 2 into which is fitted the holder *3* of the snap tool *7*. Nut *2* is secured in place by fixed nut *4* and thus prevented from detaching itself from the riveting piston *5*. Nut *2* is further secured against rotation by guide pin *8* which moves in groove *9* of riveting piston *5*. Sleeve *1* serves to adjust, in a most precise manner and independent of the length of the snap tool used, the protruding end *X* of the rivet pin, destined to form the rivet head, while helical spring *6* lodged in the body of piston *5* and acting on loose nut *2* holds end *X* in this initial position.

The device works in the following manner: At the beginning of the operation, i.e., while upsetting the shank and forming the snap head, the adjusting screw sleeve *1* with nut *2* is pressed against the piston *5* until the tap edges of the sleeve and of the snap tool are at the same level.

Sleeve *1* remains in that tensioned position until the pressure on snap tool *7* ceases, upon which helical spring *6* brings the sleeve back to its initial position. It is clear that this riveting method enables the forming of an ideal rivet joint satisfying any and all technical specifications; for if we resolve the process into its stages we find:

(a) That first the shank material is forced uniformly and simultaneously from both sides into the rivet hole.

(b) Upon which the material flows into the countersunk portion of the rivet hole (transition from shank to head) and only when this has taken place.

(c) That the two heads are formed on the plates simultaneously and a purely metallic contact is realized, i.e., without the interposition of any foreign matter.

From the foregoing it is evident that pin rivets must necessarily have the greatest tightness obtainable and do not require any subsequent calking. Practice has proven that pin rivets which have been snapped in accordance with this patented method show a tightness of 99 percent.

The claims set forth by the Skoda Works for this method state that it satisfies in every respect all the latest technical requirements of a perfect rivet joint which assures the safety of a boiler in service. When both rivet heads are formed simultaneously the oxide layer is detached from the rivet pin, which brings about a clean entirely metallic contact between the rivet head and the plate, resulting in a tight fit of the rivet, which requires no calking. The calking of the countersunk portion of the rivet hole is also reduced to a minimum.

It is claimed that the pin-riveting device enables a correct and uniform distribution of the rivet metal on either side of the plate which ensures a neat and clean riveted joint. The rivet pin is heated uniformly for its entire length and the rivet heads are formed on either end simultaneously, which ensures that the rivet hole is filled completely, an advantage which cannot be realized with other methods where the upsetting effect is greatest at the snap head end. The pin-riveting device may be fitted to any hydraulic or pneumatic riveting machine. The entire design of the device enables the rapid conversion into an ordinary riveting set simply by unscrewing the adjusting-screw sleeve shown in Fig. 11.

The use of this method, it is stated, helps cut down production cost. The consumption of snap-tool steel is reduced. Another advantage lies in the fact that a worn snap tool which requires repairing and thus becomes shorter can be used after several repair operations as the adjusting sleeve admits of its being set to fit the length of the tool. A final feature, which is of advantage, is that the rivet material is heated once only.

In using the pin-riveting method in constructing steam boilers, it is of great importance to absorb the oscillations of the piece to be riveted and to avoid any lateral displacement of the work caused by the pressure in the riveting machine being transmitted to the snap tool during the period that the two heads are being formed. To insure a perfectly concentric formation of the heads, it is necessary to establish during short intervals a reliable but easily shifted connection between the work and the pressure head of the riveting machine.

To accomplish this kind of connection, centering pins of the rotary head are respectively inserted into and withdrawn from the adjoining rivet holes, thus securing the boiler against motion during the riveting process. With the help of these centering pins it is possible to work in three different directions of the seam; that is, vertically, horizontally and obliquely. Figs. 3 and 12 are views of the universal rotary head used for pin riveting.

The top sketch in Fig. 12 is an elevation of the rotary head with centering pins for riveting horizontally or vertically. In turning the head round its axis *a* into position *b* or *c* the device is adjusted to make oblique rivet joints.

The bottom sketch is a horizontal section through the rotary head with the centering pin in position for horizontal riveting. In closing the rivet heads the centering pin engages completely the adjoining rivet hole. The same occurs in the case of vertical or oblique riveting.

The rotary head *1* is pivotably mounted on the snap tool holder *2* of pressure head *3* of the riveting machine and is fixed thereto with push fit by two screws *4*. The rotary head is provided with two grooves, one vertical and the other horizontal, both having a millimeter graduation, for the guide bars *5* of the centering pins *6* which with the help of their zero mark and the millimeter scales can be adjusted precisely and then fixed by screws *7* into a position corresponding to the pitch of the rivets of vertical or horizontal boiler seams.

It need hardly be mentioned that by this method only, —inserting the pins into and withdrawing them from the adjacent rivet holes during the riveting process, will be obtained perfectly concentric pin rivet heads.

Position II, in dash lines, shows the work prior to the riveting.

Position I illustrates the end phase of the riveting process.

For making oblique rivet joints, the rotary head is brought into working position by a toothed segment meshing with worm *8* fitted in bearing *9* which is fixed by screws *10* to the pressure head of the riveting machine.

The bearing is likewise provided with a graduation showing exactly the degree of inclination imparted to it by the worm with the help of a socket wrench acting on the square head of the worm end.

The Owens Boiler Circulator

Among the devices which have been introduced for improving the circulation in Lancashire and Cornish boilers is the Owens circulator, manufactured by Owens Boiler Circulator, Ltd., 57 Victoria street, London, England. Essentially, it consists of a steel hood or saddle, supported on malleable iron bridges fitted over the back part of the furnace. It therefore completely encloses the water space over the hottest part of the boiler, and two spaces are thus provided on each side of the flue, the superimposed curved hood promoting longitudinal and elliptical circulation of the water by utilizing the natural force of the steam bubbles. On escaping from the fire bridge, these bubbles pass along the inner surfaces of the curved hood and throw the ascending stream of water in a horizontal direction to the back

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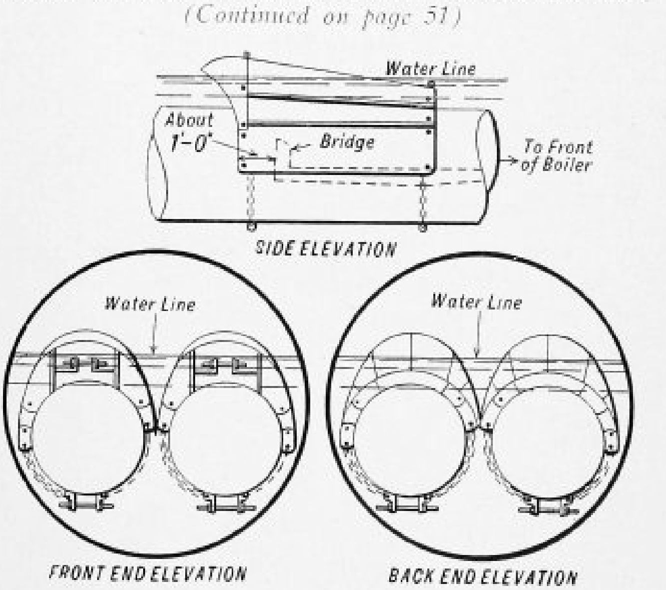


Details of Owens circulator

Future of Automatic Arc-Welding in Boiler Work*

By G. H. Koch†

One has only to consider the difficulties that now beset the designer and builder of high-pressure vessels to realize that the day of the all arc-welded boiler is not far away. When steam boilers first came into extensive use, there were many disastrous explosions. These were due to ignorance and to faulty design and construction. The boiler codes were formulated and adopted by different states and cities to minimize the loss of life and property. These same codes are enforced as laws in the communities where they are adopted. While these codes have well served their purpose in assisting the safe development of boiler design they have grown in a straight-line path along the riveting practice of joining sheets and plates.

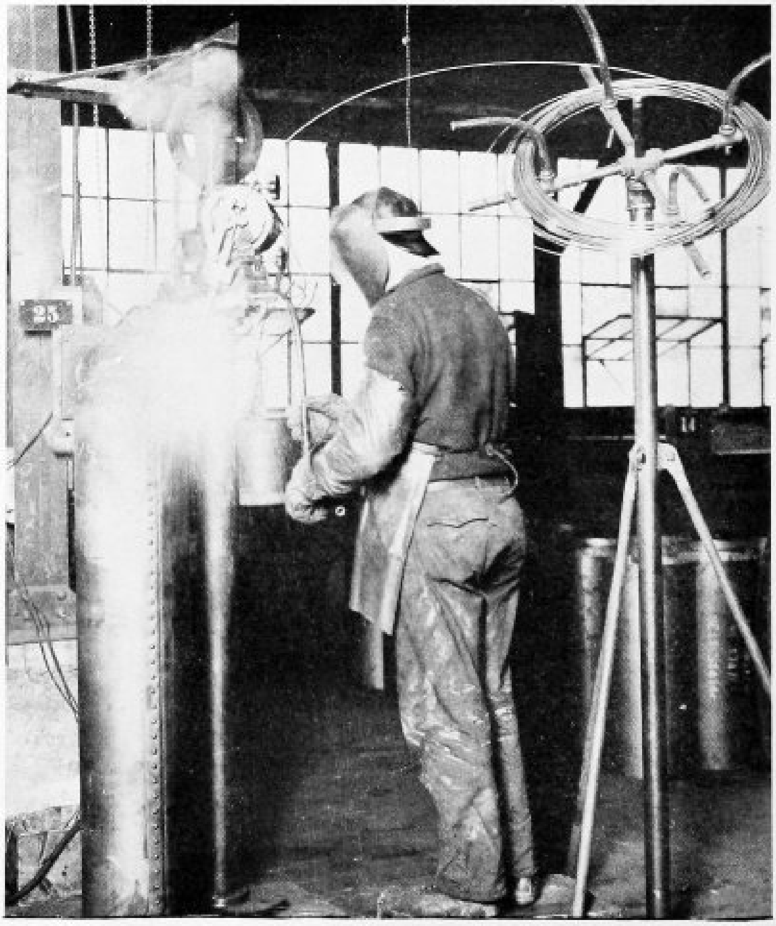
Riveting has long been a tried and proven method of construction. Results can be anticipated with accuracy—so much so, that strength efficiencies are tabulated in standard handbooks in terms of rivet size and spacing for different plate-thicknesses and types of joints. The results can also be well controlled by specifications as to the quality and preparation of the materials. Inspection for adequacy and deterioration is simplified by the fact that the qualifications of a joint are pretty largely branded on its exterior surfaces.

The demand for higher plant efficiencies is reflected in larger boilers and higher steam pressures. Plate thicknesses are consequently increasing to a point where riveting is out of the question. Boiler drums are already being made at great expense from seamless hollow cylinders, a product of the steel piercing mills. The boiler manufacturers are turning toward the arc-welding processes used in the construction of similar vessels for the chemical and petroleum industries. Oil-cracking stills have long been made for higher pressures and temperatures than are common in boilers. Wall thicknesses of 6 inches have been used in some enormous stills. The heaviest vessels have been made by arc-welding and not a single service-failure has developed.

The boiler industry might profitably take notice of the development of arc-welding in the structural building trade. The steel erectors for large city buildings are governed by city codes, which are analogous to boiler codes in their restriction of improved methods of joining steel members. In spite of the fact that welding introduces the very desirable feature of noise elimination in steel erecting, the large cities are very cautious in permitting its introduction. In the face of this situation an enormous progress has already been made throughout the country. Today over one hundred buildings have been erected either partially or entirely by arc-welding and more than eighty cities have provisions for welding in their building codes. This progress has been very gradual but it serves as a background for the universal application of arc-welding in the structural-steel building trades in the near future.

The problem of the boiler manufacturers is not especially more difficult or hopeless. The same automatic arc-welding processes with special preparation and subsequent annealing as employed in the manufacture of oil-cracking stills would serve as an ideal basis for the development of large fired pressure vessels. If such boilers were first manufactured experimentally and put into service outside of the code jurisdiction, valuable test and service data could be accumulated and a precedent would be established for the gradual adoption of welding. Such a move should originate with the united body of boiler manufacturers under the auspices of the boiler code committee itself. Unless this development takes place along with the education of the boiler manufacturers in the use of the arc-welding tool, some one organization will seize the opportunity to weld the first boiler too large for riveting. The ap-

Fig. 1.—Automatic-arc welding head used on small water heating tank construction



* Address delivered at Convention of Master Boiler Makers Association, Pittsburgh, Pa., May 20-23, 1930.
† General engineer, Westinghouse Electric & Manufacturing Company.

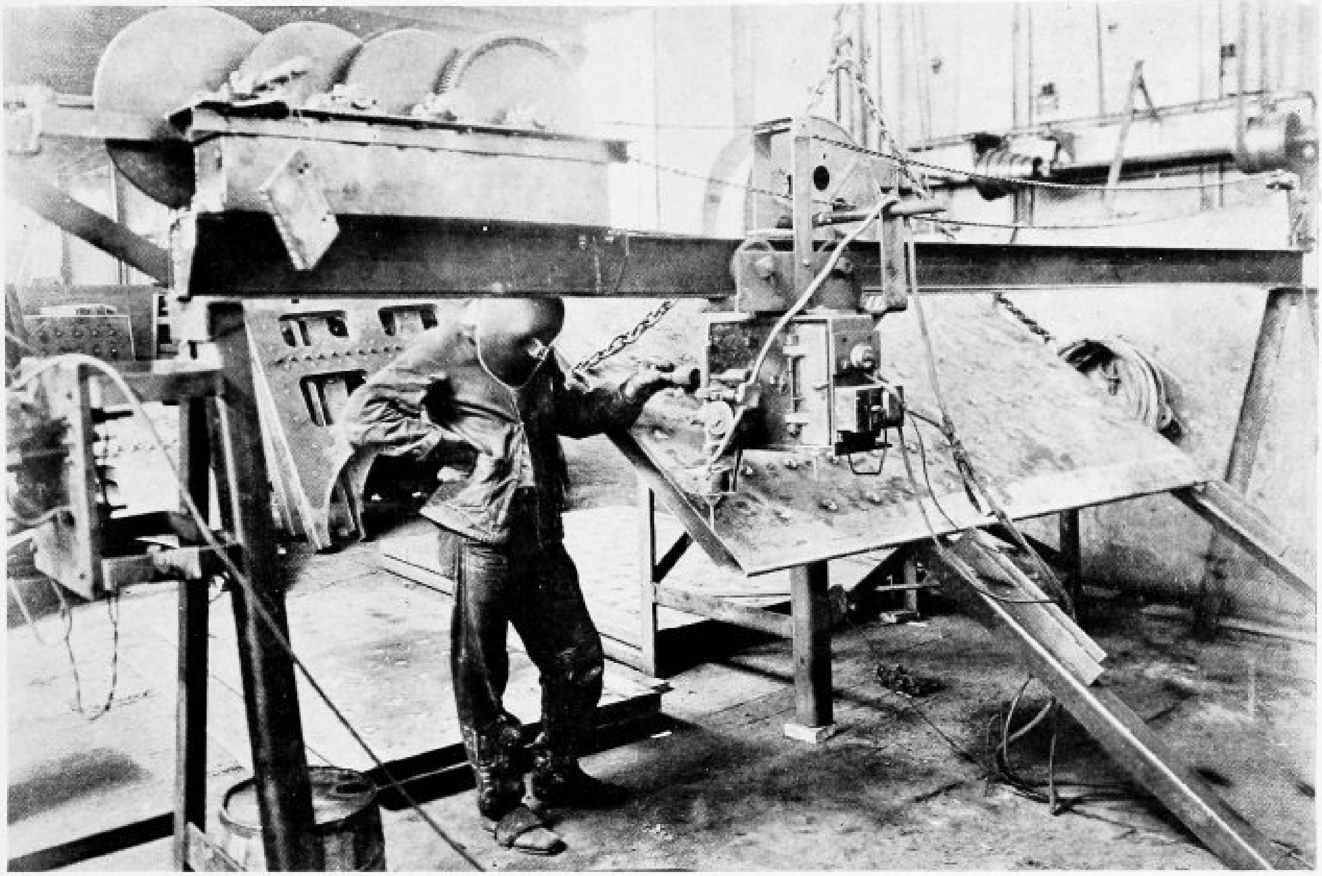


Fig. 2.—Welder used for making cap welds on ¼ inch side sheets of boiler

plication of the same process to smaller lower pressure boilers will be simple enough and the evolution may be quite rapid.

The general argument used against welding, of course, is that it is untried and unproven. This situation cannot be changed by inaction. Some of the detail objections are: Firstly, that it is difficult to formulate a set of rules or specifications to obtain a given result as regards effective strength; secondly, that it is difficult to inspect a joint to determine the quality of the weld and the presence and magnitude of internal strains.

Similar impediments could have been raised against riveting practice in the very early days of boiler making. They can be overcome by careful research. They have been set aside in welded vessels very similar to boilers and with thicker walls operating at higher temperatures and higher pressures. The welding procedure is carefully worked out to obtain ductile and dense welds with minimum shrinkage strains. The complete vessels are annealed after completion to remove the last traces of internal strains and carefully tested before shipment. Methods of exploring a finished butt-weld are being developed to give an inspector a direct-reading indication of the soundness of the joint. The last objections to welding are being gradually pushed aside.

The greatest contribution towards reliability and consistency in welding is the development of the automatic arc-welding head. It replaces the trained eye and hand of the welder to maintain thermal conditions at the arc. It can be adjusted for a given arc length, welding current and welding speed as dictated by experience on a given plate thickness and can be relied upon to produce duplicate results. When the boiler codes make provision for arc-welding, they will probably specify automatic arc-welding. Tables of welding current and speed as well as arc length and number of passes will take the place of corresponding information in riveted construction.

In automatic arc-welding all motions are controlled by machinery. The electrode is fed to the arc by a motor and control sensitive to arc voltage so that the length of the arc is maintained at constantly the same value. This mechanism is called an automatic arc-welding head. During the operation the arc is moved along the seam by driving either the welding-head support or the work at a prescribed speed by a separate motor. In some applications the arc is given a transverse oscillating motion at the same time. This is also a uniform movement controlled by a motor. The entire procedure takes place without attention on the part of the operator except for starting and stopping the work. Due to the unchanging conditions, uniform results are obtained and a much higher production is assured than would be possible manually. This is largely due to the fact that the thermal conditions at the arc remain constant and the welding current may, therefore, be increased to the limit with a corresponding increase in speed for a given operation.

In manipulating the arc with the automatic arc-welding head, the electrode wire is drawn down from a reel between two knurled power rollers and pushed through a long straight nozzle to the arc. The rollers are driven through a gear train by an electric motor, the speed and direction of which are controlled by the arc conditions. If the arc is slightly too long, the

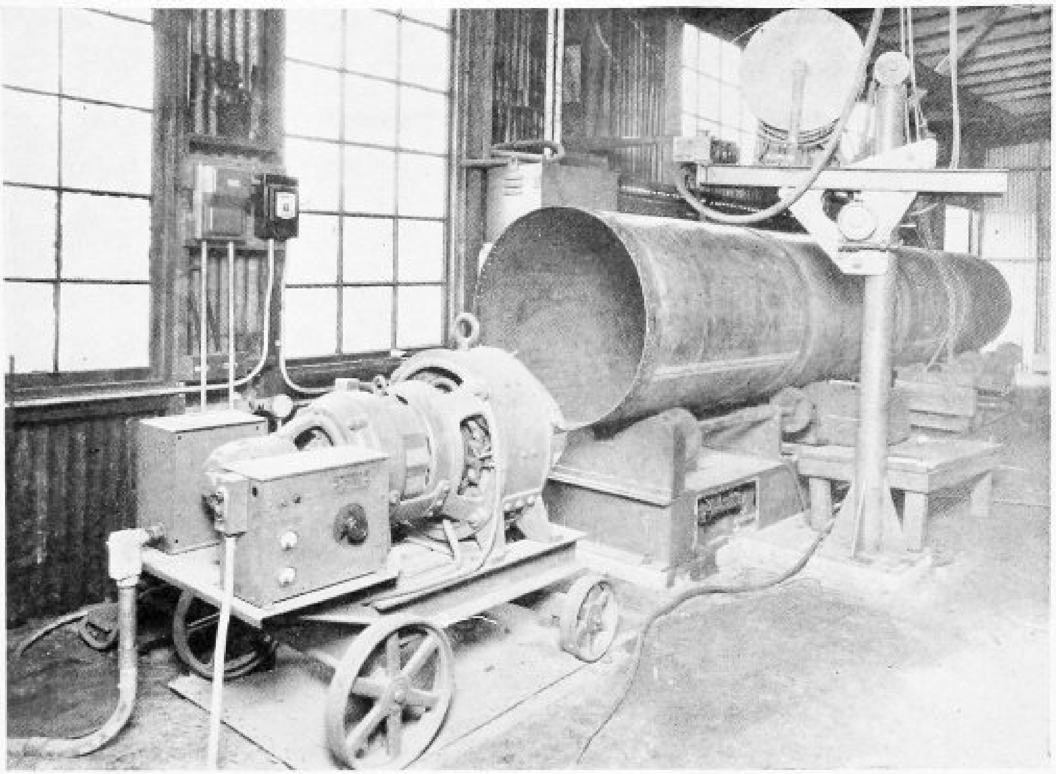
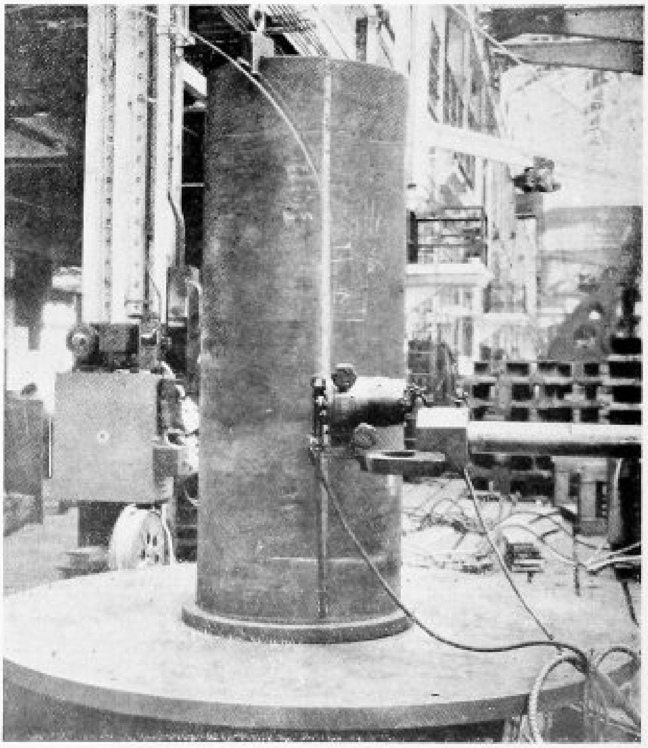


Fig. 3.—(Left) Circumferential seam lap welding equipment. Fig. 4.—(Below) Automatic arc welder in use on cylinder made of ¾-inch steel plate



motor speeds up to feed the electrode faster; if it tends to become too short, the motor will decrease the electrode feeding rate to maintain a constant arc voltage. The control is very sensitive and quick in response. The head is fully automatic in that it will strike its own arc and maintain a uniform arc length even over an irregular surface. The head measures about one foot cube overall except the nozzle and weighs about 75 pounds. The welding current passes from the nozzle bar to the electrode through the sliding contact near the arc. This particular form of nozzle is adapted for only bare or lightly flux-coated electrodes.

TABLE I.—COMPARISON OF ARC-WELDING SPEEDS

Manual Welding				Automatic Welding			
Plate Thickness	Wire Size	Amps.	Feet Per Hour	Plate Thickness Inches	Wire Size	Amps.	Feet Per Hour
½"	5/16"	250	3	½	3/16"	350-275	15
⅜"	¼"	225	4	⅜	3/16"	310-280	23
¼"	3/16"	175	6.5	¼	3/16"	360	45
3/16"	5/32"	150	9	3/16	3/16"	340	60
⅛"	⅛"	125	15	No. 12	5/32"	200	100
				No. 14	5/32"	185	120
				No. 16	5/32"	185	165

In Table I are shown the comparative speeds of automatic and manual welding with bare or lightly coated electrodes for equivalent results in the same welding shop. As a general rule it may be assumed that the automatic welding head will perform a given operation in ⅓ to 1/6 the time required by a skilled manual welder. The first figure holds for material greater than ¼ inch in thickness whereas the greatest time saving is effected on the thinner sheets.

Automatic arc-welding is now universally used in small tank construction. Fig. 1 shows an automatic arc-welding head in operation on a small water heater tank. In this case the tank is rotated by a small turntable, while the head welds the tank top to the shell. Some specifications still call for riveting these tanks but the manufacturers prefer to use a greater rivet spacing and then weld at the lap edge to provide maximum strength and insurance against leakage. The welding speed on 14 gage to 17 gage tank varies between 18 and 30 inches per minute.

Low-pressure boilers for heating installations are using welding to a large degree. Some manufacturers assemble such boilers without a rivet. All sheets are lap- or butt-welded and stay bars welded into the sheets take the place of staybolts. Fig. 2 shows an automatic arc-welding head used to make a lap weld on ¼-inch thickness plate for the side sheet of a boiler. Speeds of 10 to 16 inches per minute are obtained on such work.

Considerable welding is done on locomotive and other fire-tube boilers of the firebox type. Welding is already permissible on all fire-side stayed surfaces up to within one foot of the top of the crown sheet. Fire doors, mud rings and side sheets are welded within these limits.

Another circumferential lap seam welding equipment is shown in Fig. 3 to join sections of well casing through butt straps. The welding head is supported from a separate pedestal arm to provide for adjustment in the vertical and lateral directions. The machine which supports and rotates the casing is of a special design to permit adding section after section to form a long cylinder. The end roller support for the casing is mounted on a small truck which can roll endwise on a track to shift the casing. Auxiliary rollers in the main structure of the rotating machine can be operated by a cam and lever to raise the casing off the transverse rotating rollers for ease in shifting the casing endwise by hand. Thus the completed casing can be moved to make room for an additional section on the machine. Between the outer pair of supporting and rotating roller shafts are another pair spaced closely together to contact small casing diameters. All four shafts are driven by a single motor and gear reduction to produce the same peripheral speed at the weld. In this manner any diameter between 6 and 48 inches can be held self-centered without adjustment.

The clamp-type seam welder is the more usual form of machine for the manufacture of short-length cylinders by butt welding with the automatic arc. These machines are particularly adaptable for relatively low production shops, since they will accommodate a large range of diameters and plate thicknesses. Moreover, they can be used to butt weld two straight plates together. The machines consist essentially of a main frame with a backing bar or anvil under the seam. Air-pressure clamping fingers press each side of the seam down against the bar independently so that the plate edges will be lined up and held in position during the welding operation. A self-propelled carriage with welding head and electrode reel travels along the seam to make the weld.

Nearly thirty miles of large-diameter pipe per day are made by automatic arc-welding. Most pipe is made with a longitudinal welded seam after rolling a plate into the form of a cylinder. A thin-walled pipe is produced by forming and welding a continuous spiral strip of steel. By making a mechanical interlock between adjacent spirals and welding the locked seam a spiral reinforcing strip is obtained. A rust-resisting steel in this pipe makes it the equivalent of heavier walled pipe and introduces definite advantages in portability.

The use of automatic arc-welding on heavier cylinders is shown in Fig. 4. The shell is about ¾-inch diameter and the flange ring at the bottom, against which a fillet weld is produced, is about 2 inches by 4 inches in section.

Short straight welds between heavy plates can often be made on the shop floor with a machine in which the welding-head support is in the form of a shaper arm which moves back and forth along the seam.

Pennsylvania Railroad Safety Record

Employes of the Pennsylvania Railroad set the best safety record in the company's history last year, it was revealed today in connection with the award of 20 trophies by President W. W. Atterbury, to the divisions and departments making outstanding marks for 1930.

Following an intensive campaign against personal injuries over a period of years, the accident record of Pennsylvania employes was reduced almost 40 per cent in 1930 under 1929. For comparative purposes records of injuries to railroad employes are compiled on the basis of the number of hours worked. Accidents on the Pennsylvania Railroad last year were reduced to 6.2 injuries per million man hours worked, as compared with 10.2 in 1929.

The new high record in accident prevention brought widespread award of safety trophies presented by President Atterbury. The central region, comprising the Pennsylvania's territory between Altoona, Pa., and Mansfield, O., was awarded the regional trophy in the system-wide safety contest for 1930. The western Pennsylvania general division, with headquarters at Pittsburgh, was awarded the general division trophy.

For the group of larger divisions on the system, the Pittsburgh division, also with headquarters at Pittsburgh, won the trophy for the lowest accident record. In the middle sized group, the Atlantic division, with headquarters at Camden, N. J., carried off the prize, while among the group of smaller divisions, the Grand Rapids division, with headquarters at Grand Rapids, Mich., won first honors.

Other trophies were awarded to various departments of the divisions making the highest safety records, including maintenance of way, maintenance of equipment, station, train and engine service groups. In the maintenance of way department the winners were the Pittsburgh, Atlantic and Akron divisions. In the maintenance of equipment department the awards went to the New York, Indianapolis and Cumberland Valley divisions; in the station department to the Pittsburgh, Cleveland and Logansport divisions, and in the train service department, the Eastern, Erie and Ashtabula and Grand Rapids divisions. In the engine service department, the Eastern, Long Island and Monongahela divisions carried off the awards.

Pneumatic Clamp for Edge-Planer

By James F. Hobart

The question has arisen as to the possibility of converting a good but rather old edge-planer with hand-clamping screws at either end of the machine to one arranged for pneumatic operation of the clamp. It is desirable to operate the clamps from the operating station of the planer and to utilize the shop compressed air pressure of 60 pounds per square inch. Such a problem often confronts the progressive boiler foreman who has in mind the modernization of old equipment at small expense.

Good results may be obtained with either a one-cylinder or two-cylinder home-made pneumatic clamp control. The two-cylinder plan is the most simple and may be used, provided an excavation can be made at each end of the edge planer in which to place the air cylinders. These small pits may be concreted or bricked on the sides and bottom and covered with removable planks, steel plate or concrete slabs. When it is impossible to make excavations, the cylinders may be mounted directly on top of the clamp-bar; or a single cylinder of same diameter, but with double piston travel, may be used instead of two shorter cylinders, as will be described in later paragraphs.

The major problem is to determine the diameter of a cylinder which will give the necessary clamping power with compressed air at 60 pounds per square inch.

The first thing to be done is to ascertain the amount of pressure which is exerted by each screw in firmly clamping the plate. This may be done in two ways: (1)—Measure the direct pull necessary to move the hand-wheel the last inch or two. One way of finding this is to tie a rope to the rim of the 18-inch hand wheel and then pull up on the rope through a spring-balance, the rope at the instant of pull being kept horizontal and at right angles to the radius of the wheel at the point where the rope is attached. Should a spring-balance be unavailable, screw down the hand wheel to give the necessary screw pressure then attach the rope to the wheel rim and carry the rope out horizontally and vertically downward over a wheel, roll or sheave; then turn back the hand-wheel a few inches, say 4 or 5, and load the vertical end of the rope until the hand-wheel is pulled ahead again the few inches which it was set back; then the weight upon the rope equals the pull required upon the clamp pulley rim to give the clamping power required.

(2).—Measure the pitch of the clamping screw. In this example, it will be assumed that the pitch is 1/4 inch. Next determine the distance through which the exerted pull must travel in order to advance the screw 1/5 inch. This distance will be about the circumference of the hand-wheel, which is approximately about 56 inches. Here we arrive at the actual leverage of a screw, which, in this case, is 1/5 to 56, or, getting rid of the fraction, the leverage is 1 to 4 times 56, or 226. Multiply this leverage by the pull exerted upon the hand-wheel tightening the clamp and we will know what clamping force will be necessary. It will be assumed that the hand-wheel pull was found to be about 100 pounds. Multiplying this power into the leverage ratio, it is found that 226 x 100 equals 22,600 pounds. Diminish this about one-half to allow for friction of the screw, which is sometimes enormous, and it is found that the net clamping power of the screw is about 11,300 pounds. Should it have been found that the necessary hand-wheel pull was only 50 pounds, then the required clamping power would have been only about 5600 pounds, or thereabouts.

Bear in mind that any change in the pitch of the screw or diameter of the hand-wheel will make a change in the power-ratio of the screw. For instance, should the pitch of the screw be 8 threads to the inch, instead of 4, then the power ratio would be doubled. However, the diameter of the screw makes no difference whatever; a 2-inch screw is no more powerful than a 1-inch screw, but it is stronger.

Perhaps a 50-pound pull on an 18-inch hand-wheel will have sufficient clamping power, so let us look at air cylinders and find what diameter of cylinder would be required to do the clamping in place of the 18-inch hand-wheel on a screw with 4 threads to the linear inch. Such a screw, having a leverage of 226, as stated, will exert a pressure, deducting 50 percent for friction, having a clamping power of about 5600 pounds.

Let us see how powerful air cylinders are. If this edge-planer happens to be in a railroad boiler shop, it may be possible to get hold of a couple of 12-inch cylinders, such as are sometimes used on locomotives for operating the driving-wheel brakes. A 12-inch cylinder will have an approximate area of 112 square inches and, when acted upon by air under 60 pounds pressure, can exert a force of about 6720 pounds. This would leave a fair margin for friction, low air pressure, etc., and still give as much stress as a 50-pound pull on an 18-inch hand-wheel.

To attach two such cylinders to the edge-planer, several ways are open. The cylinders may be attached directly to the under side of the edge-planer and the piston rod made fast directly, by suitable connections, to the clamping bar. Thus arranged, the connections are simple, but have the disadvantage of requiring working pressure on the stuffing box, and the rod area must be deducted from the cylinder area. Should the cylinder be inverted and bolted directly to the edge-planer, the piston rod may be attached directly to a sort of yoke, from which connections may be carried up on either side of the cylinder to the clamp-bar.

In case pits cannot be made in the floor and the cylinders must be mounted on the clamp bar, suitable connections may be made according to requirements. In either case, the two cylinders must be piped to a D-type slide valve for a throttle, whereby air may be admitted and released by moving a lever, so as to press the clamp-bar down or to raise it for the insertion and removal of plates.

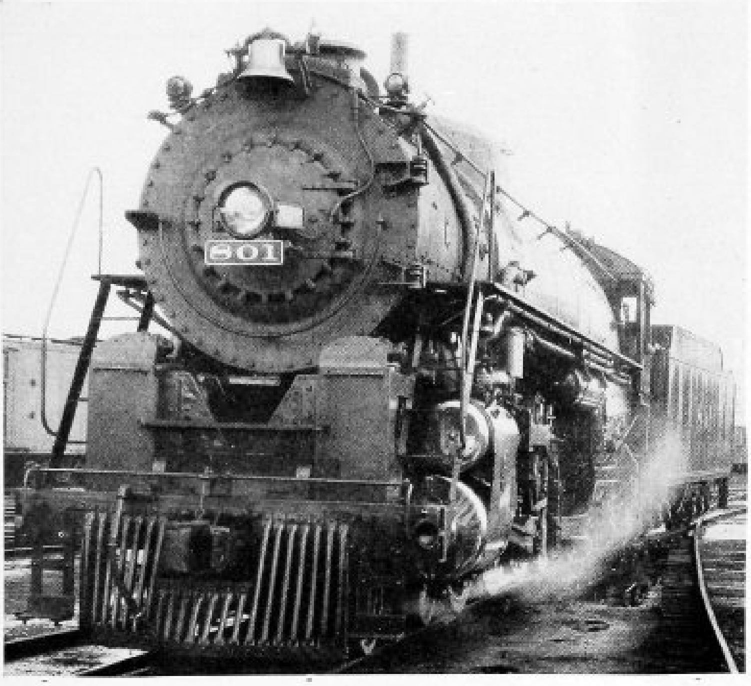
In case the cylinders cannot be placed underneath, or if small, long-stroke cylinders must be used, a single cylinder may be mounted to slide a few inches upon the clamp-bar. Then connections may be made by means of suitable levers, so as to operate either bell cranks, one at either end to raise and lower the clamp-bar, or to operate a toggle joint at either end of the bar, whereby more power may be available through a longer movement of the piston. In this case, the control will be simpler as only one cylinder must be controlled, but a regular D-type slide valve or its equivalent, actuated by a lever, will be found desirable to admit steam to either end of the cylinder at will, and at the same time to exhaust the vapor from the other end of the steam or air cylinder, as either may be used.

Novel Boiler for New Guinea Gold Fields

By G. P. Blackall

The Australian works of Babcock & Wilcox, Ltd., which were completed a few years ago at Regents Park, near Sydney, are the largest boiler works in Australia, being located on a site of 50 acres and providing every facility for the manufacture of boilers up to the largest sizes in use. A special boiler of particular interest is now being made at these works, having been ordered for operation in the New Guinea gold fields. This boiler is to burn low-grade wood fuel and to operate at an altitude of 7000 feet. The poor draft obtainable at such a height largely increases the difficulty of manufacturing a suitable boiler and furnace. Further, this boiler will have to be transported from the coast to site of erection, the major distance by airplane over impenetrable jungle and the remainder by native labor. It is a watertube boiler, using small bore tubes and of special construction so as to make the drum of the smallest possible dimensions. Moreover, the boiler is to be of such a type that no riveting in the field will be necessary in order to assemble it. It will be interesting to await data regarding the performance of this novel generator.

It is hoped that much information will be made available in the near future at which time it will be released for publication.



Coming in from a test run

High-Tensile Steel Used in Boilers of New Locomotives

During the month of September, 1930, the St. Louis Southwestern placed in service a series of ten Baldwin-built, 4-8-4 type, oil-burning, steam locomotives to replace 2-8-0 type locomotives in handling the fast merchandise and perishable freight trains which comprise such a large proportion of Cotton Belt business. The new locomotives, known as the Class L-1, are used largely in main line movements between Pine Bluff, Ark., and Tyler, Tex. With a normal rated tractive force only 18 percent greater than that of the Class K-1 locomotives replaced, they are handling approximately 30 percent more tonnage at higher speeds.

This is expected to result in a reduction of about 20 percent in train mileage. The new locomotives were designed with a tractive force of 61,500 pounds, as great as could be had with a ratio of adhesion close to 4, considering the loading permissible on existing bridges and other roadway structures. As a portion of the territory over which the locomotives are operated is of undulating character with ruling grades of 1.2 percent, 7000 feet long, it was necessary to provide large boiler capacity in order to negotiate these grades at the minimum desired speed of 15 miles per hour.

Silico-manganese steel, having a minimum ultimate strength of 70,000 pounds per square inch, was furnished by the Lukens Steel Company for the boiler shell and outside firebox wrapper sheets, thus permitting the use of thinner sheets and a corresponding increase in size of boiler without exceeding the weight limitations. This steel compares with carbon steel of 55,000 pounds per square inch ultimate strength, as commonly used. Boiler staying and bracing were designed so that the maximum stress on all firebox stays did not exceed 6550 and on braces 8000 pounds per square inch. The boiler was built for a working pressure of 250 pounds per square inch, this pressure being decided on as being the middle ground between lower, less efficient pressures and somewhat more efficient higher pressures, with the possibility of the increased efficiency being offset by increased boiler maintenance. The use of 250 pounds steam pressure instead of 200 pounds used on K-1 class improves the economy and gives a smarter locomotive with better acceleration.

The boiler is equipped with a Type E superheater which, it is estimated, permitted the following increases over what would have been possible with a Type A superheater: Tube and flue heating surface, 6 percent; total evaporating heating surface 14.5 percent, and sustained boiler horsepower, 27.1 percent. Because of favorable tests previously conducted by the St. Louis Southwestern on Class K-1 locomotives, the L-1 class was also equipped with a feedwater heater and thermic syphons. The Worthington Type S heater was used, although the tests were conducted on the older Type BL heater and indicated that approximately 15 percent of the water used was recovered, with a fuel saving of 6 to 15 percent depending on the load factor and the operating conditions. Three Nicholson thermic syphons were applied, two in the firebox and one in the combustion chamber, as previous tests are said to have indicated fuel savings up to 13 percent on K-1 class, equipped with only two syphons in the firebox. The use of the American front end throttle permits the delivery of the steam to the cylinders by a short route and makes superheated steam available almost at the instant the throttle is opened. With the Type E superheater covering almost the entire area of the tube

New Cotton Belt 4-8-4 locomotive built at The Baldwin Works

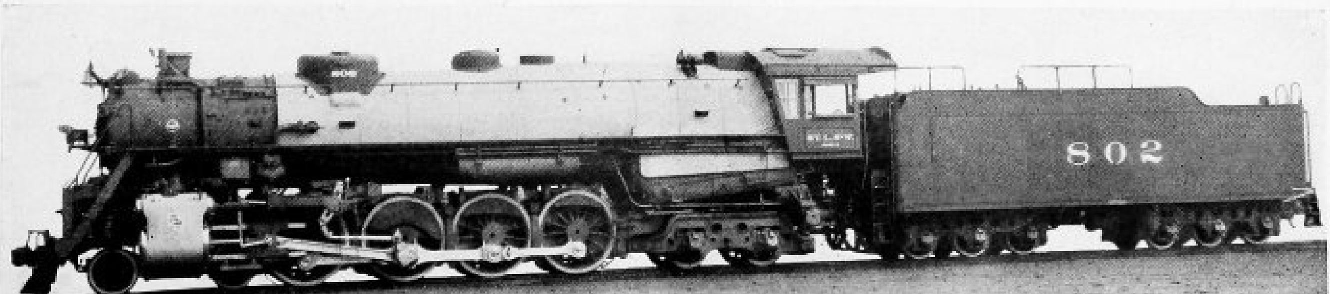


TABLE SHOWING THE PRINCIPAL WEIGHTS, DIMENSIONS AND PROPORTIONS OF THE ST. LOUIS SOUTHWESTERN 4-8-4 TYPE LOCOMOTIVES

Railroad	St. Louis Southwestern
Builder	Baldwin Locomotive Works
Type	4-8-4
Service	Freight
Cylinders, diameter and stroke	26 in. by 30 in.
Valve gear, type	Walschaert
Valves, piston type, diameter	14 in.
Maximum travel	7¾ in.
Weights in working order:	
On drivers	242,500 lb.
On front truck	82,000 lb.
On trailing truck	98,000 lb.
Total engine	422,500 lb.
Total tender	307,000 lb.
Total engine and tender	729,500 lb.
Wheel bases:	
Driving	18 ft. 9 in.
Rigid	12 ft. 2 in.
Total engine	45 ft. 0 in.
Total engine and tender	87 ft. 7 in.
Wheels, diameter outside tires:	
Driving	70 in.
Front truck	36 in.
Trailing truck	43 in.
Journals, diameter and length:	
Driving, main	12½ in. by 14 in.
Driving, front	11 in. by 15 in.
Driving, others	11 in. by 14 in.
Engine truck	Roller bearing
Trailing truck	9 in. by 14 in.
Boiler:	
Type	Conical
Steam pressure	250 lb.
Fuel, kind	Oil
Diameter, first ring, outside	86 in.
Firebox, length and width	132⅛ in. by 96¼ in.
Combustion chamber, length	54 in.
Tubes, number and diameter	52—2¼ in.
Flues, number and diameter	200—3½ in.
Length over tube sheets	20 ft.
Grate area	88.3 sq. ft.
Heating surfaces:	
Firebox	258 sq. ft.
Combustion chamber	104 sq. ft.
Thermic syphon	107 sq. ft.
Tubes and flues	4,259 sq. ft.
Total evaporative	4,728 sq. ft.
Superheating	2,060 sq. ft.
Combined evap. and superheating	6,788 sq. ft.
Tender:	
Style	Water-bottom, riveted and welded
Water capacity	15,000 gal.
Oil capacity	5,000 gal.
Rated maximum tractive force	61,500 lb.
Weight proportions:	
Weight on drivers ÷ total weight engine, per cent	57.3
Weight on drivers ÷ tractive force	3.94
Total weight engine ÷ combined heating surface	62.2
Boiler proportions:	
Tractive force × diameter drivers ÷ comb. heat. surface	634
Comb. firebox heat. surface ÷ grate area	5.31
Comb. firebox heat. surface, per cent of evap. heat. surface	9.92
Superheating surface, per cent of evap. heat. surface	43.6
Tractive force ÷ comb. heat. surface	9.07

sheets, it is impracticable to install a superheater damper; therefore, to maintain some circulation through the superheater, superheated steam is used for more auxiliaries than would be the case if economy only were considered. The L-1 class uses superheated steam for the air compressors, hot- and cold-water pumps, dynamo, oil-burner atomizer and blow-back, blower and whistle.

While the nominal rated tractive force of the L-1 class, 61,564 pounds is approximately 18 percent greater than the K-1 class, it is contemplated that the L-1 class will handle approximately 30 percent more tonnage at a higher speed and without excessive speed on the descending grades. Owing to the capacity of the boiler, the initial starting effort does not drop off so rapidly at speed, this being shown in the chart. The maximum horsepower output is at least 50 percent greater than that of the K-1 class, while at 15 miles per hour, it is practically 30 percent greater.

It is expected that with a reasonably high load factor it will be possible to produce 1000 g.t.m. with 7.42 gallons of fuel oil as against 8.73 gallons with the K-1 class. This means a decrease in unit fuel consumption of 15 percent.

The tender is built on a General Steel Castings Corporation cast steel, water-bottom tender frame which utilizes space previously wasted, lowers the center of gravity for a stated capacity and reduces maintenance on account of the elimination of the bottom sheet of the tank and the wood decking formerly used. The tender capacity of 15,000 gallons of water and 5000 gallons of fuel oil necessitated the use of six pairs of wheels. It is estimated that this capacity will permit operating a maximum distance of 84 miles without taking water and 330 miles without refueling.

Various devices in the cab have been located so that the enginemen can conveniently operate them and the comfort of the crew has been well provided for by the installation of comfortable seats with arm rests, lockers and racks for supplies, tools and extra clothing; first-aid kit; clear-vision and storm windows; cab awnings and curtains; a radiator for heating the cab in cold weather, and five adjustable ventilators for warm weather; also the usual electric lights and ice water container.

The Cotton Belt management believes that a locomotive, neat and attractive in appearance, is a desirable asset. Therefore, the design provides for a symmetrical streamline appearance with straight running boards, hand rails and throttle rigging, as free from miscellaneous appliances, piping and other details as possible, although due consideration has been given to accessibility for repairs. The boiler and cylinder jackets have been finished with Sherwin-Williams lacquer in an attractive dark Nile green color. The cylinders and valve-chamber head casings are chromium plated.

The specifications for the locomotive were prepared by the mechanical engineering department who not only co-operated unusually closely with the builder, the Baldwin Locomotive Works, in working out the final details of the design to suit the special service and requirements of the customer, but supervised construction at the builder's plant.

New Hazard for Welders Pointed Out

The *Zeitschrift für Gewerbehygiene*, a German magazine, recently published an account of an accident that should be especially interesting to persons whose work involves the use of acetylene cutting torches in boilers or other closed vessels.

Two men were inside a boiler doing some cutting by means of these torches. They had finished a considerable portion of their work when the man who was attending to the gas supply on the outside heard calls for help. Both welders emerged from the boiler with their clothes blazing so fiercely that they sustained very severe burns.

The cause of the accident was rather unusual although, according to the German author, it was quite understandable. The torches were in working order and were being correctly handled. However, as the cutting work required an excess of oxygen, this gas quickly filled the vessel and permeated the men's clothing. When a spark accidentally struck the clothing of one of the workmen the oxygen-impregnated cotton material burst into a lively combustion.

Oxygen is both odorless and tasteless and as a consequence its presence even in large quantities cannot readily be detected. Because of these qualities the foregoing incident seems to point to the necessity of thoroughly ventilating boilers and tanks when cutting or welding is going on inside. In some cases even the use of a blower may be advisable.

Thermal Expansion of the Locomotive Boiler*

By H. L. Miller†

The great fundamental law of nature, upon which the entire railroad world is based is very simply expressed in the elementary physics texts. It states that, "solids, liquids and gases, expand when heated and contract when cooled." Natural laws, unlike our so-called laws passed by our legislative bodies, are always functioning and never fail. When we get to understand them we find them to be as constant and reliable in their action as the multiplication table. Two times two is always equal to four, and if you change the temperature of a piece of steel you also change its dimensions if it is free to move. We confine the water and steam in the boiler, and the application of heat produces expansion in the water and steam, but the expansion is prevented by the steel shell and the steam builds up pressure within its volume. If we confine a piece of steel and heat it, it will build up pressure within itself. If we could get around this law with regards to our fireboxes and flues, everything would be fine in the boiler shop from the viewpoint of the management in regard to cost of repairs and replacements to fireboxes.

It is very easy to measure the expansion and contraction of a steel bar with changes in temperature. We know that a bar of mild steel 10 feet in length will expand about 0.460 inch when heated from 75 degrees F. up to 575 degrees F. It is very difficult to measure the temperatures in the plates while in service, particularly the firebox plates. But we can measure close enough to calculate the range of temperature in the firebox plates while in service, and can thus figure the amount of expansion we have to contend with.

Dr. Greenslade of the Flannery Bolt Company has done some very good work along these lines and we will first study a chart prepared by him to show the differences in temperature to be found on a cross-section through the firebox walls.

The figures in this chart are based on known physical constants of steel and water and boiler scale and the temperature figures check very closely the actual measured temperatures found by G. L. Fowler and various other investigators. It will be noted that the plate surface next the fire shows a temperature of 734 degrees F. and the temperature on the water side of the plate is 584 degrees F. This shows a drop of 150 degrees F. in the ⅜ inch thickness of the plate, with an average temperature of about 659 degrees F. for the mean temperature of the side sheet. There is a big drop due to the low conductivity of the film of boiler scale, and going through the water to the wrapper sheet we find that the average or mean temperature of the wrapper sheet is about 380 degrees F. This is about 275 degrees F. lower than the firebox-plate temperature. Now we have bolted these two plates together with staybolts at 4-inch spaces and something is either going to give or else build up a big pressure or strain in the plates. If these plates were 10 feet long and were fastened together at one end only and one was 275 degrees F. hotter than the other it would expand about 0.260 inch, or roughly, one quarter inch more than the one at lower temperature. If the hotter plate were compressed back to the length of the cooler plate it would require a load of approximately 12,000 pounds per square inch of cross section of the plate. For a strip of plate 4 inches wide by ⅜-inch thick the cross section is 1½ square inches and the load would be about 18,000 pounds. If we have a row of rigid staybolts along the middle of this strip and 4 inches apart we would have 40 bolts to resist this movement on the part of the hotter plate. Fig. 2 shows what happens with a rigid bolt construction. The staybolts bend, the plate buckles, and actual measurements in the boilers show that the resistance of the staybolts cuts down the total movement between the plates to considerably less than it would be if the hotter plate were free to move.

G. L. Fowler took measurements on two

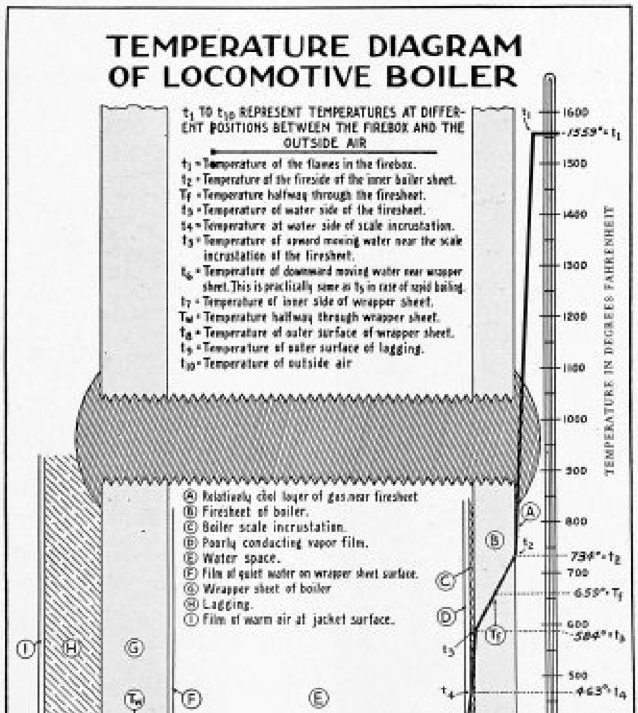
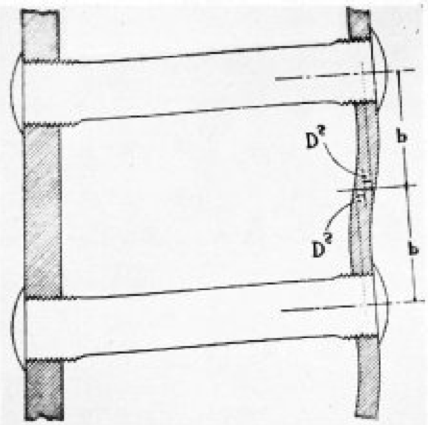


Fig. 1.—Temperature diagram of water leg in locomotive boiler

* Paper presented at a recent meeting of the New England Railroad Club, held in Boston, Mass.

† Metallurgist, Republic Steel Corporation, Youngstown, O.



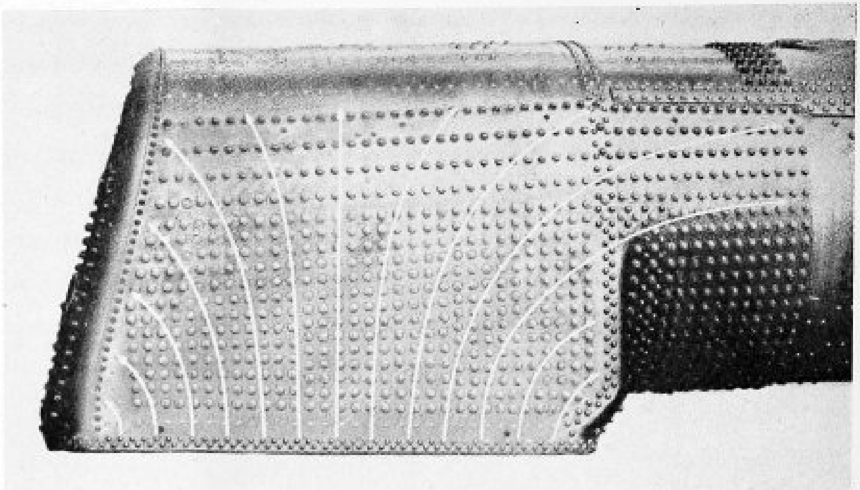
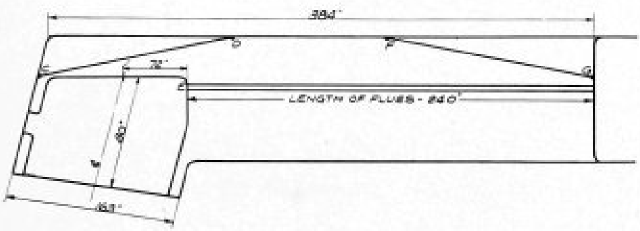


Fig. 2.—(Above) Bending of staybolts and buckling of firebox plate due to unequal expansion. Fig. 3.—(Right) Expansion diagram



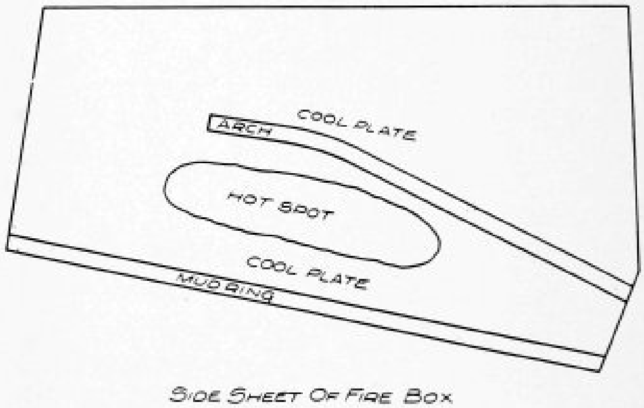
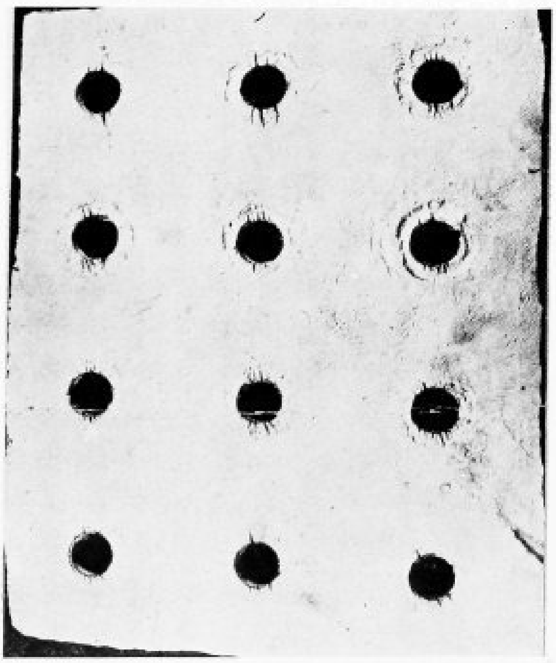


Fig. 4.—(Above) Section through Boston & Albany A-1 type boiler. Fig. 5.—(Right) Temperature chart of side sheet in firebox



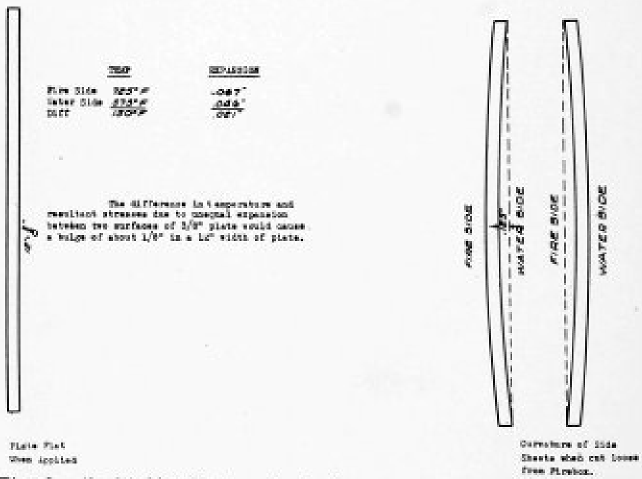


Fig. 6.—(Left) Vertical cracks in hot spot in side sheet. Fig. 7.—(Above) Effect of heat on plate with water on one side only

engines one with rigid bolts and one with flexible bolts and his report shows that the ratio of movement between sheets with flexible stays as compared with the sheets rigidly stayed is as 31 to 13. When the flexible bolted plate moved 0.031 inch more than the outside plate the rigid stayed plate showed only 0.013 inch movement. We have two opposing forces here, on the one hand we must contend with breaking staybolts due to repeated cycles of bending with every change in temperature of the plates. On the other hand with the flexible bolts we transfer the bending movement more to the plate and get the condition of greater buckling in the plates. Service tests over long periods seem to show that the plates can absorb these strains better than the bolts and this accounts probably for the large number of flexible bolts in use today.

Fig. 3 illustrates the ideas of the Flannery Bolt Company with regard to the direction of movement due to thermal expansion in the firebox. Notice that a neutral zone with regards to front and back movements is located about at the center of the firebox. The greatest movement apparently would be at the upper front corners of the firebox or combustion chamber.

Fig. 4 represents a cross section through a Boston & Albany type A-1 boiler. The measurements shown are the measurements on the boiler. Now if we allow for a temperature range in the firebox plates of from 500 degrees F. to 650 degrees F. according to how hard the engine is being fired we find by calculation that the possible difference in movement between the inner and outer sheets at the point *E* would be from 0.120 inch to 0.502 inch or from ⅛ inch to ½ inch. There are 20 flexible stays along the diagonal line from *E* to the center line at the mud ring, to resist this amount of creep.

But going back to the point *C* we find that the backhead is buckstayed to the shell at the point *D* and the firebox door sheet is stayed to the backhead at that point too. Now if the flexible staybolts along the top knuckle or flange of the door sheet, have a little space under the caps for expansion and if the buckstays were a little slack, the crown sheet might expand towards the point *C*. But if it cannot move backwards toward *C*, it would start from *C* as a base and the creep would all be forward in the direction of the point *E*. Now the front flue sheet at *G* is stayed to the shell at *F*. The total length *C, D, F, G* would expand about 0.800 inch in coming from 70 degrees F. up to 380 degrees F. the temperature of the outer shell. The crown sheet from *C* to *E* would expand from 0.475 inch to 0.700 inch with a temperature range in service of from 500 degrees F. to 650 degrees F. The 24-foot tubes with a temperature range of from 445 degrees F. to 520 degrees F. would expand from 0.406 inch to 0.605 inch. The total expansion of tubes and crown sheet would range between 0.880 inch and 1.297 inches or from 9/10 inch to 1¼ inches. The difference in expansion between the outer and inner parts would be between 0.085 inch and 0.502 inch or 1/12 inch to ½ inch. This difference is piled up in the form of stress on the flange in the flue sheet and is the reason for the cracking in the knuckle. The expansion in the vertical direction of the flue sheet from the mud ring to the point at *E* and the sagging of the crown sheet due to the stretch in the staybolts also bends the flue sheet knuckle.

There are also inequalities in temperature in the plates themselves with resultant strains set up in the plates. Fig. 5 is a picture of the unequal heating conditions in a side sheet of a firebox. We have a hot spot under the arch with cooler metal above and below it. The hot spot is generally 3 to 5 times as long horizontally as it is vertically. Consequently this section of plate wants to expand more in a horizontal direction than it does in the vertical direction. But it is surrounded and confined by cooler plate and it cannot relieve itself by bulging in towards the fire because the staybolts hold it to a flat plane so it just upsets or squeezes itself together when hot and then, when it cools down, it is under strain in the opposite direction and here is the result. These cracks running vertically from the staybolt holes, in Fig. 6, are the results of strain in the horizontal direction. A failure in a part is always at right angles to the load. The plate tries to pull away from the staybolts when cold and the water leaks out on the hydrostatic test and the boiler maker pounds on the staybolt expanding the bolt in a hole which is already under stress and thus he adds insult to injury and the plate gives up the unequal battle. The cracks are always up and down because the pull is in the horizontal direction due to the shape of the hot spot. They always start on the side of the plate next the fire, as in Fig. 7.

Now in referring back to Fig. 1, you will remember that the firebox plate was at 734 degrees F. next the fire and 534 degrees F. on the water side with a drop of 150 degrees F. through the plate. The plates are always flat when put in the boiler but when cut loose after being in service they always curl or dish as if backing away from the fire.

If we have a piece of plate 12 inches long and heat it to 725 degrees F. it would expand 0.067 inch and if heated to 575 degrees F., it would expand 0.046 inch. The difference is 0.021 inch. Suppose the side next the fire did expand 0.067 inch and the side next the water only 0.046 inch it would cause the plate to bow out towards the fire with a curvature ⅛ inch per foot. But the plate cannot do this on account of the staybolts holding it flat. So the hot side gets compressed when hot enough and then when it is cooled down it pulls the sheet into a reverse buckle. But as long as the staybolts are holding it flat it will be under strain on the fire side of the plate and the greatest strain is in the line of greatest expansion and compression which causes the cracks to start on the fire side of the plate and to run vertically. The hotter the hot spot, the greater the compression of the metal and the quicker the failure of the plate.

(To be continued)

High Pressure Locomotive Boilers

During the last few years the attention of locomotive engineers has been given to the use of steam at what may be called high pressure, or, in some instances, ultra-high pressure, as a means of improving the thermal efficiency of the steam locomotive. The economic value of high-pressure steam has been known for a considerable time, but, for a variety of reasons, little has been done in the matter of increasing boiler working pressures above those actually necessary for the production of the required power, and, in fact, the reverse has been the case, for it is within the recollection of many that on the introduction of superheating there was a general drop in pressures, and a certain amount of thankfulness expressed that such a course was possible without sacrificing the power of locomotives. The movement towards high pressures has, however, now definitely been made, and this for two very excellent reasons. One is the desire for greater power, and the other, the wish to improve the economic performance of the locomotive.

When considering the question of steam pressures, boiler design naturally demands first attention, as it is here that we are brought face to face with the real problem, and such being the case, it will be profitable to glance at what has already been done. Broadly, the type of boiler most suitable for the requirements of the locomotive is, we think it will be agreed, the usual locomotive type boiler, as it is called. If this is conceded, then the question asked is—to what extent is it suited to high-pressure steam, and how far can we go? Fortunately, we have a little definite information which may be of interest.

Normally, the locomotive-type boiler has been successfully employed for steam pressures ranging from, say, 180 to 225 pounds per square inch for many years. Now numerous examples are to be found working at 250 pounds pressure, both in England and especially in the United States, where the Pennsylvania led the way in 1916, when the 2-10-0 freight engines operating with a limited cut-off were introduced. It is here rather interesting to point out that these engines constitute an example of a successful attempt to utilize the advantages of the expansive properties of high-pressure steam. Following the introduction of these locomotives, pressures have been raised to 275 and 300 pounds, still maintaining the usual boiler, and the Delaware & Hudson, after three years' experience with 275, and over two with 300 pounds, have constructed a normal type boiler to carry 325 pounds working pressure. It may be remarked that the Maffei turbine locomotive works at 313 pounds, and the Beyer, Peacock turbine engine carries 300 pounds pressure, both having the conventional type of boiler.

The above sums up the present situation, so far as the usual type of boiler is concerned, and we can now turn our attention to water tube constructions. The Baldwin and McClellan designs both emulate the Brotan principle, aiming at the substitution of the direct-stayed firebox for one made up of water tubes, leaving the barrel section and the usual fire and flue tube arrangement as before. The Muhlfeld boiler again incorporates the tubular form of firebox, but re-introduces flat stayed end sections, and also retains the boiler barrel section, though of relatively small diameter, and this is, in reality, its important feature.

The Brotan design, so far as the tubular firebox is concerned, is no doubt admirably suited to high pressures, but the large diameter barrel portion is a distinct disadvantage, on account of the heavy plating necessary, and while high tensile material, such as nickel steel, is now being introduced, the thickness of shell plates will soon reach the limits imposed by cold rolling. In addition the question of weight will assume importance. The Muhlfeld boiler, with its small barrel section, appears to have some advantage therefore over contemporary practice, and, assuming the employment of superior steels, as in the case of the *James Archbald,* working at 500 pounds, the design has much to commend it.

So far we have dealt with boilers working at pressures up to 500 pounds. When we go higher, examples at our disposal now are very different in almost every particular. There is the Schmidt double-pressure design, and the very remarkable Loeffler generator, as applied to the Schwartzkoff locomotive. With these we find ourselves in the realms of super-pressures of 900 pounds in one case, and in the other of no less than 1500 pounds.

Beyond the boiler types mentioned, there is that applied to the London & North Eastern experimental high-pressure locomotive, and constructed according to the Yarrow-Gresley principle. In this we have the first purely watertube boiler, which has been fitted to a locomotive of otherwise usual design, and every credit is due to the sponsors of this interesting innovation in steam locomotive practice.

While discussing high-pressure steam as a means of promoting fuel economy, it must not be thought that the saving in coal consumption will of necessity be proportional to the improvement made in the cylinder efficiency. That can only be providing the efficiency of the high-pressure boiler remains equal to that obtainable with one of the conventional type operating at a lower steam pressure. This is a point not to be overlooked, for inasmuch as boiler temperatures will be higher with augmented pressures, smoke-box temperatures will also be increased, meaning an increase in the loss of heat carried away through the stack. This applies to any single-pressure boiler and points to the fact that some sort of economiser or air preheater should, properly speaking, be fitted to reclaim, at any rate in part, losses from this cause.

Another point to be considered is the influence of the watertube firebox on combustion efficiency. With the watertube firebox a large amount of heating surface is readily obtained, and as the percentage of the liberated heat in the firebox absorbed by the heating surface increases, at a given rate of firing, with the amount of heating surface, it will be necessary to provide adequate combustion volume in order to prevent the chilling of the fire, and the consequent reduction of the combustion efficiency, due to the greater heat absorption.

Briefly, the above reviews the efforts made by locomotive engineers to provide for the generation of steam at higher than normal pressures. Ultimately the form of boiler which will persist depends upon the amount of success attending the use of these higher steam pressures. By this is meant the actual economic gain obtained through an increase in pressure of, say, 300 pounds, using a normal-type boiler, and one of abnormal construction, carrying anything up to 1500 pounds, as in the Loeffler arrangement. Two factors will decide the issue: One will be the economic performance of the generator as such, and the other the efficiency with which the engines will make use of the steam thus provided.

In making the above statement, we overlook for the present the great over-riding factor of practical utility. The underlying principles of high-pressure steam and the economic gains theoretically obtainable are easily established, but upon the proportion of the savings shown by theory to be possible which is realised in practice, will depend the success—or otherwise— of the proposed ventures into the realms of higher steam pressures. We are indebted to *The Railway Engineer* for the foregoing summary of high pressure steam development in locomotive boiler design. The constant advancement of boiler design is world wide and not confined to any one country.

An Example of High Stress in a Rivet

Caustic embrittlement had nothing to do with the cracking of the rivet shown in the accompanying illustration, for it was found by an inspector during a recent shop inspection of a new boiler. The failure was attributed to stresses set up in the rivet shank directly under the head at the time of driving.

Rivet failed because of internal stress in shank

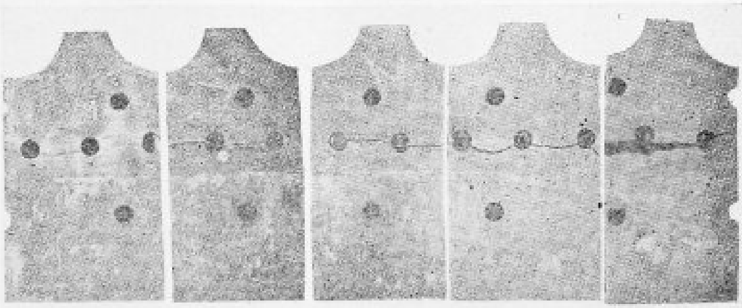
In this connection it is interesting to note: (1) That where caustic embrittlement is encountered one of the first symptoms is usually the snapping off of rivet heads; (2) that the theory by means of which this caustic action is explained is that caustic centers its attacks on the parts of the metal that are stressed very close to the elastic limit.

The question has sometimes been raised by some who hesitate to accept the embrittlement theory as to just how much basis there is for the assumption that extreme local stresses can exist at points in a boiler seam. From the evidence shown here, as well as from similar cases encountered at other times, it seems to be a fact that such stresses not only can but do exist.—*The Locomotive.*

Broken Rivets Indicate Caustic Embrittlement

The encountering of caustic embrittlement recently in two large batteries of watertube boilers located in regions where this kind of boiler trouble had not previously made its appearance should impress on plant men the importance not only of avoiding the use of feed-water treating methods that are capable of producing water of improper sulphate-carbonate ratio, but of reporting at once to plant officials or the insurance company the finding of broken rivet-heads and leaks at riveted joints.

At one plant in the western part of New York state the drums of seven boilers of the Babcock and Wilcox cross-drum type were affected so extensively that their continued use would have been dangerous. At another plant, located in Utah, six out of a battery of 14 boilers of the Stirling type had to be taken out of service for repair.



In the cross-drum boilers the place where the caustic attack centered was the butt strap forming the ligament for the horizontal circulator tubes. This seam was not easily accessible from within the drum because of the presence of a steam baffle plate. In fact it was only by removing this plate, which was not ordinarily done except when the circulator tubes were to be cleaned, that the inside rivet heads were exposed to view.

Fig. 1.—(Top) Pieces of shell plate from ruptured seam. Fig. 2.—(Bottom) Microphotograph showing rivet hole crack magnified eight times

When preparing boiler No. 8 for cleaning in December, 1929, attendants found that one of the rivet heads had broken off and fallen down behind the circulator plate. They called the shop repair gang to replace the rivet and while the riveting work was under way several other rivet-heads were shaken off by the vibration. In all, eleven rivet-heads either fell off in this way or were knocked off under the hammer test. Later, plant attendants had a similar experience with boiler No. 7, but as repairs could be made by the plant gang they did not deem the trouble serious enough to warrant reporting it to plant officials.

The first suspicion of the presence of embrittlement came in October of last year when one of the engineers happened to be present while workmen were removing the circulating plate from boiler No. 1. With the seam exposed, this engineer tried hammer testing a few of the rivet heads and found that he was able to snap two of them off. He reported the condition to the officials and they in turn asked the insurance company to send an inspector for a complete investigation.

One of the peculiarities of the case was that no signs of leakage could be seen at rivet heads or seams of any of the boilers in which rivets had been broken. However, after driving out the shanks of some of the broken rivets and polishing the walls of the holes with emery cloth, the inspector was not long in detecting several fine, hairline cracks. Although invisible to the naked eye these cracks were clearly apparent under a magnifying glass.

While examining boiler No. 6 in which the cracks seemed to be in the first stage of development, the inspector was told of the previous finding of broken rivets in boilers Nos. 8, 7, and 1, so he was more or less prepared for what was disclosed when the butt-strap of boiler No. 1 was removed and the shell plate was found cracked for a distance of 42 inches along a line of rivet holes. Pieces of shell plate taken from this seam are shown in Fig. 1. None of the other boilers was affected quite as badly as this one but all were cracked to such an extent that it was deemed best to order new drums.

Soda ash and lime were used in treating the feed water at this plant. It is thought that until two years ago the carbonate content of the treated water was very high in proportion to the sulphates. Since then, however, care had been taken to regulate this ratio in conformity with the proportions recommended for the 225 pounds per square inch at which pressure the boilers operated.

Leakage of the mud-drum seam under the bridge wall during a hydrostatic test and the subsequent finding of broken rivets prompted the examination that disclosed embrittlement cracks in six of the fourteen boilers at the Utah plant. Fig. 2 is a reproduction of a microphotograph showing one of the rivet hole cracks magnified about eight times.

Until 1917 the feed water at this plant was treated with boiler compound. At that time a soda ash and lime system was installed but no effort was made to regulate the quantities of these materials in keeping with the nature of the water. It was not until 1923 that a good method of control was established and really not until 1929 that a routine check was started on the sulphate-carbonate ratio. There seems to be little doubt but that caustic action got a foothold during the long

Published through the courtesy of *The Locomotive*, of the Hartford Steam Boiler Inspection and Insurance Company, Hartford, Conn.

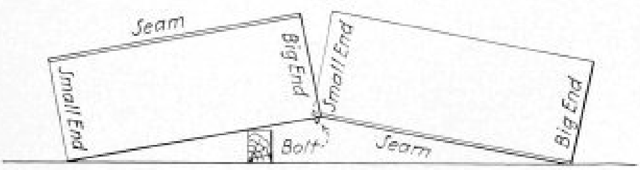
period when no check was kept on this ratio and when much more soda ash may have been used than the scale-forming impurities in the feed water warranted.

Assembling Circular Courses

By George Gardner

A rule used frequently where one length of circular work has to fit inside another is to make the inside length six times the thickness less in circumference than the outside. This allows for fitting. On smokestacks, ventilators, etc., where the sheets are thin, eight times the thickness should be allowed for greater ease in assembling.

Most smokestack lengths are made from one pattern and are of the in-and-out type. The small end is in-



Method of fitting circular courses

dicated usually by a reduction in pitch of the longitudinal seam towards that end. This end could be more plainly indicated if an extra hole were punched on the circumferential seam between the center hole and the next at the small end. This will indicate at a glance which is the small end, and since it goes inside and the extra hole is only in the inner end it will not be detrimental.

These in-and-out lengths of smokestacks are really frustums of cones and a camber should be given to each end of each length in order that the finished stack will be straight. The amount of camber is very small on stacks up to 24 inches diameter and say $\frac{1}{8}$-inch thick but it should not be overlooked.

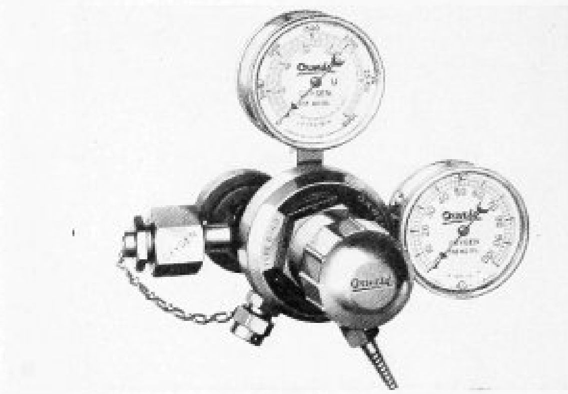
I have seen a great deal of difficulty encountered in assembling lengths of circular work such as smokestacks and boiler courses. The following, however, is a method by which stacks can be assembled easily and rapidly:

Place a block under the large end of one length with the other end on the ground, and the longitudinal seam on top. Then insert the small end of the other length inside the length on the block so that the joint hole of the longitudinal seam is over the center hole of the outer end. Put a bolt in that hole (which can be done from the outside) through the open space at the top. Then take out the block and let the ends drop to the ground. The whole weight will fall on the joint tending to close it together. Using chisel-end bars, guide the joints together. If properly made, it will be found easy to connect the joints with slight hammering. Continue this process for each length remembering to keep the longitudinal seam of the outer end on top each time.

On thick plates and when inserting heads, etc., it may be necessary to use bolts in the circular seam holes of the outer length. These bolts should have thick offset washers on the outside so arranged that by screwing up the bolt the outer part is pulled out at the same time the washer impinges on the inner part and forces it in. A number of these will help considerably on tight joints and by careful hammering the joint may be made to enter after which the bolts can be removed.

Two-Stage Oxygen Regulator

A constant line pressure free from any fluctuation is most desirable for good results in welding. To this effect, the Oxweld type R-43 oxygen welding regulator, recently introduced by the Oxweld Acetylene Company, 30 East 42nd street, New York, guarantees a freedom from fluctuation by means of a system of two-stage pressure reduction. This two-stage reduction is accom-



Regulator guaranteeing freedom from fluctuation

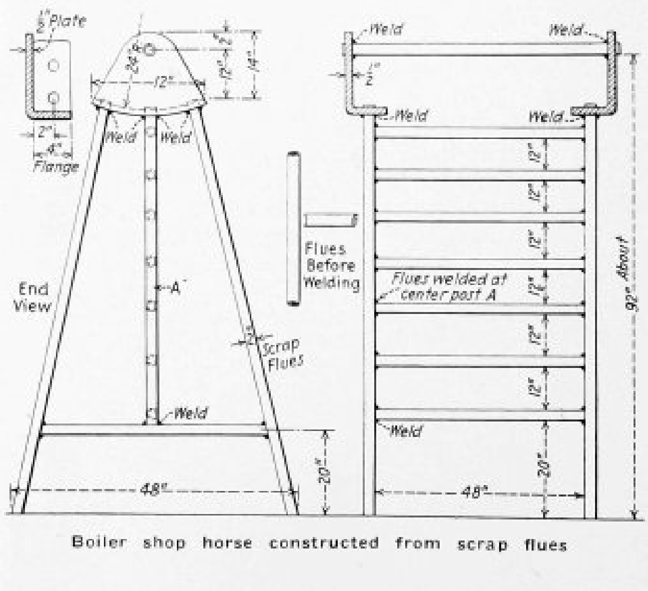
plished through two separate and independent sets of diaphragms, valves and springs.

The external appearance of the regulator should be noted. Instead of the usual handle-type, pressure-adjusting screw found on all other Oxweld regulators, there has been substituted a screw with a ribbed cap. This radical change in external design not only presents a neater and more compact appearance but also will avoid the possibility of breakage as there are no projections on the handle to be bent accidentally.

Boiler Shop Horse

The accompanying drawing shows an interesting and useful boiler shop horse developed by H. A. Lacerda, Watervliet, N. Y., for use in supporting scaffolding or for other purposes in the shop.

The fact that it is constructed from scrap material found in any boiler shop, together with the fact that it is light in weight and rigid in construction, should ap-



Boiler shop horse constructed from scrap flues peal to many boiler makers. Standard scrap flues are employed throughout with the exception of two pieces of ½-inch boiler plate at the top of the horse. It is entirely welded, is neat in appearance and may be easily moved about the shop. It is estimated that it takes a welder about eight hours to cut the flues and weld the boiler shop horse.

Bending One-Piece Firebox With Combustion Chamber

By Phil Nesser

Having read many suggestions in your valuable paper from other writers about the job of bending a one-piece firebox with the combustion chamber attached, the writer will endeavor to pass on our method, which we believe is a cheaper and better method than any of the others suggested.

We have bent a few fireboxes of the type mentioned and never had to use a sledge to shape them up. As we all know, after the combustion-chamber part has passed through the rolls one time, it can not be rolled back again; for this reason we must make it roll right the first time through. We said it could not be rolled back, but if you do it with the method here given, it is even possible to roll back, as the rolls are in tight contact, whereas with other methods it could not be rolled back, as the contact of the rolls on the firebox sheet would not pull enough to turn the top roll.

The firebox sheet is usually ⅜-inch firebox steel. The pressure of the roll upon a narrow strip of this steel, as the combustion chamber, will not turn the top roll; but, if a heavy bent bar be placed upon the top surface of the sheet, between the rolls, then the heavy bar not only turns the top roll, but also bends the firebox combustion chamber to the correct radius the first time through. This heavy bar, or three or four heavy bars placed side by side, can be made of bar iron. The size we used was 1½ by 6 inches, but 2 by 2 or any other size bar iron would do the trick. Of course, it must not be so thick that it strains the roll feed screws when pressure is applied upon it.

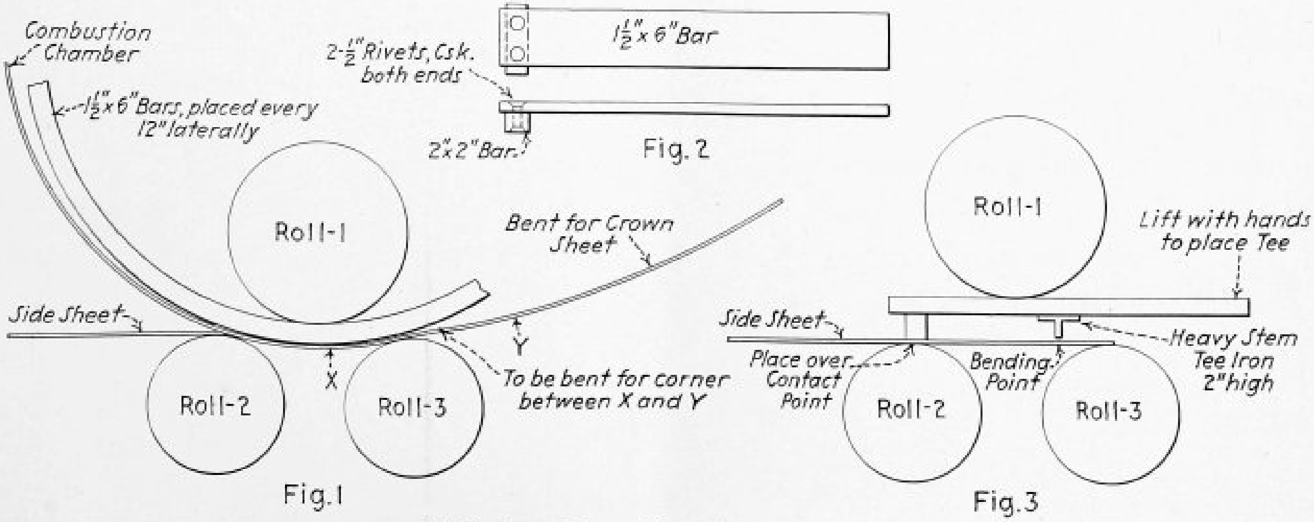
If the combustion chamber is not a perfect arc, that is if it has a larger radius in the bottom than up around the side, you can bend the bars with different radii to the proper shape before starting on the firebox. The bars are bent slightly smaller than the radius of the required firebox sheet, because the sheet will spring away from the bar after passing through the roll. By taking a piece of scrap cut from the same sheet, passing it through the roll with the bar on top of it, you can see what kind of a radius you are going to get when you bend the firebox sheet.

Next we will give the method used in bending the leg, or the mudring bend. This bend comes so near the edge of the sheet on some designs of fireboxes that it is a trick to get the sheet to bend at the proper place. Take a piece of bar iron 1½ inches by 6 inches about 24 inches long, drill two $\frac{9}{16}$-inch holes 4 inches apart at right angles to the side, and 1½ inches from one end. Take a piece of 2-inch by 2-inch iron, 6 or 8 inches long, place it across the 1½-inch by 6-inch bar. Mark the holes, countersink both pieces and rivet them together as shown in Fig. 2. Next get a piece of strong tee-iron with about a 2-inch stem. This can be 18 inches long, if the stem is heavy, say ⅝-inch; then by placing the bar upon the sheet at the point of bend, as shown in Fig. 3, and moving along the entire length, raising and lowering the top roll each time, lifting with the hands and moving the bars, the bottom can be bent as required. Some fireboxes are bent more at the back end and some are bent at both ends. This must be regulated by checking with the door-sheet flange at the back and with the flue or throat-sheet flange in front.

Now for the method of bending the combustion chamber. We took a bar 16 feet long, bent it into a full circle, then cut it into three parts. This made about a 62-inch circle. Then we bent the three bars a little more and started on the job.

We bent the leg bends first, the bends right above the mud ring. Next we bent across the top center, or the curve for the crown sheet. Then we came to the combustion chamber and bent both sides with our bars as explained, not having to open the rolls as the bars are only one-third of a circle. This being done, we bent the two top corners as shown on Fig. 1, between points *x* and *y*. These we bent last. We then opened the end of the roll and took the work out ready to fit up.

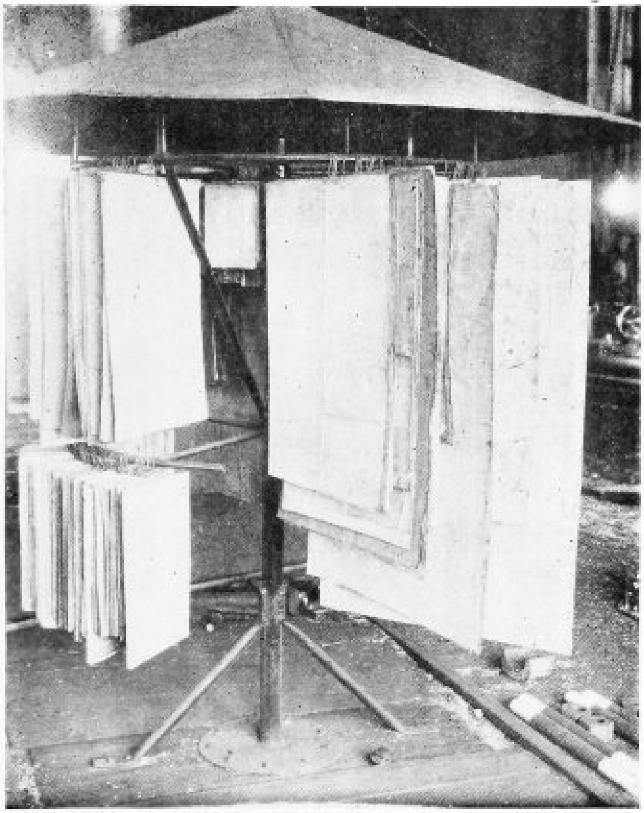
By examining Fig. 1, the bars may be seen as placed upon the sheet between the rolls. Both of the methods of bending described above can be used on other kinds of work. Sometimes we bend a light sheet that will not pull the top roll, and we use the bent bar for the purpose.



Details of method used for rolling firebox sheets

A Circular Rack For Blue Prints

In the machine shop of the D. & R. G. W., at Pueblo, Colo., blue prints are made accessible and are at the same time kept clean by placing them on the welded pipe rack shown in the illustration. The 7-foot section of 3-inch pipe which forms the central support of the rack is welded on a metal plate 18-inches in diameter



Circular rack for filing blue prints in the shop

which is bolted to the floor. Two angle braces of 1-inch pipe, welded to the upright section and bolted to the floor aid in making the rack secure. A circular section of 1-inch pipe, used to hold the small prints, extends part way around the rack 3 feet above the floor. It is supported by two angle braces of 1-inch pipe which are welded in place.

A complete circle of 1-inch pipe, supported by three horizontal and three angle braces of the same material is welded in place 5 feet above the floor to carry the larger prints. Another circle of ½-inch pipe, welded to the top of five 10-inch vertical sections of 1-inch pipe, supports the canopy roof of sheet metal on its frame of 1-inch tubing. Metal hooks are placed in the stiff top bindings of the prints to facilitate their being moved about on the rack.

Work of the A. S. M. E. Boiler Code Committee

The Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the code is requested to communicate with the secretary of the committee, 29 West 39th St., New York, N. Y.

Below are given records of the interpretations of the committee in Cases Nos. 670, 671, 672, and 673, as formulated at the meeting on December 5, 1930, all having been approved by the council. In accordance with established practice, names of inquirers have been omitted.

Case No. 670.—*Inquiry:* Does a vessel of shell-and-tube construction similar to a tubular boiler, which is used for the generation of steam by means of waste gases only, and is not in direct contact with flame or fire, come within the classification of a fire-tube boiler, or can it rightfully be classified as an unfired pressure vessel?

Reply: It is the opinion of the committee that a vessel in which steam is generated by means of waste gases, should be classed as a boiler.

Case No. 671.—*Inquiry:* Is it the intent of Par. U-64 of the code that the requirement for hydrostatic pressure tests of 50 pounds in excess of the maximum allowable working pressure for vessels that do not operate in excess of 100 pounds per square inch, is to apply to all unfired pressure vessels regardless of size? It is pointed out that for a 21-foot-diameter vessel to operate at 25 pounds, the hydrostatic test pressure would be 3 times the working pressure, which would require an excessive thickness of shell.

Reply: Par. U-64 was formulated with general reference to pressure vessels of average size as compared with that on which the inquiry is based. For the size and type of vessel referred to, the committee is of the opinion that the same hydrostatic test as is specified for vessels to operate in excess of 100 pounds per square inch should apply, and would recommend to the state authorities that they consider it on the basis of a test to 1½ times the working pressure. A revision to this effect is under consideration.

Case No. 672.—*Inquiry:* Will a low-pressure, welded, steel-plate, steam-heating boiler meet the requirements of the code if some of the flat surfaces are braced by structural-steel shapes welded to the exterior side of the plates and the principal heating surface is formed of a number of pressed-steel diaphragm plates of 3/16-inch thickness which have water on one side and the products of combustion on the other?

Reply: It is the opinion of the committee that the specially formed diaphragm plates in the construction shown do not fall under the classification of "boiler plate" as specified in Par. H-11 of the code. Flat surfaces braced by structural-steel shapes fusion welded to the exterior side of the plates will meet the requirements of the code, provided the rules in the "Standard Practice for Making Hydrostatic Test on a Pressure Part to Determine the Maximum Allowable Working Pressure" are complied with and the boiler meets the requirements of the code in all other respects.

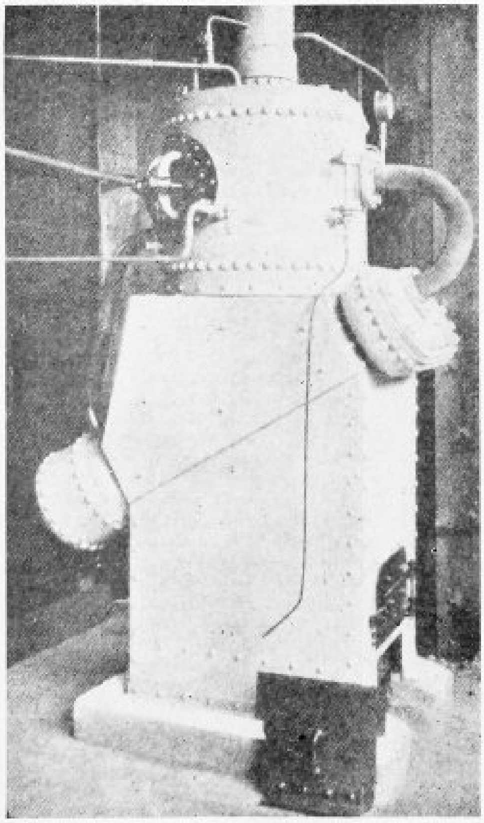
Case No. 673.—*Inquiry:* Is it the intent of the requirement in Par. P-186 of the code, relative to the pitching of staybolts on the flat surface surrounding the firedoor opening that has been formed by flanging in the edges and butt welding, that the nearest staybolts to the opening must be arranged in a row concentric with the opening or parallel to the edges, or may the flat surface be considered as sufficiently stayed if every portion thereof up to the edge of the opening is within an area covered by striking an arc of radius equal to the allowable pitch, struck from the center of the nearest staybolt?

Reply: It is the opinion of the committee that if every part of the area of the flat surface adjoining the firedoor opening comes within an arc of radius equal to the allowable staybolt pitch struck from the center of the nearest staybolt, the area may be considered as sufficiently stayed.

British Firm Develops Vertical Watertube Boiler

A new type of vertical boiler, which in many ways overcomes some of the inherent disabilities of the usual vertical boiler, has been developed by Fraser and Fraser, Ltd., Bromley-by-Bow, London. This boiler, of the watertube type, permits the burning of wood, bagasse or other local fuels and is not difficult to clean internally. While the boiler has been produced only in a small size, it may be built over a wide range of capacities.

The lower part of the boiler is rectangular, and consists of a firebrick-lined furnace across which is set an inclined nest of watertubes. The upper part is a cylindrical drum with a central uptake, and is connected to the headers of the tube nest by curved pipes. The normal water level is just below the end of the pipe leading from the top header. This is the discharge pipe for the steam generated in the tubes. The feed water is introduced in the drum just below the water level, and the cold water descends by way of the downtake pipe connected to the bottom header. The circulation is very positive and tends to confine the depositing of any sediment to the lower part of the bottom header, which is not exposed to heat and has a blow-off cock at its lowest point. The headers are provided with bolted covers, so that the tubes are readily accessible for cleaning or expanding. There are no stay tubes, the tubes being simply expanded into the pressed headers. The tube nest is supported by the curved pipes so that there is the fullest possible freedom for expansion. For cleaning the tubes externally a door is provided in the casing immediately above the bottom header. The drum can be completely cleaned internally through a manhole in the side.



Fraser vertical watertube boiler

The four sides of the furnace are bolted together, and the grate is rectangular in shape, all the firebars being of the same length. The firedoor and ashpit opening can be made the full width of the furnace, if desired, and there is ample depth between the grate and the underside of the tubes, so that a large proportional furnace volume is obtainable. For burning bagasse, the furnace would be extended in the front, as perhaps might be done if wood in long pieces was to be used as fuel. The furnace is also suitable for oil firing, and, should the boiler eventually be made in large sizes, it would lend itself very readily to the fitting of a mechanical stoker, or a step grate for burning sawdust or rice husk. The boiler could also be adapted for use as a waste-heat boiler.

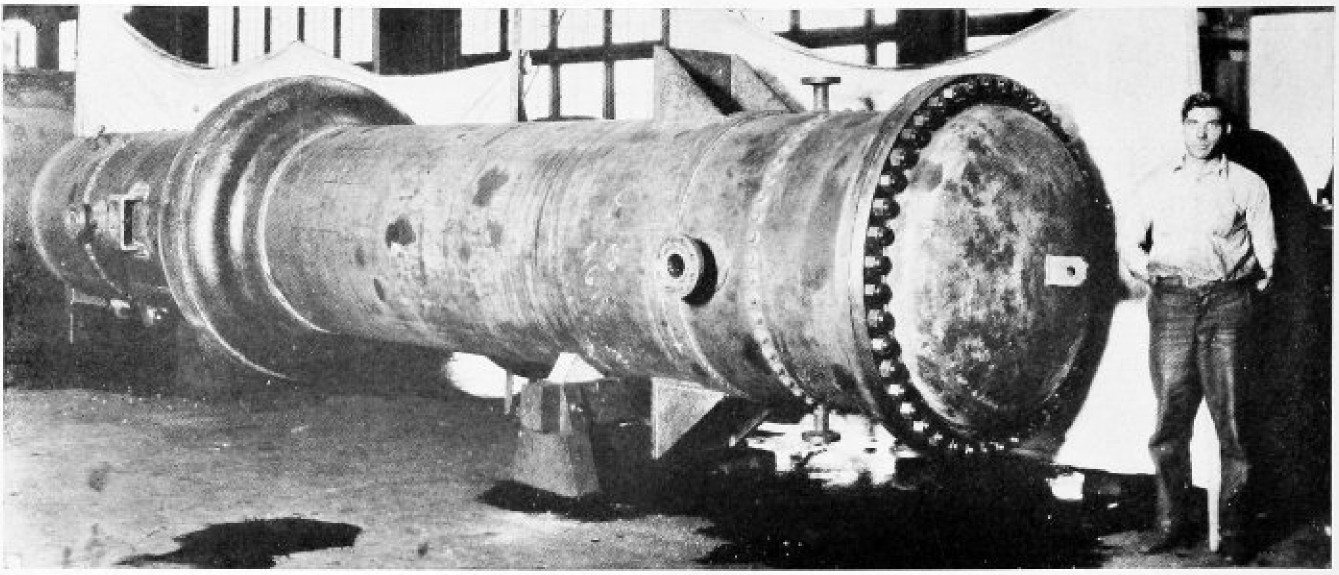
The furnace lining is formed with ordinary firebricks on a backing of asbestos millboard. The boiler can be dismantled easily and re-erected. This property, while greatly facilitating shipment, also makes the boiler very suitable for installation in basements and other confined spaces.

So far this boiler has only been made in one size, that is, with a drum 2 feet 6 inches in diameter. With the boiler initially standing cold, steam was raised to the working pressure of about 80 pounds per square inch in, roughly, half-an-hour from the lighting of the fire, without using a steam jet after steam was available. The headers, pipes and drum were not lagged, though they would be in a normal installation. The fitting of a superheater or feedwater heater in the triangular space above the tubes could be arranged.

This boiler has a total heating surface of 80 square feet, a grate area of 3 square feet, and is 7 feet high. The tubes are 1½ inches in external diameter. The chimney is 9 inches in diameter and 32 feet high. The boiler, when demonstrated, was situated in the open, was unlagged, and the weather was cold, the feed water being at 42 degrees F. With a working pressure of 80 pounds per square inch, and coal of a calorific value of about 11,000 British thermal units per pound, an evaporation of 450 pounds of water per hour was obtained. This was at the rate of 6 pounds of water per pound of coal and 5.625 pounds per square foot of heating surface from cold feed. The draft was 0.23 inch of water. On increasing this, by means of a steam jet, to 0.3 inch, the rate of evaporation became 530 pounds per hour. A further increase of draft, up to 0.5 inch, gave an evaporation rate of 600 pounds of water per hour.

As a matter of curiosity, the effect of 0.8 inch of draft was tried. This gave an evaporation of 1000 pounds per hour, but, as was to be expected, the thermal efficiency markedly decreased, and the uptake temperature was much too high. The upper part of the casing was remarkably cool and special attention was given to the lower part of the drum where the bottom seam was exposed to hot gases. The boiler did not suffer in any way under the heavy loads, and the tests were indicative of what might be done to meet an excessive temporary steam demand.

We are indebted to *Engineering* for the information and the illustration used in this article.



Preheater exchanger fabricated by a special shielded-arc welding process. This vessel operates at 200 pounds per square inch pressure and 750 degrees F.; it weighs 17 tons and when erected will be 29 feet in height

Arc Welding in 1931

*By J. F. Lincoln**

Every year since the late war finds the use of arc-welding gaining greater momentum in practically every industry. Regardless of the economic outlook for 1931, it is safe to say that this process will be applied more widely and more frequently than in any preceding year. There are several factors which determine the logic of this prophecy. Part of these factors lie within the development of the process and part are outside causes.

The development of electrodes during the past year for the welding of various steel alloys will bring about a much wider application of arc-welding and in turn permit a wider use of these alloy metals, particularly that of stainless steel and other corrosion-resisting metals.

Like any new process, arc-welding has met from time to time apparently insurmountable obstacles to its application. Refinements and developments of the process have always occurred to sweep such obstacles aside, thus opening new fields for the use of the process. Until lately the use of arc-welding was forbidden in general in the fabrication of pressure vessels and similar containers which come under the jurisdiction of insurance codes. This restriction is based on the former limits of weld strength and ductility. In cases where it was possible to obtain welds of the required physical characteristics the cost of production was almost prohibitive. By placing on the market a completely shielded arc process, which economically produces welds of 60,000 to 75,000 pounds per square inch tensile strength and having a ductility at least equal to that of rolled steel, the barrier which prevented the use of the electric arc in the fabrication of these pressure vessels was definitely removed. One of 20 preheater exchangers which are now being fabricated by this shielded arc process for oil refinery service is shown in the illustration. These pressure vessels are indicative of the type which constitute a new field recently opened for arc welding by the shielded arc process.

The introduction of this shielded arc process is revolutionizing the use of arc-welding in the fabrication of many products and the erection of many types of structures. The arc-welding of pipe lines will be greatly stimulated. Several large oil and gas carriers are even now under construction by this process.

Due to the greatly increased speed obtainable by the use of the shielded arc process, greater economies will be effected not only in the welding of pipe-line joints, but also in the fabrication of many products and structures. Since in 1931 production costs will more than ever before prove most essential in determining the progress of many businesses, those who are now using electric arc-welding should be cognizant of the economical as well as the physical advantages offered by the shielded arc.

Economic pressure will force manufacturers to redesign their metal products, not only to improve their service, but also to lower the manufacturing cost. This condition offers an incentive to many manufacturers to discard their traditional designs in order to give their products the advantages of arc-welded steel construction. Additional stimulus to the redesigning of metal products for arc-welded steel construction is provided by the Second Lincoln Arc Welding Prize Competition, which is offering 41 cash prizes totalling $17,500, to designers and engineers who show the greatest skill and ingenuity in applying the advantages of arc-welded construction to their designs.

As far back as 1914 the writer's company was advocating the replacement of cast iron by arc-welded steel construction. Each year since then an increasing number of manufacturers have realized the advantages obtained through this modern construction. It is safe to predict that during the next 12 months more manufacturers than ever before will improve their products and reduce their production costs and lower their inventory by redesigning their products for arc-welded steel instead of castings.

The current movements in the large cities against unnecessary noises will undoubtedly effect a greater use of arc-welding in the erection of buildings, but the progress of arc-welding in the structural field will not be solely accelerated by its quietness. More and more the architects, engineers and structural fabricators are realizing the economies which this process offers. The additional strength which the shielded arc process gives to arc-welded connections will undoubtedly allay the fears of the most conservative engineers as to the reliability of

* President, the Lincoln Electric Company, Cleveland, O.

this modern construction. It is significant that in one of the largest industrial plants now under construction some 200 arc-welded trusses will be used. Since more than 100 municipal building codes permit the erection of arc-welded structures, and since not a failure has occurred in the 100 arc-welded structures which have been erected to date, it is only logical to assume that more buildings erected during 1931 will receive the benefits of this modern construction.

Regardless of general economic conditions during 1931, we will continue to advance and improve, and in this progress arc-welding will play an increasingly important part. Just how far we progress depends in no small measure upon industry's intelligent use of electric arc-welding.

Blow-Off Muffler

An entirely new type of blow-off muffler that is a radical departure from the conventional types has recently been perfected by The Bird-Archer Company, Chicago. This muffler is made in the form of a separator and is mounted on top of the boiler. The separation of the steam and water is accomplished by the application of the centrifugal principle. The blow-down enters the cylindrical muffler tangentially. The water is thrown to the outside and drained off by gravity and delivered to the track. The steam is discharged vertically into the air much like the discharge of the pops, except that there is much less noise.

The advantages of this design lie in the perfect disposal of the blow-down with safety to all concerned. The steam is disposed of in such manner as to cause no obstruction to the enginemen's vision. There is no danger to switch crews riding on the footboards.

The design of this muffler provides free passage of the blow-down without any obstruction. There is nothing to clog up. Obviously, this muffler can cause no disturbance to the ballast nor trouble due to blowing cinders or sand into the journals. It is possible to blow the boiler at any time, regardless of wind or wayside conditions.

Bird-Archer blow-off muffler

Boiler Circulator

(Continued from page 33)

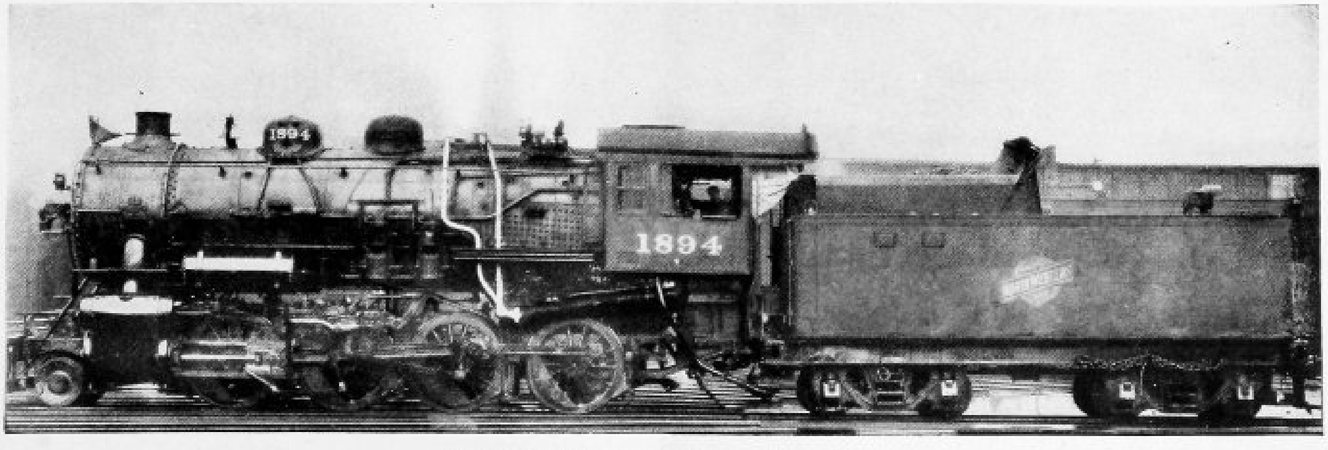
of the boiler, instead of upwards towards the steam space. The effect, the makers explain, is to prevent priming and to promote such a flow as will continuouslv draw the water from the lower and colder parts of the boiler over the hottest part of the furnace and to propel it longitudinally towards the back.

The circulator is secured to the furnace by means of specially constructed chains, securely anchored in position by means of stretching screws. If for any reason it is necessary to dismantle the circulator the work is quite simple and straightforward. As the circulator causes the bubbles to be washed over the surface of the plate, the rate of evaporation is increased by constantly allowing fresh water to come into contact with the heating surface, the principle being to remove the bubbles as fast as they form, with the result that more heat is transmitted through the boiler plates for the generation of steam.

As the work of fitting the circulator does not involve drilling or riveting, the strength of the boiler is in no way impaired. The apparatus is claimed to create a positive and rapid circulation of the whole body of water, and to maintain every particle of water at or near steam temperature.

New Catalogue

A unique catalogue published recently by Joseph T. Ryerson & Son, Inc., Chicago, includes practically every type of tool and portable machinery used in the metal-working field. Unlike most catalogues of this nature, all supplies are omitted, the book being devoted entirely to equipment for manufacturers, job shops and contractors.



Blow-off muffler installed on a locomotive

The Boiler Maker

VOLUME XXXI NUMBER 2

PUBLISHED Monthly by the Simmons-Boardman Publishing Company, 34 North Crystal Street, East Stroudsburg, Pa., with Executive Offices at 30 Church Street, New York City.

Chicago: 105 W. Adams Street. Washington, D. C.: 17th and H Streets, N. W. Cleveland: Terminal Tower. San Francisco, Cal.: 215 Market Street.

Subscription Price: United States, Canada and Mexico, $3.00; Foreign Countries, $4.00 a Year. Single Copies, 35 Cents.

Request for change of address should reach us on or before the 15th of the month preceding the issue with which it is to go into effect. It is difficult, and often impossible, to supply back numbers to replace those undelivered through failure to send advance notice. In sending us change of address, please be sure to send us your old address as well as the new one.

THE BOILER MAKER is a member of the Associated Business Papers, Inc. (A. B. P.), and the Audit Bureau of Circulation (A. B. C.)

EDITORIAL STAFF: H. H. Brown, Editor. L. S. Blodgett, Managing Editor. W. Lumbard, Associate Editor.

Contents

Communications

Fusible Plugs

TO THE EDITOR:

After reading the report of the boiler explosion of Reading Company locomotive 1705, killing seven employees and injuring ten others, my opinion is that this explosion would have been prevented if the boiler had been equipped with fusible plugs. The fusible plugs would have melted out of the engine before the crown sheet was hot enough to pull off of the radial stays; and the engine watchman or some one would have noticed steam blowing in the firebox.

I have been inspecting locomotive boilers for 17 years, and have found several locomotives in the round house with fusible plugs melted out and no damage done; and I have seen locomotives pulled in with fusible plugs melted out on the road, with no damage except a crown sheet burned at the front end and the top row of flues leaking.

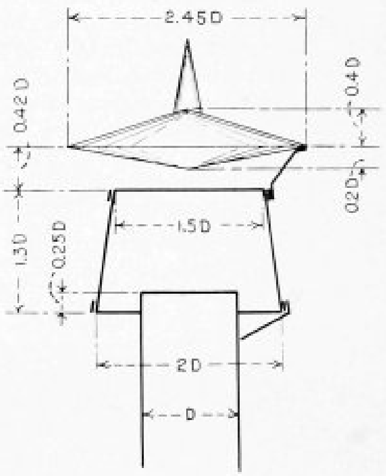
However, on a large locomotive fitted with a combustion chambers and brick arch, with the engine working hard on a heavy grade, I think that a fusible plug could melt out, because of low water, and the fireman or engineer not notice it until damage had been done.

Helper, Utah. J. G. SIMONSON.

Smokestack Hood

TO THE EDITOR:

In the issue of THE BOILER MAKER for July, 1930, I noticed in the Questions and Answers department on page 209, the inquiry on the theory of a smokestack hood. I am familiar with this type of deflector, which is



A typical smokestack hood

used to keep out rain and snow as well as for forcing the draft.

In the illustration, showing a typical smokestack hood all dimensions are given in multiples of the diameter of the smokestack. The hood is constructed of thick roof-iron plate. This hood is very useful for a smokestack of a diameter up to $1\frac{1}{2}$ feet. The hood comprises two connected cones, and a frustum of a cone open at the top and another at the bottom. These two parts are fastened to the smokestack by three or four flat-iron bitts.

Helsingfors, Finland. N. GOULJAEFF, M. E.

Thickness of Material

TO THE EDITOR:

We must all agree with J. H. Mondirk's praise of THE BOILER MAKER, as given in the December issue. Also we note his remarks pertaining to the showing of the thickness of material in layouts and the figuring thereof. I myself was unable to get the "dope" on that for quite a while, until studying carefully various articles given in *Motive Power*, the forerunner of THE BOILER MAKER. I grasped the fact that most all plans and elevations were drawn to the neutral diameter of material used. Probably Brother Mondirk's friends to whom he passes on his copy have missed that item.

It is well to have a clear understanding of the importance of using the neutral line in plans for the development of patterns. So to make it clear, we find Fig. 1 representing the outside diameter of a cylinder, made of

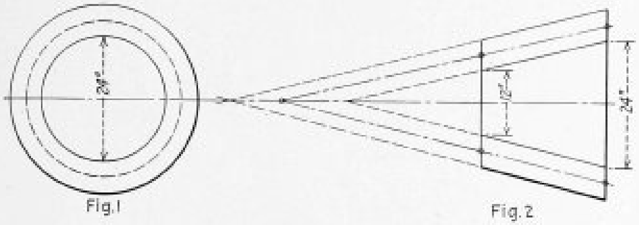


Diagram for finding neutral diameter

½-inch material, with an inside diameter of 24 inches. For the sake of clearness, we have exaggerated the thickness of material. The dotted inner circle represents the neutral diameter and that is the diameter we figure by, so all you have to remember is this: For an inside diameter, say of 24 inches we will just figure for a 24½-inch diameter. In other words, to the specified inside diameter just add the thickness of material used and thus get your circumference to the seam line.

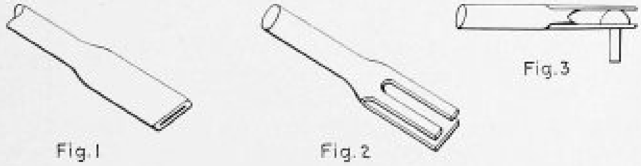
To more clearly illustrate the importance of the neutral line, we show in Fig. 2 the frustum of a cone, drawn with the same thickness of material as in Fig. 1. The radius lines for outside and inside diameter are drawn to show the difference it would make in the pattern if we used either one of those radii, when we should use only the neutral line which is marked *0-0-0*.

I shall be glad to be of assistance to any of Mr. Mondirk's friends inasmuch as I am able along this line; but why not get them to subscribe to The Boiler Maker, thus insuring that they will promptly benefit thereby.

Lorain, O. Joseph Smith.

Spring Tongs

James Wilson, of Montreal, Canada, contributes the accompanying sketch of a cheap and easily made pair of spring tongs which are light in weight and handy for putting hot rivets in small places which cannot be easily reached with ordinary rivet tongs. Made from a piece



Scrap steel pipe used for rivet tongs

of scrap steel pipe with the aid of a drill and a hack saw, this handy tool should find a place in any boiler shop.

In making these tongs a piece of pipe is flattened at one end as shown in Fig. 1. It is then cut at the sides of the flattened portion and the flattened pieces separated a distance equal to the depth of rivet head. One of the flat pieces is drilled and slotted with a slot slightly larger than the rivet shank as shown in Fig. 2. The tong is then complete.

In service the hot rivet is thrown on the ground, the prongs forced over the rivet and caught as shown in Fig. 3. In this position the rivet may be inserted easily into the hole.

Business Notes

The Reading Iron Company, Reading, Pa., has announced the appointment of F. W. Deppe, formerly district sales representative at St. Louis, Mo. as general manager of sales with offices at 230 Park Avenue, New York, N. Y.

Arthur W. Willcuts, assistant sales manager of the railroad division of Joseph T. Ryerson & Son, Inc., Chicago, Ill., died December 14, at St. Louis, Mo. At the time of his death, Mr. Willcuts was playing golf with several friends at the Woodlawn Country Club. He was born January 14, 1882, at Marion, Ind., and later moved to Indianapolis where he joined Joseph T. Ryerson & Son, Inc. He was transferred to Detroit for a short time and then to St. Louis where he had resided during the last ten years.

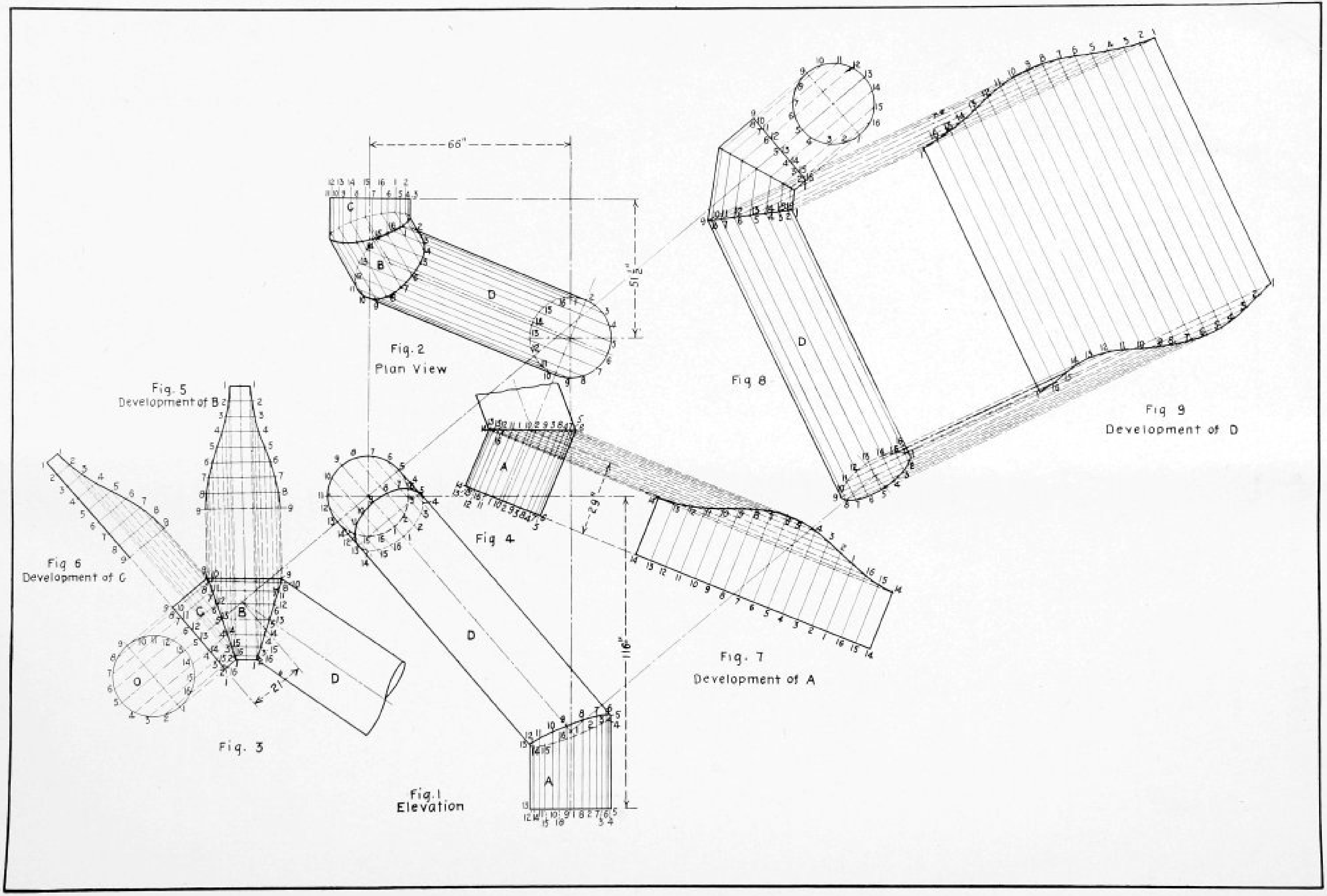
The Globe Steel Tubes Company, Milwaukee, Wis., who has manufactured seamless steel tubing for over 20 years, has organized a subsidiary to be known as the Globe Stainless Tube Company. This new organization will carry on a business of engineering, designing, and manufacturing stainless steel tubes and tubular installations for corrosion and heat resisting purposes. The principal officers of the new company will be the same as of the parent company, and sales will be handled through the same sales offices in principal cities.

Claus Greve was elected chairman of the board and L. W. Greve and John DeMooy were named president and treasurer respectively of the Cleveland Pneumatic Tool Company, Cleveland, O., at the recent annual meeting of the board of directors. Heretofore Claus Greve has been president and his son, L. W. Greve, has been treasurer of the company which was founded in 1899 by the former and which now ranks as one of the largest American manufacturers of pneumatic tools and machinery.

H. W. Foster was re-elected as vice-president, H. S. Covey was re-elected as secretary and Arthur Scott was re-elected as superintendent by the directors. A. F. Barner was named assistant secretary. All the directors, including S. G. Down of Pittsburgh, were re-elected. Those named above, excluding Mr. Barner, constitute the directorate.

Joseph T. Ryerson & Son, Inc., Chicago, on January 1, acquired the lines of maximillers, production millers and automatic indexing machines heretofore produced by Kempsmith Manufacturing Company, Milwaukee, Wis. The transfer involves outright purchase of good will, patents, patterns, inventory and other assets pertaining to these lines. The cone-drive milling machines produced by the Kempsmith Company are not involved in the transaction.

The Ryerson Company will act as general distributors of the line, direct the sales policy and furnish, through a special engineering staff, including Walter Mickelson, formerly associated with Kempsmith, the necessary services to the trade and support to its local sales agencies in the active promotion of these machine tools. The acquisition of the milling machine line rounds out the group of machine tools which the Ryerson machinery division is handling.



Method of developing pipe for vapor line

Questions and Answers Pertaining to Boilers

This department is maintained for the purpose of helping those who desire assistance on practical boiler shop problems. Inquiries should bear the name and address of the writer. Anonymous communications will not be considered. The identity of the writer, however, will not be disclosed unless the editor is given special permission to do so.

By George M. Davies

Layout of Pipe With Double Elbow

Q.—I would like to have the correct method for laying out such a pipe as is indicated in the drawing. This was made from a piece of 30-inch O. D. pipe. The sketch referred to above represents a vapor line from still to tower in a refinery.—J. H. M.

A.—The sketch of the pipe as submitted with the question shows an expansion joint in the lower member. I have not attempted to show a development of this expansion joint as there was insufficient information on the sketch to do so but have developed the pipe as though the expansion joint were omitted.

To develop a pipe of this type it is only necessary to obtain a view or projection of each section of the pipe, where all the surface lines are in their true lengths and in definite relation to each adjoining section. The development shown, can, with this thought in mind, be more readily followed.

Fig. 1 shows the elevation and Fig. 2 the plan view of the pipe. Figs. 3 and 4 show the projected views of the top and bottom sections of the pipe. These views are in their true length and sufficient information is given on the sketch to lay them out as shown.

To develop sections *B* and *C*, extend the center line of section *C* and with a diameter equal to the diameter of the pipe draw a circle, divide this circle into any number of equal parts, 16 being taken in this case. Number these points from *1* to *16* as shown, project these points into sections *C* and *B* and number the points as shown.

The developments of section *B* and *C* are shown in Figs. 5 and 6. The horizontal distances between the points 1-2, 2-3, 3-4, etc, being taken equal to the equal spaces into which the circle in Fig. 3 was divided. The patterns are completed by projecting the points as shown. Each development representing one half of the completed development of the section.

The next step is to project the points of section *C* and *B* into the elevation, completing the top section of the elevation. Then project the points into the plan view as shown, completing the plan view, care being taken to keep each point in its proper location. Project each of the points from the plan view into Fig. 4 as shown.

Then project the points *1* to *16* in section *A* of the plan down into the elevation and with the corresponding vertical heights taken from Fig. 4 complete the lower section of the pipe in the elevation, completing the elevation.

Next project Fig. 8 from the elevation Fig. 1. The center line of section *D*, Fig. 8, being parallel to the center line of section *D*, Fig. 1. The surface lines of section *D*, Fig. 8, are in their true length.

The development of section *D* is shown in Fig. 9, and is obtained in like manner as outlined for sections *B* and *C*, except that it is a complete development of section *D*.

The development for section *A* is shown in Fig. 7 and is also obtained in the same manner as outlined for sections *B* and *C* except that it is a complete development of section *A*.

Working Strength of Manhole Cover

Q.—We are desirous of knowing what working steam pressure a steel manhole cover, 11 inches by 15 inches by ½-inch thick, will stand. We would like, if possible, in your answer your formula for this figuring so that it can be applied to other thicknesses as well. F. E. M.

A.—There is not sufficient information given in the question to determine the working steam pressure the manhole cover is good for.

Exact formulas for finding the bending moments of flat plates supported along their edges and subject to stresses created by pressures normal to their surfaces have not been determined. The formulas given by different authorities are founded on assumptions and should be considered as approximations only; they should be used with caution, as the results obtained are not likely to be very accurate.

Elliptical plates supported at the periphery and distributed load may be figured by the formula:

$$P = \frac{s \times t \times (1 + c^2)}{2 \times K_1 \times b^2}$$

where

P = load per unit area, pounds per square inch.
t = thickness of plate, inches.
$2a$ = major axis in inches.
$2b$ = minor axis in inches.
$c = \frac{b}{a}$.
s = maximum stress, pounds per square inch.
K_1 = For mild steel 0.42 (fixed) to 0.71 (freely supported).
K_1 = For cast iron 0.67 (fixed) to 1.13 (freely supported).

Rectangular plates supported at the periphery and subjected to a uniformly distributed load are calculated by the formula:

$$P = \frac{s \times t \times (1 + c^2)}{2 \times K_1 \times \frac{b}{2}}$$

where

P = load per unit area, pounds per square inch.
t = thickness of plate in inches.
a = length in inches.
b = width in inches.
$c = \frac{b}{a}$.
s = maximum allowable stress, pounds per square inch.
K_1 For mild steel 0.48 (fixed) to 0.72 (freely supported).

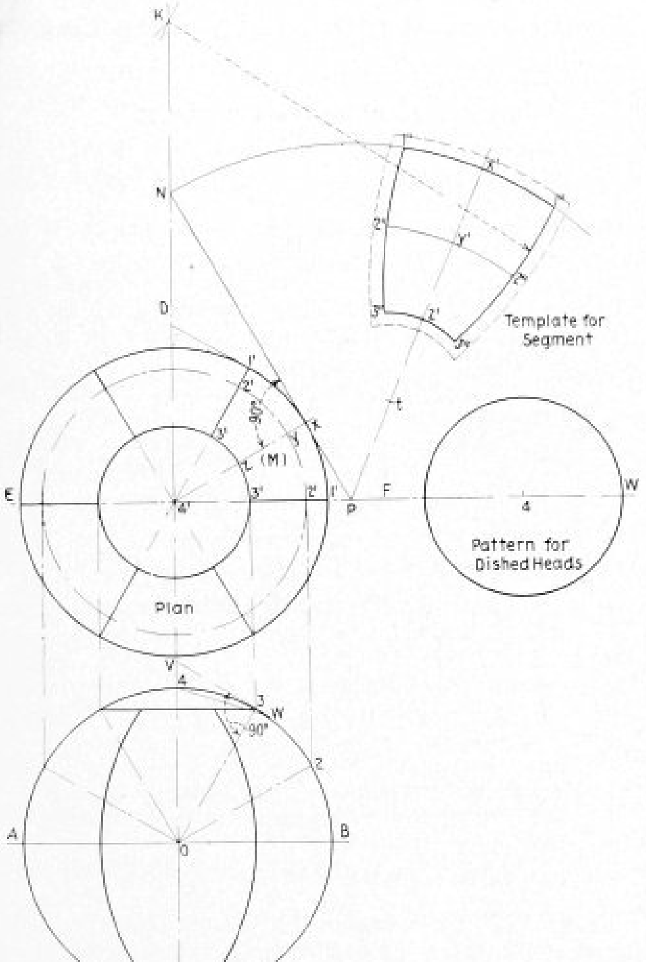
K_1 For cast iron 0.75 (fixed) to 1.13 (freely supported).

The values of K_1 are dependent upon the method of support and upon the initial force required to give a tight joint (to prevent leakage) before the load is applied.

Layout of a Sphere

Q.—Kindly send me a complete description on how to lay out the shell of a sphere in six equal parts the shape of which would be roughly rectangular instead of being shaped like a piece of an orange peel. T. M. P.

A.—I do not believe it is possible to develop a sphere, with any degree of accuracy, with such a limited number of sections and in the manner outlined in the question. I am therefore offering the following solution which,



A simple method of laying out a sphere

although not exactly the same as requested, is a practical solution to this problem.

The development of a spherical head is accomplished by making a template of one of the gores or segments and duplicating this the required number of times to complete the sphere.

The first step is to lay off the center lines *A-B*, *C-D*, and *E-F* for the plan and elevation. With the point *O* in the elevation as a center, describe a circle with a radius taken from the center of the sphere to the neutral thickness of the metal. Draw a corresponding circle in the plan view.

The line *A-B* divides the elevation into two symmetrical halves, thus a development of the top half of the elevation, duplicated, will form a complete sphere.

Divide the circle in the plan into any number of equal parts, in this case six. Now consider only one of these segments as at *M* shown within the points *1'-3'-3'-1'* of which a pattern will be developed for a template.

Divide the arc *1-4* of the elevation into three equal parts. Number the division *1, 2, 3, 4* as shown. Parallel to the line *C-D* and through the points *2* and *3* draw lines cutting the line *E-F* at *2'* and *3'*. With *4'-3'* of the plan as a radius and with *4'* as a center, scribe a circle. With *4'-2'* of the plan as a radius and with *4'* as a center, scribe another circle.

Bisect the angle *1'-4'-1'* of the plan by drawing the line *4'-x*. At right angles to the radial line, *4'-x*, draw line *N-P* tangent to the circle at *x*. Extend line *N-P* to cut line *E-F* at *P* and *C-D* at *N*. With *N-P* as a radius describe the arc *x'N*, and from point *P* draw a straight line *P-X'* in any convenient position.

From point *X'* lay off the arc lengths *1-2* and *2-3* of the elevation on *P-X'*, thus locating the points *Y'* and *Z'*. Make the distance *Z'-t* equal to the length of line *3-V* of the elevation. This line is tangent to the circle at the point *3* and is drawn at right angles to the radial line *0-3*.

With the point *P* in the plan as a center and *P-Y'* as a radius, draw an arc through point *Y'*. With *t* as a center and *t-Z'* as a radius, draw an arc through *Z'*, making both arcs of indefinite length.

Next, transfer the arc lengths *1'-1'*, *2'-2'* and *3'-3'* of the plan to the pattern at *1"-1"*, *2"-2"* and *3"-3"*. These lengths may be laid off with a traveling or measuring wheel.

Now determine a center, as at *k*, from which an arc can be drawn through the points *1'*, *2'* and *3'* in the pattern. From this center also draw arcs for the outside edge of the cap. The segments are then raised or bumped to the required curvature of the head. If heavy plates are used, they should be heated before shaping the segments to form.

A circular dished head is used for the purpose of forming the segments. Blanks for heads of this kind are easily laid off, the radius being equal practically to the distance between points *4* and *W* of the elevation. The arc distance *3-W*, is the lap of the head over the small ends of the gores.

Since this solution does not answer the question as stated, it is possible that some of our readers could supply the correct layout of this problem.

Effect of Oxy-Acetylene Burning

Q.—I have certainly received a great deal of help and information from your work. Am submitting a question which I hope you will answer.

Does the practice of burning a hole with an acetylene and oxygen torch injure the metal? For example: A hole 3 inches in diameter is burned in a wrapper sheet for installation of a sludge remover pipe which is welded in by the electric-arc method. Will the high temperature of the flame or the action that might be caused by the acetylene gas and oxygen do any damage? C. J. W.

A—In cutting holes with the acetylene and oxygen torch, the heat is applied locally and is intense only at the point where the cutting takes place; for this reason the heat does not penetrate or injure the metal to any great extent.

Burning a hole in the wrapper sheet where the sheet is supported by staybolts is permissible; however, the hole should either be reamed out or chipped clean before welding in the sludge remover pipe.

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States and Cities That Have Adopted the A.S.M.E. Boiler Code

States

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California	New Jersey	Utah
Delaware	New York	Washington
Indiana	Ohio	Wisconsin
Maryland	Oklahoma	District of Columbia
Michigan	Oregon	Panama Canal Zone
Minnesota	Pennsylvania	Territory of Hawaii

Cities

Chicago, Ill.	St. Joseph, Mo.	Memphis, Tenn.
Detroit, Mich.	St. Louis, Mo.	Nashville, Tenn.
Erie, Pa.	Scranton, Pa.	Omaha, Neb.
Kansas City, Mo.	Seattle, Wash.	Parkersburg, W. Va.
Los Angeles, Cal.	Tampa, Fla.	Philadelphia, Pa.
	Evanston, Ill.	

States and Cities Accepting Stamp of the National Board of Boiler and Pressure Vessel Inspectors

States

Arkansas	Missouri	Pennsylvania
California	New Jersey	Rhode Island
Delaware	New York	Utah
Indiana	Ohio	Washington
Maryland	Oklahoma	Wisconsin
Minnesota	Oregon	

Cities

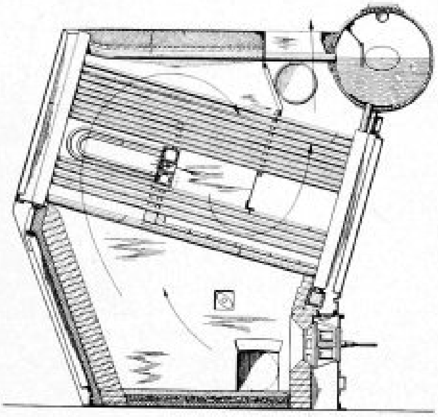
Chicago, Ill.	St. Louis, Mo.	Nashville, Tenn.
Kansas City, Mo.	Scranton, Pa.	Omaha, Neb.
Memphis, Tenn.	Seattle, Wash.	Parkersburg, W. Va.
Erie, Pa.	Tampa, Fla.	Philadelphia, Pa.

Selected Boiler Patents

Compiled by Dwight B. Galt, Patent Attorney, Washington Loan and Trust Building, Washington, D. C. Readers wishing copies of patents or any further information regarding any patent described, should correspond directly with Mr. Galt.

1,737,809. BOILER AND SUPERHEATER HAVING REPLACEABLE TUBES. THOMAS B. STILLMAN, OF SOUTH ORANGE, N. J., ASSIGNOR TO THE BABCOCK & WILCOX COMPANY, OF BAYONNE, N. J., A CORPORATION OF NEW JERSEY.

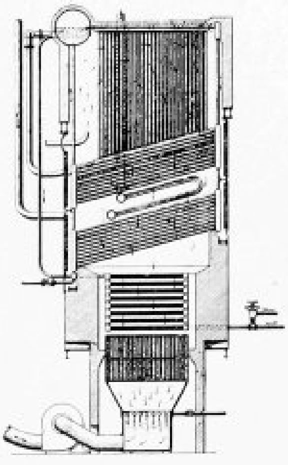
Claim.—In a steam boiler, spaced banks of watertubes connected at their ends to headers extending across the space between the banks, a superheater located in the space between the banks and comprising headers extending transversely of said boiler tubes and spaced apart and each dis-



posed adjacent one of said banks, removable panels for closing the space between said headers, U-tubes connected to said headers and divided into spaced groups, the distance between any two adjacent groups being greater than the diameter of the tubes, the spaces between the groups permitting a tube to be turned therein, whereby an individual tube may be removed from or inserted in position in the superheater through the space enclosed by said U-tubes and through an opening formed by removing a panel. Three claims.

1,725,798. STEAM BOILER. HERMAN C. HEATON, OF CHICAGO, ILLINOIS, ASSIGNOR TO THE BABCOCK & WILCOX COMPANY, OF BAYONNE, NEW JERSEY, A CORPORATION OF NEW JERSEY.

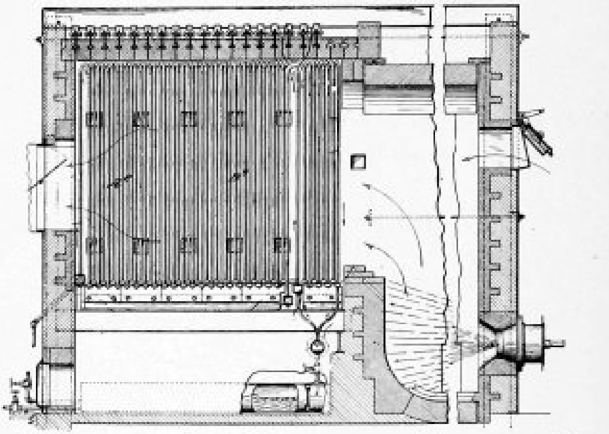
Claim.—A boiler having a bank of inclined water-tubes, uptake and downtake water chambers connecting the ends of said tubes, an upper steam and water drum above and spaced from said bank, a row of vertically disposed tubes connecting the tops of said downtake chambers with said drum, a row of horizontally disposed tubes connected to said drum, a row of vertically disposed tubes connecting the tops of the uptake water chambers with the ends of the tubes of said horizontal row, a row of vertically disposed tubes at each side of said row of horizontally disposed tubes and connections with said vertically disposed tubes and said drum affording



a circulation through said vertically disposed tubes, said bank and said rows of tubes forming a combustion chamber, and a finely-divided fuel supplying mechanism having an upwardly directed nozzle projecting through one of said rows of vertically disposed tubes and projecting the fuel upwardly at one side of said chamber, the gas outlet for the chamber being positioned beneath said bank. Four claims.

1,741,701. SERIES BOILER. DAVID S. JACOBUS, OF JERSEY CITY, N. J., ASSIGNOR TO THE BABCOCK & WILCOX COMPANY, OF BAYONNE, N. J., A CORPORATION OF NEW JERSEY.

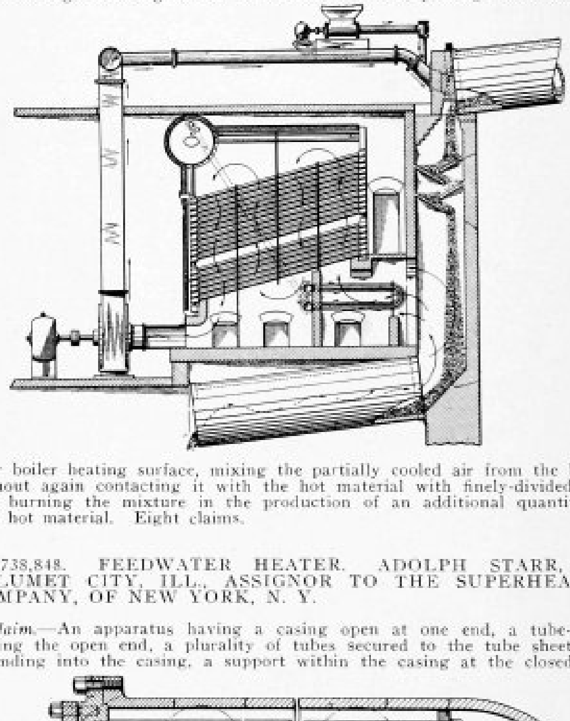
Claim.—In a fluid heater, a series of substantially parallel fluid-containing compartments and return tubes having their ends connected thereto,



successive tubes connected to a given compartment being connected alternately to adjacent compartments on opposite sides of the given compartment, the planes of successive tubes making an angle with each other, and means for directing hot gases over said tubes. Eleven claims.

1,741,663. METHOD AND APPARATUS FOR UTILIZING WASTE HEAT. HERMAN B. SMITH, OF PLAINFIELD, N. J., ASSIGNOR TO THE BABCOCK & WILCOX COMPANY, OF BAYONNE, N. J., A CORPORATION OF NEW JERSEY.

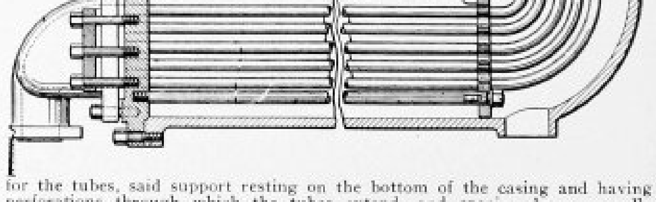
Claim.—The method of reclaiming heat from hot divided solid non-combustible material comprising the steps of heating air by moving the same through a falling stream of the hot material, passing the heated air



over boiler heating surface, mixing the partially cooled air from the boiler without again contacting it with the hot material with finely-divided fuel and burning the mixture in the production of an additional quantity of said hot material. Eight claims.

1,738,848. FEEDWATER HEATER. ADOLPH STARR, OF CALUMET CITY, ILL., ASSIGNOR TO THE SUPERHEATER COMPANY, OF NEW YORK, N. Y.

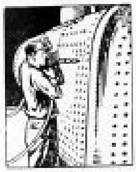
Claim.—An apparatus having a casing open at one end, a tube-sheet closing the open end, a plurality of tubes secured to the tube sheet and extending into the casing, a support within the casing at the closed end



for the tubes, said support resting on the bottom of the casing and having perforations through which the tubes extend, and spacing bars normally keeping the support in position, the support perforations being large enough so the support can be slipped along the tubes to the tube sheet when the connections between the support and spacing bars are released. Four claims.

The Boiler Maker

Reg. U. S. Pat. Off.



Locomotive Boiler Practice

Through the courtesy of several of the larger railroad systems in the United States and Canada, the standards of locomotive boiler inspection and maintenance practice, which they have developed, have been made available for publication. The first article prepared from this material, covering certain of the Erie Railroad Company's methods, appears in this issue.

In certain fundamentals the standards of the railroads are similar, based as they are on requirements of the Bureau of Locomotive Inspection, Interstate Commerce Commission. The methods employed to meet the maintenance needs of different classes of power, varying service demands, diverse water conditions, necessarily must follow quite different lines. In addition, the standards of method vary considerably because of the great difference in facilities available.

This series of articles will continue for several months, it being the object to present the representative boiler practice of railroads in all parts of the country. If our readers will compare the methods of carrying out boiler repairs in other shops, with their own, beneficial changes may suggest themselves, which will make certain operations simpler or reduce their cost. If there are any points on which further explanation would be desirable, or comments on any of the methods, write to us about them.

Master Boiler Makers

As most of our readers already know, the annual meeting of the Master Boiler Makers' Association for 1931 has been definitely canceled, in conformity with the request of the American Railway Association, Mechanical Division, that railroad associations' meetings be curtailed for the year. This action inevitably will disrupt the progress of the association, unless its members co-operate with the officers to maintain interest in its work. In this connection it is understood that committee reports will be published and distributed for discussion. After sufficient time has elapsed for the careful consideration of the reports, the comments of members will be combined with them in a book which will take the place of the customary convention proceedings.

If this procedure is followed and the same care in preparing reports and subsequent discussion observed, the work of the association can be renewed at the 1932 convention without any break in the continuity of effort having occurred. If the association is to function efficiently in the future, every member should do his utmost to overcome the handicaps which the present conditions have made necessary.

Without the opportunity this year for member companies of the Supply Men's Association to present their products for examination and study by the master boiler makers of the country, some other procedure must be followed to inform the industry of developments being made in this field. To both associations, The Boiler Maker offers its pages for the presentation of all information pertaining to their work, as would ordinarily be the case if the convention were held.

It is our earnest desire that advantage be taken of this offer and the suggestion is made that supply companies forward descriptions of any new products adapted to use in the boiler shops, and details of processes or procedure methods developed for carrying out boiler construction or repairs.

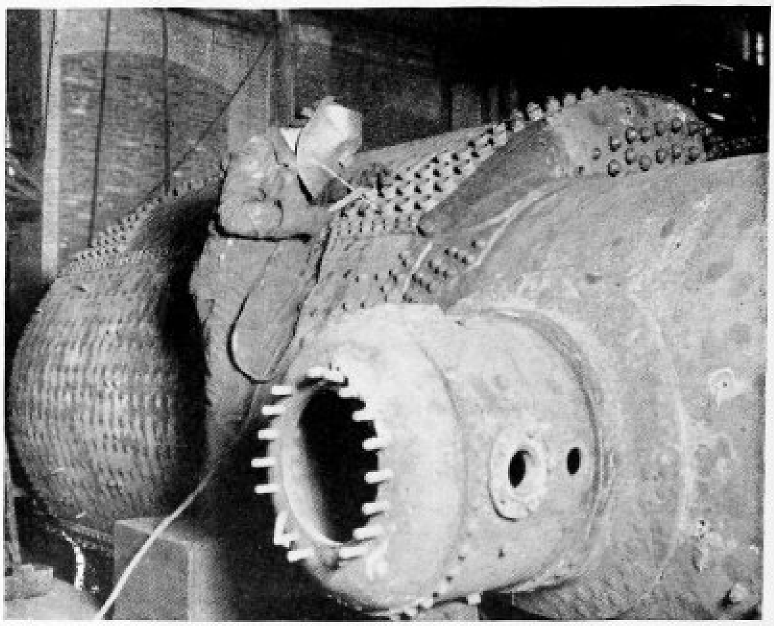
Welding Code

For the benefit of readers wishing to approve or comment on provisions of the proposed specifications for fusion welding prepared by the American Society of Mechanical Engineers, Boiler Code Committee in conjunction with the American Welding Society, revisions to the Code now under consideration are given in this issue. The changes indicated are to be incorporated in the Code for Unfired Pressure Vessels, and in the Code for Power Boilers. Communications should be in the hands of the secretary of the committee at 29 West 39th street, New York, not later than April 6.

Conical Shapes

One of our readers has requested information concerning the subject of fabricating conical shapes from boiler plate up to ⅝-inch thickness for use particularly in tank construction. He states that he is called upon at times to produce cone tops or bottoms on welded tanks. These cones range from 30 inches to 120 inches inside diameter and have depths from 20 inches to 60 inches. At present he is producing the cones on hydraulic presses or bending rolls and is particularly desirous of obtaining any short cuts to this problem.

It is quite possible that some of our readers have also been confronted with this problem and may have worked out good methods for this type of fabrication. We will be glad to receive solutions to this problem.



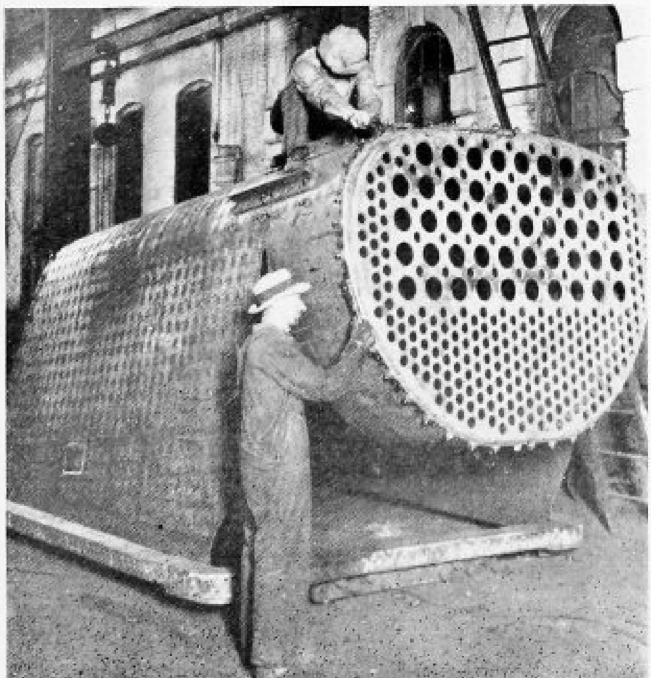
Erie Railroad

Standards of

Locomotive Boiler Practice

In the following article various instructions are outlined for the inspection and repair of locomotive boilers which have been developed by the mechanical department of the Erie Railroad Company for use in all its shops. The first installment will cover inspection, firebox work, flue practice and staybolting. Further articles will appear in a later issue. The instructions follow:

Boiler Inspection, Interior: Whenever a sufficient number of flues are removed to allow examination, but at least after not more than 48 calendar months' service within five consecutive years, the entire interior of the boiler must be examined for cracks, pitting, grooving or indications of overheating and for damage where mud has collected or heavy scale formed. The edges of plates, all laps, seams and points where cracks and defects are likely to develop or which an exterior examination may have indicated, must be given an especially minute examination. It must be seen that braces and stays are taut, that pins are properly secured in place and that each is in condition to support its proportion of the load.



All boilers must be thoroughly scaled and washed before applying flues in order to permit this interior inspection.

Boiler Inspection, Exterior: The exterior of every boiler shall be thoroughly inspected under hydrostatic pressure whenever the jacket and the lagging are removed. This inspection must be made after not more than 60 calendar months service within six consecutive years.

When boilers have had lagging removed for exterior inspection or firebox repairs at time of classified repairs it is required that they be thoroughly cleaned and given a coat of freight car paint on the outside after work is completed.

Boiler Testing: Every boiler before being put into service and at least once after 12 calendar months service within two consecutive years, shall be subjected to a hydrostatic pressure, 25 percent above the working steam pressure.

The dome cap must be removed following the hydrotatic test and the interior surface and connections of the boiler examined as thoroughly as conditions will permit. If necessary in order to enter the boiler, the throttle standpipe must be removed. Boilers of H-4 locomotives, or other classes that cannot be entered without the removal of dry pipe and steam pipes, shall have inspection made as far as conditions will permit, and notation made on the margin of the report, stating that "dome cap and standpipe were removed and interior inspection made as far as conditions would permit."

Boiler Alteration Reports: When any repairs or changes are made, which affect the data shown on the boiler specification card filed with the Interstate Commerce Commission, an alteration report form 2878 B. U. S., properly certified giving details of such changes, must be filed with the Commission within 30 days from the date of their completion. Alteration reports should cover:

(a) Application of new barrel sheets or domes.
(b) Application of patches to barrels or domes of boilers or to portion of wrapper sheet of crown bar boilers, which is not supported by staybolts.
(c) Longitudinal seam reinforcements.
(d) Changes in size or number of braces, giving maximum stress.
(e) Initial application of superheaters, brick arch or water bar tubes, giving number and dimensions of tubes.
(f) Change in the size of arch tubes or permanent removal of arch tubes, with drawings accompanying the alteration report, illustrating the manner in which arch tube and arch tube cover holes were plugged and stayed.
(g) Changes in number or capacity of safety valves.
(h) Changes in the size, number or length of boiler flues.
(i) Increase or lowering of steam pressure.

Report of patches should be accompanied by drawing or blue print of the patch, showing its location in regard to the center line of the boiler (giving all necessary dimensions, and showing the nature and location of the defect).

Patches (Longitudinal Seams): When it is required that a patch extend from one circumferential seam to another, the thickness of the plate shall be the same as the shell sheet and the size and spacing of the rivets and thickness of welt plates in the patch shall be the same as the original longitudinal seam, in that course of the shell.

The section removed shall extend to the original longitudinal seam in one direction, so that no more than two longitudinal seams shall exist in any one course.

Patches (Circumferential Seams): Fig. 4 illustrates 4 typical diamond-shaped patches applied to boiler shells at or adjacent to circumferential seams, to cover pitted or corroded sheets. Directions for laying out such patches should be carefully followed to obviate destroying the original efficiency of the boiler.

In case it becomes necessary to apply a horizontal row of rivets to any shell patch, the spacing of the rivets must coincide with the spacing and size of the rivets in the longitudinal seam, and welt plates applied of the same thickness both inside and outside.

This cut also illustrates a typical boiler check patch for cast steel boiler check and standard boiler check which will be found generally applicable.

Pencil sketches of all patches, other than those described, indicating the location and extent of the defect, shall be submitted to the mechanical engineer for approval before proceeding with the work.

Punching Boiler and Firebox Plates: All holes punched in boiler and firebox plates should be punched $\frac{1}{16}$ inch small and reamed to size after sheets are properly bolted together.

Whenever holes are drilled, they should be drilled full size and not reamed unless holes fail to match up.

Application of New Sheets to Boilers and Fireboxes: Whenever a boiler, either locomotive or stationary, requires new sheets or part sheets, it is required that a special form be made out showing all the information required. If new boilers are built at the company shops, or at the locomotive works, the same form must be filled out; being sent in from the locomotive works by the railroad chief inspector.

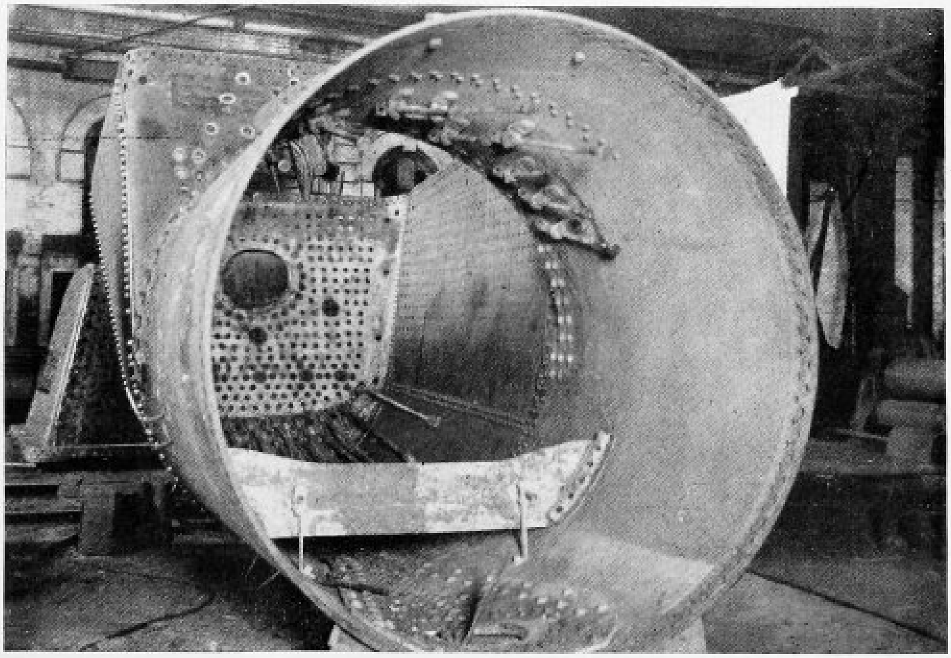
This form is also to be made out for each boiler receiving any new sheets and must be forwarded to the chief mechanical engineer, Meadville, Pa., at the end of the month in which the engine leaves the shop.

Flues, Application: All burrs and scale must be removed from flue holes, front and back flue sheets and if holes are more than $\frac{1}{16}$ inch out of round, they must be reamed true. Flue holes, however, must not be reamed more than $\frac{1}{8}$ inch over size.

Copper ferrules 0.075 M.M. gage, $\frac{1}{16}$ to $\frac{1}{8}$ inch wider than the thickness of the flue sheet are to be fastened in the back flue sheet with sectional expanders; the ferrule to be flush with the sheet on the fire side.

Flues are to be swedged $\frac{1}{8}$ inch smaller than tube

Fig. 1.—(Upper left) Electric arc welding a set of flexible staybolt sleeves. Fig. 2.—(Lower left) Bolting up a combustion chamber flue sheet during the firebox assembly operations. Fig. 3.—(Right) Boiler in position to receive the firebox assembly



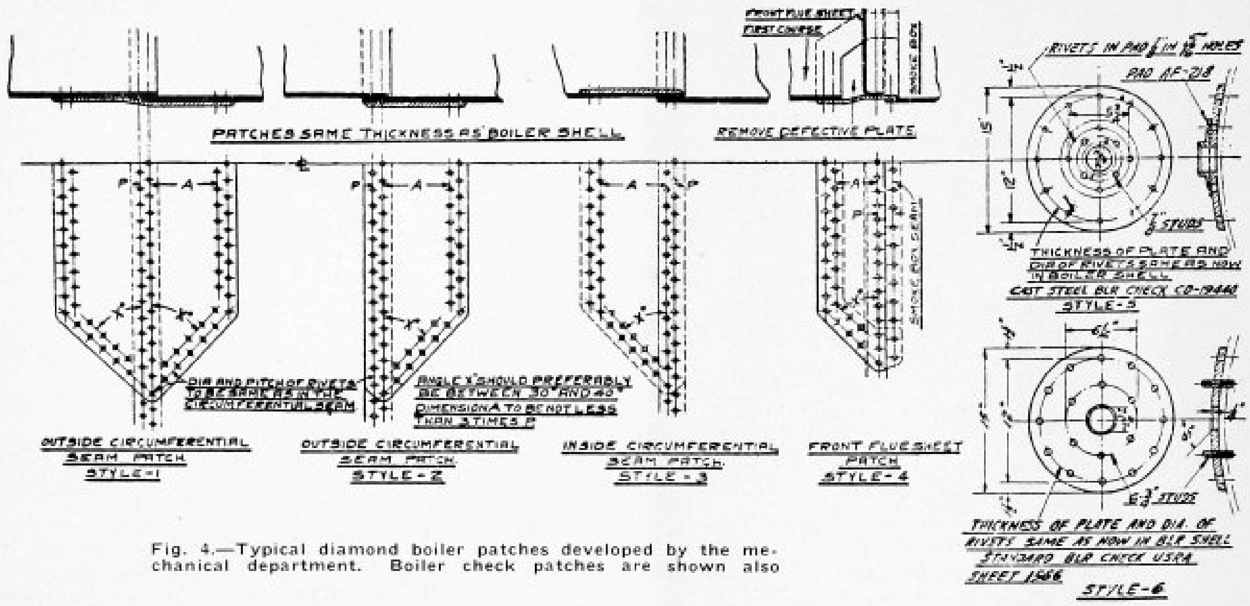


Fig. 4.—Typical diamond boiler patches developed by the mechanical department. Boiler check patches are shown also

diameter for tubes and 1 inch smaller for superheater flues and the scale either filed or ground off the swedge. All flues must be subjected to a hydrostatic test pressure of 250 pounds per square inch or to 90 to 100 pounds air pressure while immersed in water before being applied to the boiler.

In applying, they should be driven through the sheets ¼ inch for superheater flues and $\frac{3}{16}$ inch for all others; rolled tight with standard roller expanders, and at the back flue sheet prosser expanded with standard prosser tool and finally beaded with standard beading tool.

Flues should be prossered by driving in at least twice and turning the expander a distance equal to one-half the width of a section. Bridges of flue sheets should be watched in prossering to avoid overstrain. When flue beads after service are away from the flue sheet, they should be beaded to the sheet and the burr, which forms from constant use of the beading tool, trimmed off.

Flues are to be opened to fit holes in the front flue sheet with a tool provided for that purpose except when flues are applied without the removal of steam pipes at which time flues will be opened after being applied to the boiler; then to be rolled tight with standard roller expanders and superheater flues to be beaded with standard beading tools.

Superheater flues shall be electrically welded to the back flue sheet after having been applied in accordance with the above paragraphs 1 to 4 inclusive.

Small flues should preferably be welded after applying in accordance with the above paragraphs, although local circumstances will govern.

Superheater flues and tubes of engines assigned to the Kent Division, will be expanded and beaded in the usual manner and not electrically welded. When the beads

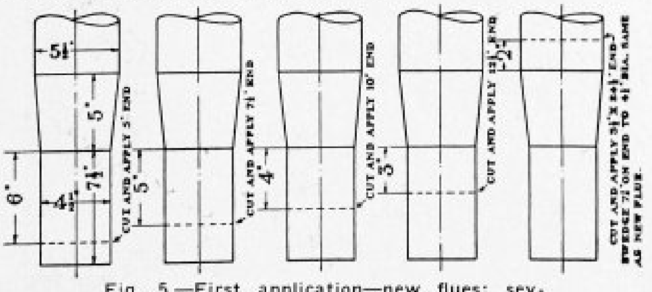


Fig. 5.—First application—new flues; seventh application same as second, etc.

become thin, however, they are to be welded to the back flue sheet.

Flue Maintenance: It is required that all flues except those electrically welded to the sheet, be thoroughly prossered at each monthly washout period.

Flue Welding and Preparation: Superheater flues shall contain not more than two welds; and shall be pieced in accordance with Fig. 5. When it becomes necessary to apply a longer end, use the next application as outlined.

Superheater flues shall be swedged to 7½ inches long on the straight and must be annealed after swedging.

Flues, other than superheater, shall contain not more than three welds; methods of piecing being shown by Fig. 6, which will include all flues with 21 inches of welds or less.

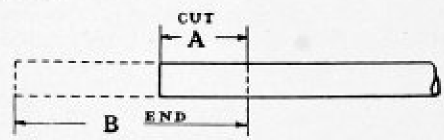


Fig. 6.—Method of piecing flues

	A	B	Remarks
First application	....	....	New flue
Second application	1½ inches	5 inches	One weld
Third application	5½ inches	8 inches	One weld
Fourth application	8½ inches	11 inches	One weld
Fifth application	11½ inches	14 inches	One weld
Sixth application	1½ inches	5 inches	Two welds
Seventh application	5½ inches	8 inches	Two welds
Eighth application	8½ inches	11 inches	Two welds
Ninth application	27½ inches	30 inches	One weld
Tenth application	1½ inches	5 inches	Two welds
Eleventh application	5½ inches	8 inches	Two welds
Twelfth application	8½ inches	11 inches	Two welds

Flues (other than superheater), having more than 21 inches of welds shall have all old welds cut off, and a piece of second hand flue welded on of sufficient size to bring it to the required length; and to this shall be added a new 5-inch piece at firebox end. Thereafter the sketch and table to govern.

Flues having worn thin, after being cleaned, having reached the following weight shall not be used further for steam boiler flues:

2 inch diameter, weight 1¾ pounds or less per foot.
2¼ inch diameter, weight 2 pounds or less per foot.
2½ inch diameter, weight 2¼ pounds or less per foot.
3 inch diameter, weight 2¾ pounds or less per foot.
3½ inch diameter, weight 4 pounds or less per foot.

4 inch diameter, weight 4½ pounds or less per foot.
4½ inch diameter, weight 4¾ pounds or less per foot.
5½ inch diameter, weight 7 pounds or less per foot.

Arch Tubes, Application: All scale and burrs must be removed from tube hole and if holes are more than 1/32 inch out of round they must be reamed true. Holes shall not be reamed more than $\frac{3}{16}$ inch above normal size.

Tube is to be cut to correct length, so as to extend through sheet ⅜ inch. All burrs and scale must be removed from ends of tubes by filing or grinding.

In bending, care must be taken to prevent overheating, distortion or kinking of the tube at the bend.

Bends in the tube must be such, that the tube will enter both ends at right angles to the plate and line up with the other arch tubes. Care should be exercised when bending arch tubes, so that the bends will not be of too small a radius to permit the turbo-cleaner to pass through the arch tube.

After the tube has been properly placed, it should be rolled tight with a standard roller expander, belling out end of tube to an angle of 45 degrees.

Arch Tubes—Maintenance: The plates, caps or plugs covering holes in the outer sheet at each end of the arch tube must be removed at each boiler wash.

The interior of the tube must then be thoroughly cleaned of scale, using a water or air turbine cleaner for this purpose. The tube must be thoroughly washed, after cleaning with a turbine cleaner, particular care being taken to see that no scale or sediment lodges in the bottom portion of the tube or at the bend.

Tubes are to be inspected for cracks, bulging, pocketing or distortion due to shifting of bricks each time fire is removed. No tube shall be allowed to remain in service showing any indication of these defects. Calking or plugging of cracks, or of leaks developed at pockets is forbidden.

After tubes have been thoroughly cleaned and inspected, care must be taken in replacing cover plates or caps to see that all joints are in good condition, that studs for plates are proper fit in sheet, nuts properly fitted to studs and a forged plate used. Threads of caps and plugs should be carefully inspected and care exercised to avoid cross threading in their application. A mixture of graphite and oil must be applied to all joints and threads to facilitate subsequent removal.

Staybolts, Water Space Rigid: Water space rigid staybolts shall be made of iron to conform to specification.

When new fireboxes, new half side sheets, new back flue sheets or ¾ door sheets are applied water space rigid bolts shall be $\frac{13}{16}$ inch diameter.

Staybolts should be carried in stock up to and including 1⅛-inch diameter, when larger staybolts than 1⅛-inch diameter are required in roundhouse renewals or $1\frac{1}{16}$-inch in back shop renewals, or new fireboxes applied, holes in outside sheet shall be electric welded and retapped for $\frac{15}{16}$-inch diameter staybolts.

Radial Bolts: Radial bolts shall be made straight, not upset on the ends for threads and of iron to conform to specification. When new fireboxes are applied, radial bolts shall be 1-inch diameter, straight thread.

Crown Bolts: Crown bolts shall be taper head type, with crown sheet fit finished with a taper of 2 inches in 12 inches and of iron to conform to specification. When new fireboxes are applied, crown bolts shall be 1-inch diameter.

Threading All bolts shall be threaded 12 U. S. form threads per inch, and manufactured according to specifications. Care should be exercised in applying bolts to see that threads are not stripped in screwing bolts into sheets and that bolts are a good fit and steam tight.

Staybolts should project through inner and outer sheets $\frac{3}{16}$ inch to allow for formation of head in riveting.

Telltale Holes: Rigid water space bolts shall have telltale holes in outer end ¼ inch diameter and not less than 1⅜ inches deep. Radial bolts shall have telltale holes drilled in outer end 4 inches deep.

Hollow rigid bolts shall be used when stayed area comes back of engine frames, brackets, braces, arch brick or other obstructions.

Staybolt Application: When enlarged holes are reduced by electric weld and retapped, care should be exercised to see that full perfect threads are formed. Staybolts are not to be applied, when,

(a) Threads in sheet do not show full perfect thread.
(b) Threads on bolts do not show full perfect thread.
(c) Bolt is loose enough to be turned by hand after screwing into second sheet.

Flexible Staybolt Sleeves, Flannery Type: Sleeves for Flannery type flexible staybolts shall be of the unthreaded, electric weld application type.

When threaded type flexible staybolt sleeves are required to be renewed, they shall be replaced by welded type sleeves.

When outside wrapper sheets are applied, holes for regular type welded staybolt sleeves shall be punched 1⅛ inches and for the flush type 2 inches.

The depth of counterbore in the outside wrapper sheet will depend upon the angle of the bore with the sheet. Where bolts are at right angles a width of seat of approximately $\frac{3}{16}$ inch will be found to be ample. Counterboring should be sufficient, however, to give an all around bearing on the curved and angled surfaces of the sleeve. Counterboring should be done with a spindle type combined reamer and counterbore.

When large or complete installations of flexible staybolts are made, the sheets should be held together by applying a flexible staybolt every four or five rows, thus holding the plates parallel while the balance of the bolts are being applied.

The sheets should be thoroughly cleaned of scale and foreign substances, including oil and grease before applying sleeves. The sleeve should then be placed on its bearing and held securely in alinement by an applicator, when being welded. Where sleeves seat at right angles to the firebox sheets, they can be held in place for welding by the head of the flexible bolt. Only sufficient metal to prevent leakage should be applied.

Flexible Staybolt Sleeves, Alco Type: Sleeves for Alco type flexible staybolts shall be of the unthreaded, electric weld application type.

When outside wrapper sheets are applied, holes for regular type welded staybolt sleeves shall be punched 1⅜ inches and for the flush type 2 inches.

The hole in the outside wrapper sheet is to be reamed with a reamer having a taper of 3 inches in 12 inches, and provided with a spindle guide attached.

The hole in the inner sheet should then be tapped, using a bushing guide with proper taper.

The outside wrapper sheet should be thoroughly cleaned of scale, oil, grease or other foreign substance before applying sleeve for welding. After cleaning, the sleeve should be applied, tapping home lightly with a light wooden mallet. The sleeve is then held in place by running in the bolt.

When welding the sleeve, a slip fit cap should be run over the threaded part of the sleeve to protect the threads from sparks during the welding process.

(To be continued)

Testing Thermic Syphons at the University of Illinois

A complete report of the test procedure and results is given in Engineering Experiment Station Bulletin 220, published by the University of Illinois, Urbana, Ill., the present article being an abstract of that bulletin. The general test program was laid down by an advisory committee, composed of Professor Edward C. Schmidt, head of the department of railway engineering, University of Illinois; B. J. Feeny, traveling engineer, representing the Illinois Central; and L. R. Pyle, vice-president, representing the Locomotive Firebox Company. E. G. Young and H. J. Schrader were in direct charge of the tests and data.

The chief purpose of the Thermic Syphon tests recently conducted at the University of Illinois, Urbana, Ill., was to measure the coal and water consumed in a modern locomotive when operated, under rigidly controlled conditions, both with and without syphons, in order to determine the magnitude of the fuel savings effected by this device. The tests were made during April, May, and June, 1930, in the locomotive laboratory on a 2-8-2 type locomotive, which was tested, first without syphons, and again after they had been applied.

Since the syphons directly affect only the boiler performance of the locomotive, the adopted criterion of performance was the evaporation per pound of dry coal. The locomotive was operated at four rates of evaporation chosen to represent the ordinary range of boiler output in everyday service. At all rates of evaporation the syphon-equipped locomotive showed a definite and notable superiority over the non-syphon engine as regards both evaporation per pound of coal and boiler efficiency. The facts with respect to the gains in these two measures of heat transmission are summarized in two of the tables, which, for the four rates of evaporation selected, show an average increase of 7.74 percent in equivalent evaporation per pound of dry coal and an average increase of 8.47 percent in general boiler efficiency.

Concerning the secondary results of the tests, it is sufficient to say that such factors of performance as rate of evaporation, steam pressure, steam quality, draft, speed, cut-off and back-pressure were practically the same with and without syphons. At the three higher rates of evaporation the degree of superheat in the steam was substantially the same with the syphons and without them, while at the lowest rate the non-syphon locomotive produced about twenty degrees more superheat. There were differences in the temperature of the gases at various points in their passage through the boiler.

This investigation was undertaken as one of the coöperative researches of the Engineering Experiment Station of the University of Illinois, in cooperation with the Illinois Central and the Locomotive Firebox Company, which manufactures the syphon. The railroad company furnished the locomotive, and all three agencies shared in the expense of conducting the tests. In accordance with the usual practice of the Experiment Station in carrying on such coöperative investigations the general program for the research was laid down by an advisory committee which not only defined the test program, but were either present or represented in

Fig. 1.—Weighing the boiler feedwater

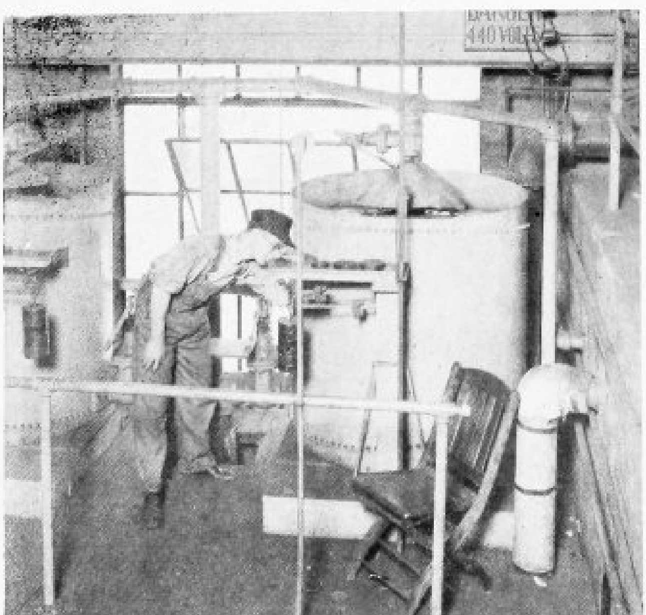


Fig. 2.—Delivering coal to the firing platform

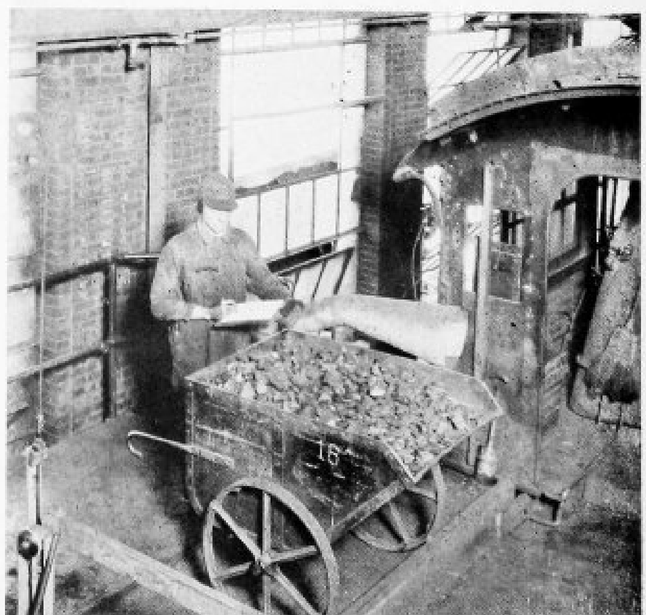


Fig. 3.—Reading temperatures

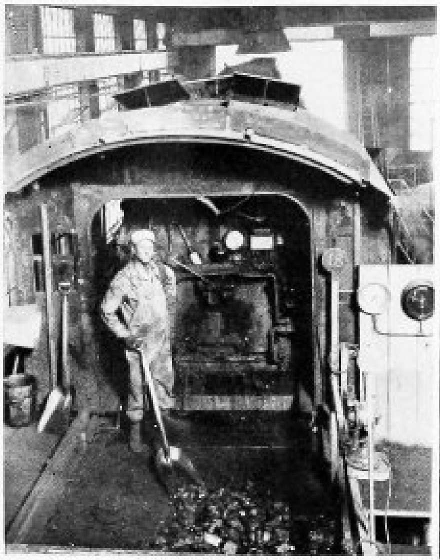


Fig. 4.—The firing platform

Fig. 5.—The control station

the laboratory throughout all tests. The conduct of the tests, however, the calculation and analysis of the results, and the preparation of the report were under the exclusive control of the Railway Engineering Department of the university, which acted for the Experiment Station and which assumes full responsibility for the validity of the tests and their results.

The locomotive used for the tests was of the 2-8-2 type with 218,300 pounds on drivers, 27-inch by 30-inch cylinders, and is rated at 54,588 pounds tractive force. The boiler is of the straight-top, radial-stay type, composed of three ring courses and the back end, with 3667.8 square feet of evaporative heating surface, which was increased to 3722.8 square feet by the installation of the syphons, and with 70.4 square feet of grate area. A security brick arch was mounted on four 3-inch arch tubes, this mounting being altered when the syphons were installed. The grates were of the rocking finger type, with 12 shaking bars on each side of the center, and a pair of 13½-inch dump grates at the back. The openings in the grate amount to 25.89 square feet, or 36.8 percent of the grate area.

The boiler was provided with a Type A superheater, built by The Superheater Company, and comprising 36 units and a header of the through-bolt type, providing 1074.4 square feet of heat-transfer surface. The superheater damper was wired in the open position during the entire time the locomotive was in the laboratory.

The front-end arrangement provided for no extension stack, but the petticoat pipe extended up to the level of the stack opening in the smokebox, leaving a passage of about 147 square inches area around the petticoat into the stack. The nozzle tip had a circular opening 6¼ inches in diameter, provided with a ⅜-inch knife-edge bridge, the edge of which was set ¼ inch below the top of the tip.

The boiler of the locomotive was in first-class condition throughout its stay in the laboratory. The surfaces in contact with the boiler water were inspected upon arrival and were found to be practically clean. Treated feedwater was used during the tests; and examination of the boiler surfaces at the close of the first series of tests without the syphons and again at the end of the second series with the syphons showed that the only deposit during the tests was a very thin powdery white coating.

The steaming of the engine, from the outset, indicated that the drafting arrangements were satisfactory, and no change whatever was made in the front-end after it was received at the laboratory. The front-end was inspected at the beginning of the tests, during their progress, and at their conclusion; everything in it remained intact.

It is to be emphasized that, except for the installation of two syphons and the change in the firebox heating surface and volume thereby entailed, no change which could affect the performance of the locomotive was made between the tests of Series I and Series II.

The fuel used during the tests was Illinois run-of-mine coal, produced at a single mine, passed over a

Table I—Boiler Performance—Main Results

Series	Evaporation rate	Test number	Test conditions (nominal): Speed, r.p.m.	Test conditions (nominal): Cut-off, per cent	Dry coal burned per hour lb.	Equivalent evaporation per hour, lb.	Equivalent Evaporation per pound of dry coal, lb.	Boiler efficiency, per cent
Series I without syphons	First	2702	80	25	2351	21,809	9.28	70.14
		2703			2335	21,277	9.11	68.77
		2706			2416	21,737	9.00	68.65
		Averages			2367	21,608	9.13	69.19
	Second	2701	120	30	3369	31,334	9.30	71.73
		2704			3461	32,232	9.31	71.06
		2707			3513	31,604	9.00	69.50
		Averages			3448	31,723	9.20	70.76
	Third	2705	120	45	5382	46,924	8.72	67.62
		2708			5484	47,857	8.73	65.59
		2714			5381	47,935	8.91	69.72
		Averages			5416	47,572	8.79	67.64
	Fourth	2710	180	45	6650	57,253	8.61	67.26
		2712			6676	55,912	8.38	65.76
		2713			6685	56,107	8.39	66.74
		Averages			6670	56,424	8.46	66.59
Series II with syphons	First	2716	80	25	2209	21,577	9.77	76.93
		2719			2161	21,573	9.98	78.13
		2724			2176	21,532	9.90	77.80
		Averages			2182	21,561	9.88	77.62
	Second	2725	120	30	3120	31,027	9.94	76.26
		2728			3079	30,860	10.02	76.55
		2729			3174	31,006	9.77	75.51
		Averages			3124	30,964	9.91	76.11
	Third	2722	120	45	4832	46,947	9.72	75.61
		2723			4915	46,870	9.54	73.26
		2731			4925	46,175	9.38	73.47
		Averages			4891	46,664	9.55	74.11
	Fourth	Averages			6058	55,058	9.09	69.93
		2718	180	45	6121	54,796	8.95	70.10
		2721			6046	55,634	9.20	70.46
		2730			6007	54,743	9.11	69.23

Table II—Equivalent Evaporation Per Pound of Coal, Adjusted to a Common Evaporation Rate

Evaporation rate 1		Equivalent evaporation per hour, lb. 2	Equivalent evaporation per pound of dry coal: Series I without syphons, lb. 3	Series II with syphons, lb. 4	Increase in the equivalent evaporation per pound of dry coal due to syphons: Pounds (Col. 4—Col. 3) 5	Percent (Based on Col. 3) 6
First		21,608	9.13			
		21,561		9.88		
	Mean (line a)	21,585	9.13	9.88	0.75	8.21
Second		31,723	9.20			
		30,964		9.91		
	Mean (line b)	31,344	9.20	9.91	0.71	7.72
Third		47,572	8.79			
		46,664		9.55		
	Mean (line c)	47,118	8.80	9.53	0.73	8.30
Fourth		56,424	8.46			
		55,058		9.09		
	Mean (line d)	55,741	8.48	9.05	0.57	6.72
Average for all four rates						7.74

Table III—Boiler Efficiency, Based on the Average Direct Results of the Tests

Evaporation rate 1	With or without syphons 2	Equivalent evaporation per hour, pounds 3	Average boiler efficiency, percent 4	Difference in efficiency, percent 5	Percentage gain in efficiency due to syphons, based on Series I 6	Percentage gain in evaporation, adjusted values 7	Average heating value of the dry coal, B.t.u. per lb.: For each series 8	Difference between series 9
First	Without	21,608	69.19	8.43	12.18	8.21	12,802	452 more without syphons
	With	21,561	77.62				12,350	
Second	Without	31,723	70.76	5.35	7.56	7.72	12,616	18 more with syphons
	With	30,964	76.11				12,634	
Third	Without	47,572	67.64	6.47	9.57	8.30	12,605	114 more without syphons
	With	46,664	74.11				12,491	
Fourth	Without	56,424	66.59	3.34	5.02	6.72	12,325	285 more with syphons
	With	55,058	69.93				12,610	
All	Without	General average values for all four rates of evaporation			8.58	7.74	12,587	66 more without syphons
	With						12,521	

Table IV—Boiler Efficiency—Values Adjusted to a Common Evaporation Rate

Evaporation rate 1	Equivalent evaporation per hour, lb. 2	Boiler efficiency, adjusted values: Series I without syphons, percent 3	Series II with syphons, percent 4	Difference in efficiency between the two series 5	Increase in efficiency due to syphons, Col. 5 / Col. 3 × 100, percent 6
First	21,585	69.15	77.18	8.03	11.61
Second	31,344	70.78	76.71	5.93	8.38
Third	47,118	68.32	73.32	5.00	7.32
Fourth	55,741	66.23	70.58	4.35	6.57
General average increase in efficiency, for all four rates					8.47

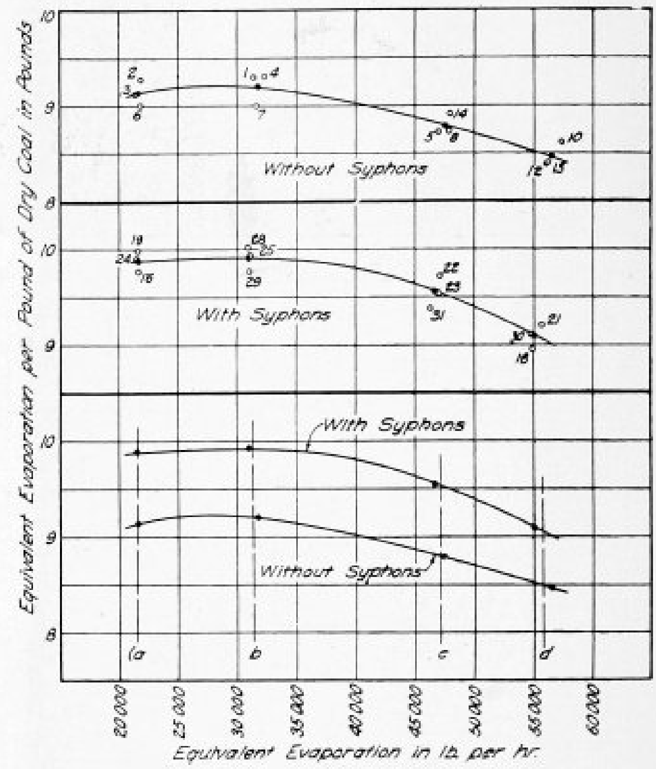


Fig. 6.—Curves of equivalent evaporation per pound of dry coal at various rates of evaporation

2-inch screen and designated as 2-inch lump coal. The average heating value of the coal, as fired, was 11,890 British thermal units per pound, the maximum value for any test being 12,133 British thermal units and the minimum, 11,623 British thermal units.

The test methods and procedure were, in general, in accordance with the requirements of the American Society of Mechanical Engineers' Test Code for Steam Locomotives.

Under the decisions of the advisory committee, tests were run, in each series, at four rates of evaporation—nominally 17,500, 27,500, 37,500, and 45,000 pound per hour (actual evaporation). These rates were chosen to represent the usual range in evaporation rate of engine No. 1742 in road service. The test conditions were so set as to attain in Series II the same rates of evaporation as in Series I; and although this similarity was not precisely realized at all rates, the difference between the two series is small, the maximum difference in average rate being only 2.4 percent.

The other main test conditions prescribed by the Advisory Committee were that not less than 20,000 pounds of coal be burned in each test, and that the program be continued until, in each series and at each rate of evaporation, three tests had been secured whose results should be in such close agreement as to establish a reliable average result for the rate in question. In order to avoid the disturbance arising from blowing safety valves, all tests were run at a nominal steam pressure of 182 pounds instead of at the usual working pressure of the locomotive (185 pounds).

During the entire main investigation 31 tests were run, numbered from 2701 to 2731 inclusive. Seven of these 31 tests failed in some respect to meet the prescribed conditions, and they are therefore not included among the tests upon which the main results and conclusions, presented in the body of the bulletin are based.

There remain therefore 24 tests which comply in all respects with the requirements laid down by the advisory committee — twelve tests in each series; and, in each series, three tests at each rate of evaporation. The conclusions, with respect to the relative performance of the locomotive with and without syphons rest upon these 24 tests.

During all tests the locomotive was hand-fired by the so-called "level firing" method. The firing was of quite unusual uniformity and regularity, as is evidenced by the very narrow range within which the time required

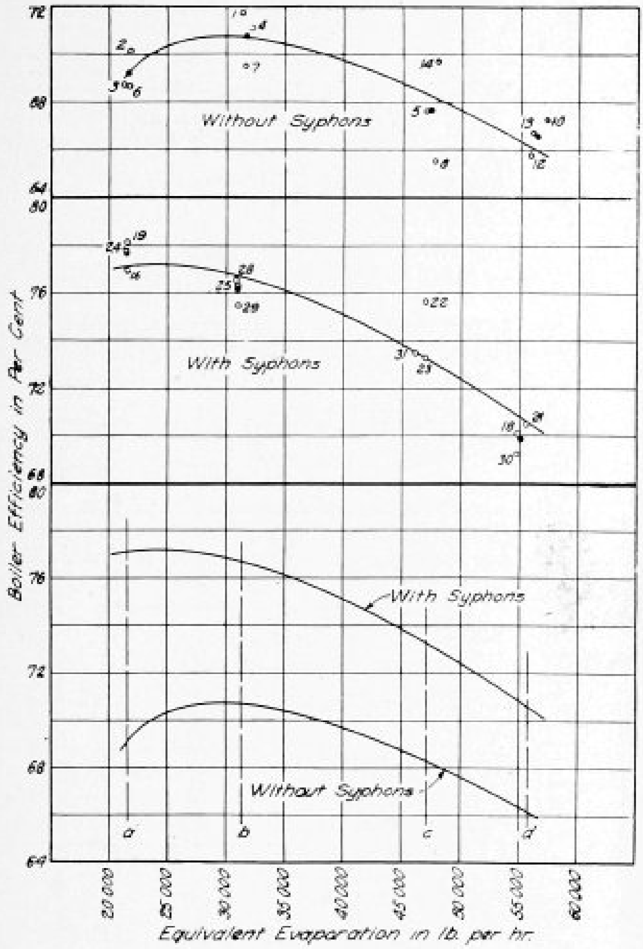


Fig. 7.—Curves of boiler efficiency at various evaporation rates

to burn ten tons of coal varied in successive tests at each rate of running. The most striking example of this regularity is afforded by the three tests run without syphons at the highest rate of evaporation (tests 2710, 2712, and 2713). These tests each lasted 2.85 hours, the variation between them being less than one minute.

The coal was received in side-dump cars which were discharged upon a concrete pavement. It was shoveled from this pavement into the laboratory barrows, each holding about 1000 pounds; the largest lumps, such as are ordinarily broken on the engine deck, being broken down at this time. The barrow was then taken to the weighing scales, where the load was adjusted to exactly 1000 pounds; and from there it was elevated to the firing platform.

For all tests the fire was built up from a clean grate, the time until full boiler pressure was attained averaging about three hours. After the steam pressure had been built up, the locomotive was run through a period varying, from test to test, from 15 minutes to half an hour, while the speed and load required for the desired evaporation rate were being established. Thereafter the locomotive was run for a further period of fifteen minutes or longer in order to establish the final setting of the injector, to obtain the desired water level in the boiler, and to ensure that all other conditions of operation were steady; and the test was started.

The speed of the engine was controlled by controlling the water-pressure within the absorption brakes. It was at all times maintained nearly constant and close to the rate desired in the various tests. Constant cut-off during any test was ensured by fixing the position of the crosshead of the power reverse gear with three steel bars of pre-determined length.

The boiler feedwater was weighed in two tanks, each holding a maximum of about 2200 pounds, and so arranged that one tank was emptying into the main feed tank while the other was being filled from the feedwater supply line. The weighing tanks were mounted on separate scales, each of which had a tare beam upon which the weight of the empty tank could be balanced. The water in the main feed tank was kept at nearly constant level so that the injectors should work against practically constant head.

Table I shows the values of equivalent evaporation per pound of dry coal for each of the tests, and also its average value for the three tests run at each of the four evaporation rates, in each series. The upper curve in Fig. 6 shows the results for the tests of Series I, without the syphons; while the curve in the center of this figure gives the results for Series II, with the syphons. The circles plotted in Fig. 6 represent the values for the individual tests (the numbers affixed to these circles are the last one or two numerals of the test numbers), whereas the round spots represent, for each of the four rates of evaporation, the *average* evaporation per pound of coal at the *average* rate of evaporation. The curves drawn in this figure are made to pass through these spots representing the average values, and they are accepted as defining the test performance of the boiler without and with syphons, respectively. In order to facilitate comparison, these curves and the plotted average values are duplicated and brought together at the bottom of the chart.

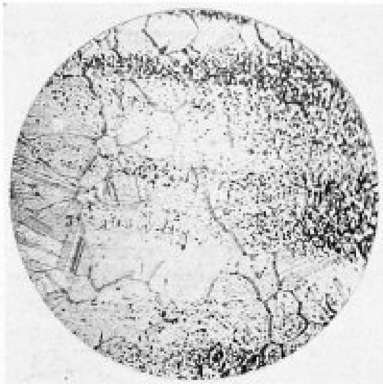
As is always the case in a locomotive, the equivalent evaporation per pound of coal falls off, in general, as the rate of evaporation increases, due to the decrease in boiler efficiency which accompanies higher rates of evaporation and combustion. Because of this decrease, and because the evaporation rates for the two series of tests are not precisely alike, the average values plotted are not directly comparable but must be adjusted, as illustrated, in Table II. The efficiency values are also adjusted for a similar reason (see Table IV).

Under the conditions which prevailed during the tests, locomotive No. 1742 generated 8.21, 7.72, 8.30, or 6.72 percent more steam per pound of dry coal when equipped with syphons than when not so equipped, at the respective hourly rates of evaporation here shown.

The values of boiler efficiency (ratio of the heat units transmitted to the steam to the heat units in the coal fired), attained during each test, and also of the average efficiency for the three tests run at each of the four evaporation rates, in each series, appear in the last column of Table I. These values are plotted in the upper part of Fig. 7, where the circles represent the efficiency values for individual tests, while the round spots represent, for each of the four rates of evaporation, the average result at the average hourly evaporation rate. For convenience in comparing them, these average values are assembled in Table III, which shows, therefore, for each evaporation rate in each series, the direct results of the tests.

Boiler efficiency, since it takes into account any existing difference in heating value, is a better criterion than evaporation per pound of dry coal; and the real superiority of the syphon, as a device for stimulating the heat transmission in a locomotive boiler, is doubtless more truly revealed by the gains in efficiency.

The syphon is especially advantageous during the period of building up the fire and attaining full steam pressure; and this advantage repeats its influence after each stop of considerable length.



Arc Welding ▲ ▲ ▲ Everdur

By T. E. Jerabek*

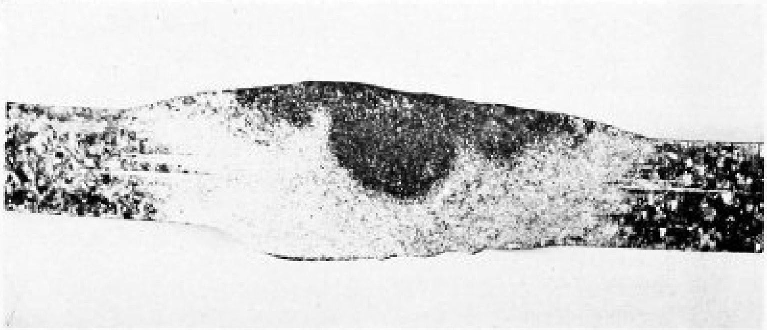


Fig. 1.—(Above) The everdur sheet (top) and the metallic weld metal (below) are almost identical in structure as this micrograph shows. Fig. 2.—(Below) A cross section of a metallic arc weld on everdur

A few years ago industry was faced with the problem of finding a metal with physical qualities equal to or greater than steel, and one that would resist corrosion and chemical action. Everdur, a copper-silicon-manganese alloy, was developed to meet that demand, and since that time its use has spread continuously. Today the spread of this modern metal is even more rapid, due in a great part to its adaptability to arc-welded construction.

Everdur is a high strength metal with physical properties equal to hot-rolled, medium-carbon steel, and greater than cold-rolled, or drawn, medium-carbon steel. It is non-rusting, non-magnetic and highly resistant to corrosive or saline gases. Developed by Charles B. Jacobs in answer to a demand for a metal which would withstand acid corrosion to be used in making quick repairs of acid works, it was patented in 1925 by the DuPont Company. In 1927 this patent and all rights of manufacture were purchased by the American Brass Company, which has continued the production of this metal and carried on its merchandising. Everdur can be readily worked either hot or cold, and will not fail by dezincification or season cracking under stress.

One of the greatest qualities of everdur is its excellent welding characteristics, especially with the electric arc, which is being used so extensively in the fabrication of metal designs. This characteristic is important because of the rapidity with which arc-welded construction is replacing the older methods of fabrication. Either the metallic-arc or the carbon-arc welding process may be used on this modern metal with good results. In using the metallic-arc process, a rod of the same composition as that of the metal is most suitable. In carbon-arc welding either the manual or the automatic process can be used with equally good results. Whether or not additional metal or a filler rod is necessary with the automatic process, depends on the seam being welded.

In arc welding everdur with the metallic electrode, as in welding steel, the size of the rod and the thickness of the plate regulates the amount of heat required. Electrodes $\frac{1}{8}$ inch in diameter with 90 to 100 amperes current are usually employed for welding sheets and plates up to $\frac{1}{4}$ inch in thickness; 5/32-inch rods with 100 to 120 ampere current on $\frac{1}{4}$-inch to $\frac{1}{2}$-inch plates; and $\frac{3}{16}$-inch rod with 130 to 160 amperes current for plates $\frac{1}{2}$ inch or thicker. These currents are applicable for reverse polarity, which is generally the arc-welding practice with non-ferrous metals. The rods, besides being of a composition similar to the parent metal, should be drawn to a sufficient degree of hardness to insure uniformity of grain structure and freedom from seams, and have a bright clean finish.

In metallic arc-welding of everdur it is also advisable to hold the arc somewhat longer than is common in arc-welding of rolled steel. The metal in this case should not be allowed to drop from the electrode, but should cross the arc in an almost steady stream. It is also good practice to concentrate the heat of the arc on as small an area as possible.

In Fig. 1 the micrograph shows the boundary of the weld and everdur, made with the metallic electrode. The metal at the top of the micrograph is everdur, while that at the bottom is deposited weld metal. Note the striking similarity of these two metals, when magnified. Fig. 2 shows a photograph of a cross section of a weld made with the metallic arc, joining two sheets of everdur. Note the very fine structure of the metal in the weld.

In joining everdur to steel with the metallic arc it is advisable to bring the metals to an even heat by preheating them before welding is begun. The arc should be struck in this preheated section and continued in one direction. Without preheating, a small shrink crack will generally appear after cooling at the point where the weld was started. If, during the course of the bead, it is necessary to suspend welding, it is advisable to resume the bead about half an inch back of the crater so that by the time the crater is again reached the metal at that point will be preheated sufficiently to insure correct penetration into the parent metal.

The procedure given above for the metallic arc-welding process is also applicable in general to the carbon arc-welding process with the exception that a short arc is held in carbon arc welding, and a filler rod of the same composition as everdur is generally inserted in the seam to furnish additional metal for the weld. The short arc is held in manual welding to concentrate the

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heat as much as possible directly on the seam and on the filler rod. In some cases it is possible to lay or clamp the filler rod in place and fuse it into place as the weld progresses. In other cases it is advisable to feed the rod into the arc with the left hand, as the weld progresses. The microphotograph shown as Fig. 3 illustrates the quality of welds made with the manual carbon arc and a welding electrode of a composition similar to the parent metal. The metal on the right of the photograph is everdur, that on the left is the weld metal. The line of fusion is well defined in this photograph which shows the point of fusion magnified.

In joining everdur metal by either the automatic or semi-automatic arc-welding process, the best results are obtained by use of the electronic-tornado process. This process fuses the metals together as the weld progresses either with or without the use of additional filler metal, and is available for automatic welding either as part of a mechanical fixture or in a self-propelled tractor type, or for semi-automatic welding in which the qualities of the electronic-tornado process are supplemented by the flexibility of human control.

Welds made by the electronic-tornado process of carbon-arc welding have a tensile strength equal to that of the parent metal and are extremely ductile. They are made with a shielded arc which protects the arc and the weld metal to such a degree as to totally exclude oxides, nitrides and other elements which tend to weaken the metal in the weld.

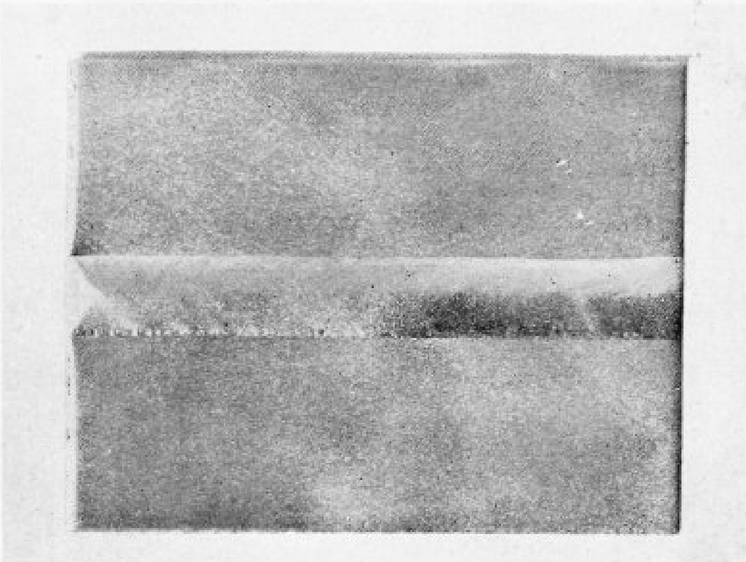
Fig. 4 shows a weld made by the electronic-tornado process. Note the fineness of the metal structure in the weld. Fig. 5 shows a top view of this type of weld.

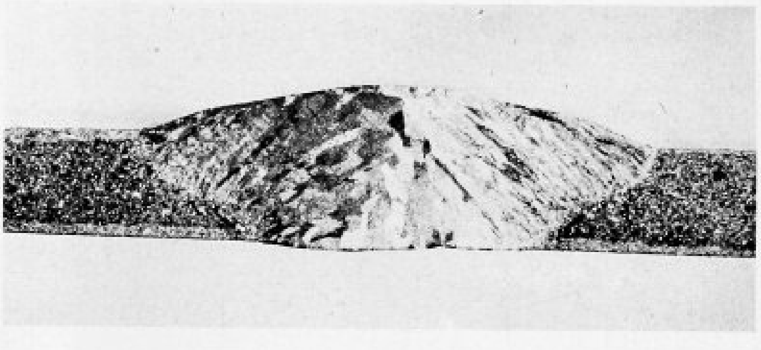
The preparation of everdur for welding is primarily the same for all types of welding. For butt welding plates of $\frac{1}{4}$ inch or thicker, a bevel is required. Plates thinner than $\frac{1}{4}$ inch do not require beveling. In cases where beveling is not required a space equal to the thickness of the plates should be left for welding. Where plates are beveled, a space of $\frac{1}{16}$ to $\frac{1}{8}$ inch between the plates is sufficient for good welding. The plates should be cleaned before arc welding is begun. This may be done either by sandblasting or pickling with a 5 to 10 percent solution of sulphuric acid at about 140 degrees, to remove the black oxides. Beveled plates need not be pickled or sandblasted but it is advisable to remove the black oxides adjacent to the top of the bevel with emery paper, a portable grinding wheel or a file. If it is known at the time of manufacture that the plates are to be welded the pickling can very conveniently be done in the mill.

In arc welding everdur, a flux should be used to obtain the best results. In metallic arc welding ordinary fused borax works satisfactorily, but the best welds are obtained by using a flux composed of 90 percent fused borax and 10 percent sodium fluoride. The flux is applied by first dampening the work with water and then sprinkling a very thin coating of flux. In the electronic-tornado process this flux is not required; the shielded arc is sufficient to exclude all the impurities present in the atmosphere.

On account of the great amount of the parent metal that is molten at the point of the arc, in welding everdur a backing bar is advisable. Copper is generally employed for this purpose, but cast iron or steel are both practical. This backing carries away the heat generated in the arc and prevents the weld metal from running through the seams.

The fabrication of products of everdur by the electric arc-welding process has given added impetus to the adoption of this modern metal for practically every type of product. Everdur has improved the physical qualities of these products by its many exceptional properties, and arc welding has supplemented those qualities by providing a means of fabrication that compares to the physical qualities of the metal itself.





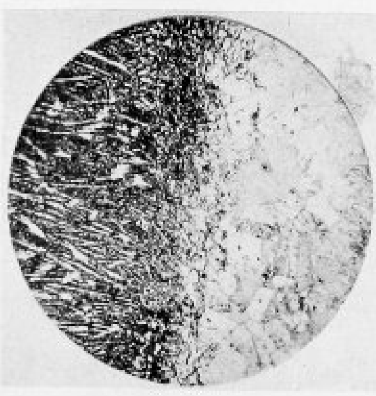
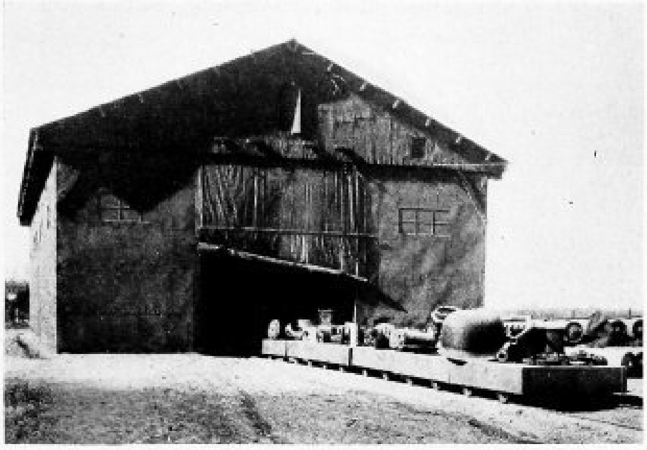


Fig. 3.—(At left) The carbon arc and a rod of the same composition as the parent metal were used, the line of fusion being clearly shown. Fig. 4.—(Above) A weld made by the automatic carbon-arc-welding process. Fig. 5.—(At Top) A top view of the weld shown in Fig. 4

Sandblasting

Effective use of a sandblast shed and equipment is being made at the locomotive shops of the Chicago, Burlington & Quincy Railroad at West Burlington, Iowa. This shed, illustrated, is approximately 30 feet wide by 80 feet long, being constructed of sheet iron on a timber frame. Shop air pressure is piped to the shed



Sand blast shed and loaded push cars at the West Burlington shops of the C. B. & Q.

through a three-inch line which makes approximately 90 pounds pressure available. In one corner of the shed is a storage bin for the white silica sand shipped to the shop in carload lots and used for sandblasting. While a sand drier is installed in the shed and was at one time used, this practice has been discontinued as unnecessary with sand of average moisture, and consequently, sand from the storage bin is simply shoveled to a vibrator which eliminates any foreign material or excessively large pieces. From the bottom of the vibrator, sand is delivered through a 2-inch pipe by air-pressure to the top of a sandblast container or drum, 36 inches in diameter by 50 inches high. By means of a gate valve, the sand in the top of the container can then be passed by gravity to the mixing chamber or tank underneath. The gate valve is closed, and air pressure applied, sand feeding by gravity and air pressure to the syphon underneath the mixing tank, where it mixes with the stream of air at shop air-line pressure and is conducted through a 1½-inch rubber hose to the nozzle pipe and the parts to be sandblasted. Two nozzle pipes, which can be used simultaneously from this machine, are ½ inch in diameter. A service life of approximately three months is secured from the hose, but the pipe nozzles cut out usually in a few hours. The sandblast operator has an assistant who works the sand and dust over on the floor and gradually gets that sand which is suitable for re-use back toward the vibrator where it is worked into the sanding system again.

Approximately thirty locomotives a month are normally handled at the West Burlington shops, and a large part of the locomotive equipment, including frames, cylinders, boilers and accessories, is sandblasted. Stripped locomotives, mounted on their front and back trucks, are moved into the sand house, except on quiet, fair days when the work may be done out of doors. Locomotive tenders and tanks are sandblasted preparatory to repainting. Small parts are loaded on push cars for movement between the shop and the sandblast shed. The boilers are sandblasted inside and out, which has the effect of thoroughly removing dirt and scale and permitting the detection of any flaws in the steel, such as cracks, and plates with an undue amount of piting or corrosion. Air pumps are sandblasted, also the exteriors of air drums, jackets, etc. Pistons and crossheads, after going to the lye vat for the removal of most of the grease, are sent to the sandblast shed and sandblasted. While sandblasting the interior of a boiler, a motor-driven fan is used to get rid of the sand in the atmosphere.

Arc-Welded Plate Rolls

The design of this machine, made from rolled steel, is being submitted as an entry in the second Lincoln Arc-Welding Prize Competition by W. A. Barber of The American Crane Company, Friendship, N. Y.

It is a plate roll having a capacity of 48-inch width. The rolls are 6 inches in diameter and the main frame is made up of 8-inch Bethlehem H. Columns. The entire machine including the roll bearings and the gear case is all one unit machined after welding.

Permission for the publication of the picture has been given by Mr. Barber.

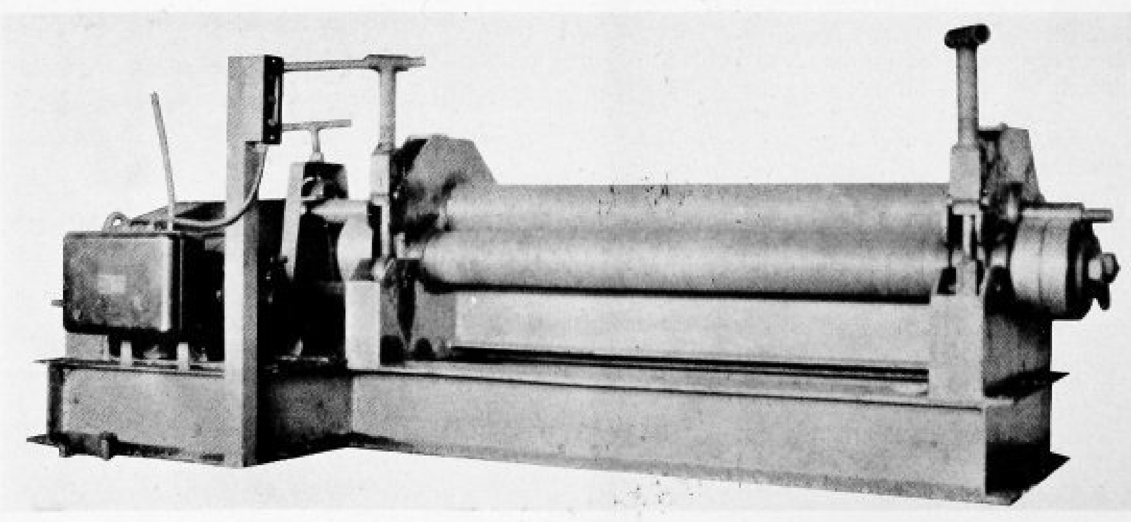
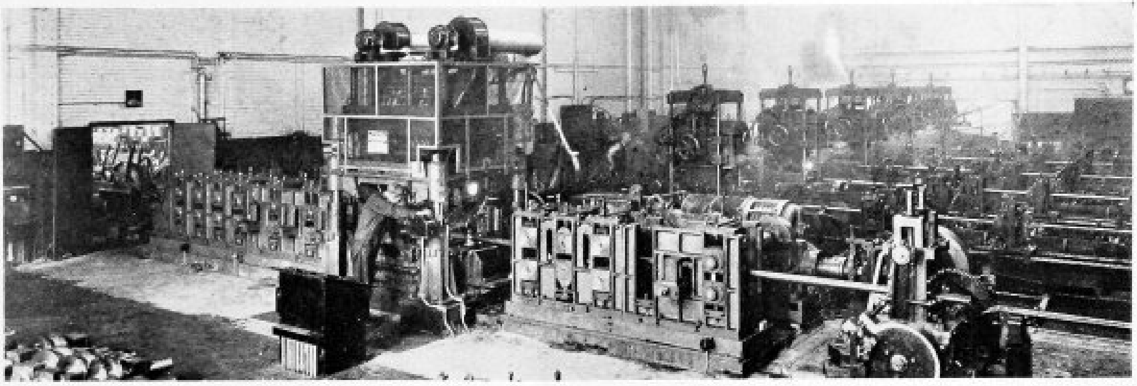


Plate rolls constructed with arc welding



Machine for welding heavy tubing

Electric Welding Steel Tubing

The completion of a new electric welding unit which greatly increases the range of steel tubing produced by the Johnson process is announced by officials of Steel and Tubes, Inc., of Cleveland, a subsidiary of the Republic Steel Corporation.

After several years of experimental work, a machine has been developed which will weld tubing of much heavier wall thickness than has heretofore been possible and up to 5 inches in diameter. Sizes formerly direct welded in this manner ranged from No. 26 to No. 11 gage. The new unit electrically welds tubing up to ¼ inch in thickness, increasing the wall range to No. 3 gage, all intermediate gages being included.

The new machine is so constructed that large coils of flat steel stock are fed into the forming rolls to be formed cold into a tube. This passes directly under the electrodes where fusion takes place without the addition of foreign metal at a speed of approximately 80 feet of tubing per minute. The welding burr is eliminated and the weld is almost imperceptible. The process is practically continuous and is not only much faster but it is claimed produces a better finished product from the standpoint of strength and appearance. Welding power for the machine is drawn from the lines at 2300 volts. When operated at full capacity, over 1200 kilowatts of electrical power is concentrated continuously in a spot no larger than the eraser on a pencil.

Continuous testing takes place, samples being expanded until the wall fractures. This fracture must occur at some point other than the weld to allow the welding machine to continue in production.

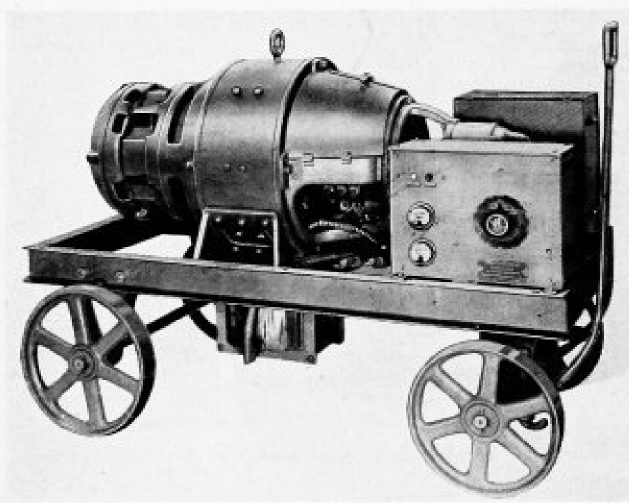
Westinghouse Flex-Arc Welders

The Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., recently brought out a series of single-operator welding sets incorporating a feature known as the flexactor, which is designed to produce a steady, uniform and flexible arc at all current values. The flexactor is a special form of reactance and its principle of operation is to lessen the time of voltage recovery and to eliminate current surges at the striking of the arc, thus preventing sticking of the electrode. By eliminating current surges, the flexactor is designed to prevent arc explosions and overshooting of the ultimate current value during momentary short circuits due to passage of metal through the arc.

The single-operator sets have a common frame and common shaft for the motor and generator with ball bearings on the generator end and roller bearings on the motor end. A separate exciter is overhung from the motor end. The control units are mounted on the side of the set, in an integral part of the frame and protected by a sheet-steel panel. The flexactor is mounted underneath the frame.

The welding unit illustrated has a rating of 300 amperes, 1 hour, 50-degree C. rise on resistance load at 25 volts in accordance with N.E.M.A. standard practice. The welding range of the unit is from 90 amperes to 375 amperes. The generator is the standard Westinghouse SK type using constant current and is differentially wound and separately excited. A line start 15-horsepower motor is used which operates on dual voltage, 220 or 440 volts, 25, 50 or 60 cycle, 2 or 3 phase. A 550-volt motor, 3 phase, 50 or 60 cycle, can also be used.

The generator field rheostat, ammeter and voltmeter,



The 300-ampere Westinghouse Flex-Arc welding set

together with the motor starter, are all mounted in an enclosed sheet-metal cabinet which is an integral part of the unit frame. The capacities of the instruments are 600 amperes and 125 volts. The Westinghouse line-start motor control used is operated by a push button and has overload and low-voltage protection and is mounted in a steel cabinet. The exciter used in conjunction with the welding unit is the standard Westinghouse CD type, 125 volts, and is for direct-current compound wound.

Pneumatic Scarfing Hammer

Among the interesting and ingenious devices developed at the boiler shop of The Baldwin Locomotive Works, Eddystone, Pa., is a pneumatic scarfing hammer shown in the accompanying drawing. This hammer has been the means of saving considerable time and effort by eliminating the hand scarfing of throat sheet corners and other corners where scarfing is required.

In operation the hammer is suspended from a jib crane and manipulated by two men holding the long handles. Next to one of the handles is the air valve and hose connection and by means of this valve the scarfing operation may be controlled.

The pneumatic tool itself is of the conventional type having a diameter of 4¼ inches at the point where it is clamped by the added handles. The two handles are similar, being constructed of iron or steel forgings. At the shaft the forgings are 1½ inches in diameter separating into the handles which are 1 inch in diameter and 20 inches apart. The overall length of the hammer is 13 feet 1 inch.

Each of the forgings is shaped so that when fitted together with two ¾-inch bolts, the pneumatic tool will be firmly clamped. For alinement purposes and to serve as a height adjustment there is a roller table arrangement constructed of a piece of ½-inch plate, 13 inches square. In the center of this plate is bored a hole large enough to permit the passage of the pneumatic tool. Four 1-inch bolts with roller attachments at the end are fitted at the corners of the plate and a ¾-inch plate 6 inches square, also bored with a large hole, is fastened to the tool and to the larger plate by means of four ⅝-inch bolts. This serves to strengthen the height-adjusting table and keep the rollers in a correct position for efficient operation of the device.

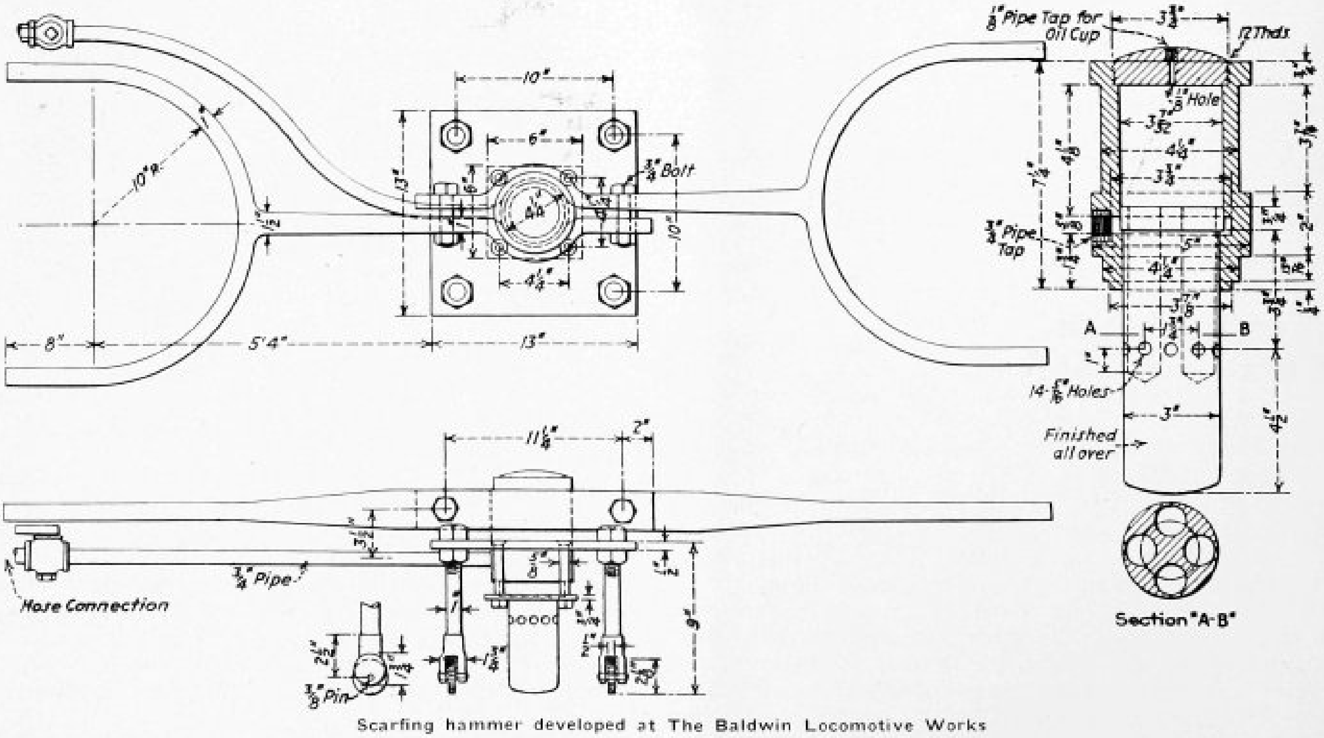
Heavy Electrode

The General Electric Company, Schenectady, N. Y., announces a new heavily-coated electrode, designated as type R., which is composed of 13 to 18 percent carbon steel covered with a heavy coating of cotton braid impregnated with an arc stabilizing flux. This electrode is available in diameters from ⅛ to ⅜-inch by 18 inches in length. Metal deposits of this electrode will have high tensile strength and will produce a homogeneous structure, resulting in a ductile weld. This is caused by the fact that, during the arc transference period, the metal is in a protective atmosphere because the electrode itself burns away quicker than the coating and excludes those elements, always prevalent in atmosphere, which cause undesirable results when an uncoated rod is used.

Welding Society Formed in St. Louis

On January 23, at a meeting held in the Forest Park Hotel, St. Louis, Mo., the St. Louis Welding Society was formed and officers were elected. This society, which consists of 65 charter members, represents 26 companies in St. Louis, East St. Louis, and Madison, Ill. Temporary headquarters of the society were established at 4620 Delmar Boulevard, the home of the Hill Equipment Engineering Company.

The following officers were elected: President, E. P. Barnes, Moloney Electric Company; vice-president, W. D. Patterson, American School of Welding; secretary and treasurer, Basil N. Osmin, Hill Equipment Engineering Company. The directors include: F. J. Feldhaus, Heine Boiler Company; George Frankey, Alpha Tank & Sheet Metal Works; A. V. Fausek, Modern Engineering Company; Lyman Goodin, Midwest Piping & Supply Co.; F. Tidewell, John Nooter Boiler Works, and A. E Eidson, St. Louis Structural Steel Company.



Scarfing hammer developed at The Baldwin Locomotive Works

Staybolting

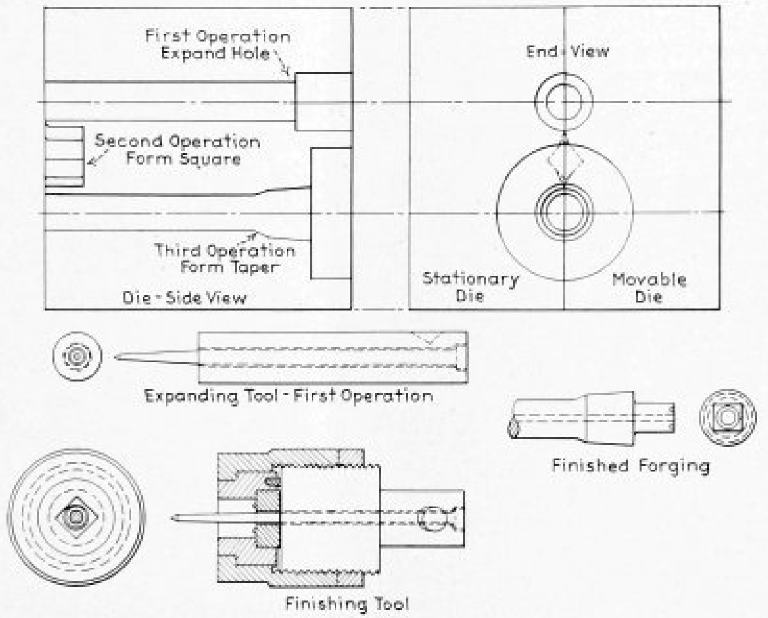
▲ ▲ ▲ for High Pressures

By C. M. Walsh*

Quoting from the last annual report of A. G. Pack, chief inspector, Bureau of Locomotive Inspection, we learn that: "Boiler explosions caused by crown sheet failures continue to be the most prolific source of fatal accidents; 84.6 percent of the fatalities during the year were attributable to this cause as compared with 68 percent in the previous year."

No doubt many of these crown sheets dropped from causes other than bolt failures, but a certain percentage of them can be definitely traced to broken stays. Hammer testing has some merit, but experience has shown that the most expert hammer tester can be mistaken at times on partially fractured bolts. This is especially true on broken bolts where the hammer blow has little opportunity to set up vibration in the sheet; a condition very often found in the radius bend.

My assumption, that there is always doubt as to the actual condition of these upper stays, is confirmed, when the crown sheet is removed in back shop. Every boiler maker charged with the responsibilities of boiler upkeep and maintenance gives the removed sheet very careful inspection, and plenty of his attention is directed to the condition of the crown stays.



Method of forming hollow long stays

Only recently, while the annual hydro test was being given an engine, the crown sheet came down at the radius about 15 inches. Inspection showed that five entire adjacent rows had failed, and a number of scattered bolts nearby in rows had snapped, bringing the total to 247 broken bolts. Happily, this occurred during a test, but as the pressure at failure was only 12 pounds over the working pressure, it is not difficult to picture the possibilities under steam.

I recall another instance wherein two entire rows of radials on either hand, (four rows in all) were found broken, the ends being sprung 1/4 inch apart. I am positive breakage in this case was progressive, and these failed bolts should have been discovered long before they were.

On one occasion I witnessed a crown sheet being burned out in pieces about 24 inches square. Inspection showed quite a few crown bolts had been broken off completely in the roof sheet, and in the fire sheet these same bolts had cracked through 90 percent more or less, of their area. There was just enough metal left to keep these bolts standing vertical in the water. In dropping the pieces to the shop floor the jar was sufficient to snap off these crown stays at the fire sheet.

None of these conditions could exist if the roads were using modern methods in staying and bracing. In an endeavor to bring about better staybolting practices, I am outlining below some of the progress made in fabrication of crowns and radials which will remove many of the hazards met in staying against present day pressures.

For many years hollow staybolt iron has been rolled. Through development of processes in railroad shops, it is now possible to forge this hollow iron into tapered and button head crowns, radials and back flue sheet braces, without closing the hole in forging. The accompanying sketch illustrates the method of forming hollow long stays, and eliminating all necessity for drilling.

Referring to the sketch the method of forging the tapered end is as follows: The first blow is merely an expansion of the hole to about 3/8-inch diameter. Squaring is then accomplished in squaring notches shown at the left end of the side view of the die. In forming the square in these notches the expanded hole is reduced to about its normal diameter, which is $\frac{3}{16}$ inch. After the square is formed, the stay is dropped to the lower pass and the taper is forged with the final blow.

The straight upset on the opposite end of a crown stay, is a very simple forging. It is made exactly the same as a solid upset except that a 1/4-inch pin is inserted in the plunger, which has been drilled full length, the pin acting in the same capacity, as in the forging of the tapered end.

In this method there is no necessity to purchase new equipment, as all dies and plungers formerly used in forging solid bolts may be employed in forming hollow stays from hollow rolled iron. The only change necessary, is the insertion of the small pin in the plungers as shown. The usual method for inserting the pin is to drill a 1/4-inch hole through the plunger from end to end. Pins are of ordinary soft steel about $\frac{3}{16}$-inch diameter tapered at one end, and slightly flattened at the opposite end. The flattened end prevents the pin from pulling out during the back stroke of the plunger. Because of the complete absence of foreign matter in the mandrel

*President and general manager of the Falls Hollow Staybolt Company, Cuyahoga Falls, O.

rolled bar, there is no tendency for hot metal to grind, bend or break the pin.

The sketch shows the heading tool for the final blow as being made up of six separate parts. This permits the change of inserts to comply with various specifications of different railways. A road doing its own forging has no need for a complicated heading tool of this type as the square, taper, diameters, etc., would remain fixed to the road's own specification. Thus the heading tool would be made up of only three parts, more or less, dependent on the standard forging practices of the road in question.

Tell-tale bolts are rapidly becoming obsolete, in both crown and side sheet applications. There are many reasons for the change to full hollow, but I call your special attention to one feature of sidewall application, which is of special interest to boiler makers. Using a tell-tale bolt in the water space, it is necessary for application to be made from the fire side in order to have the tell-tale in the heavy sheet. This necessitates torch cutting of the bolt on the fire side, resulting in uneven ends for driving. Furthermore the intense heat of the torch destroys the fit we are trying so hard to obtain in good bolt applications.

Contrasting full-hollow water-leg stays with the above, we find conditions covering the application much more favorable to good bolt performance. The stays can be run in from the wrapper sheet, thus permitting bolt gangs to work out in the open. The square, chamfered, well finished end of the stays is spotted in the fire sheet, at just the right length for good driving. The cutting is done at the wrapper sheet, where irregularities in burning-off can be better handled. If there is a slight surplus of stock left for driving after cutting, the gun can stay on the bolt longer without damage to the stay, on account of the extra thickness of the wrapper. Burning off at the wrapper sheet assures a perfect fit which is not destroyed by the heat of the torch. Quite the reverse is true if cutting is done in the fire sheet. Modern bolt makers hold their product to very tight specifications, and variations must be to very close tolerances. Railroads on their part, are exceedingly careful in tap inspection and insist on taps being kept up to size. All this commendable effort is wasted, when the bolts are applied from inside the box.

Back flue sheet braces made of hollow rolled iron, are now standard on a number of roads, and they are showing very satisfactory results. In big power these braces approximate 72 inches finished length. With solid braces if rupture occurs near the front end, the hanging weight of the broken stay is sufficient to mislead the man making the hammer test. With a hole through the center of the brace, for the entire length, all doubt is removed, as failure will be immediately indicated.

In forging hollow stays by this method, there is no extra labor cost involved, as exactly the same number of forged ends are obtained as in the forming of solid crown bolts. This is also true of the threading and subsequent operations. With labor and die costs equal and only a very slight extra cost for pins, any railway mechanical executive will agree that the full hollow bolt represents real staybolt improvement. This development is particularly significant in these days of constantly increasing pressures, and the resultant trend toward abnormal strains and stresses.

The absolute effectiveness of full hollow stays and braces has never been questioned, where safety, efficiency and economy are considered. For years progressive railway mechanical officials were impressed with the benefits derived from the use of hollow crowns and radials. In spite of this preference they refused to adopt them because methods of fabrication of hollow crowns, from solid iron, were exceedingly costly. This price spread between hollow and solid crown stays was prohibitive, and roads were reluctant to assume the extra cost. Today some of the large systems have adopted the use of rolled hollow stays. Every indication points to their complete satisfaction.

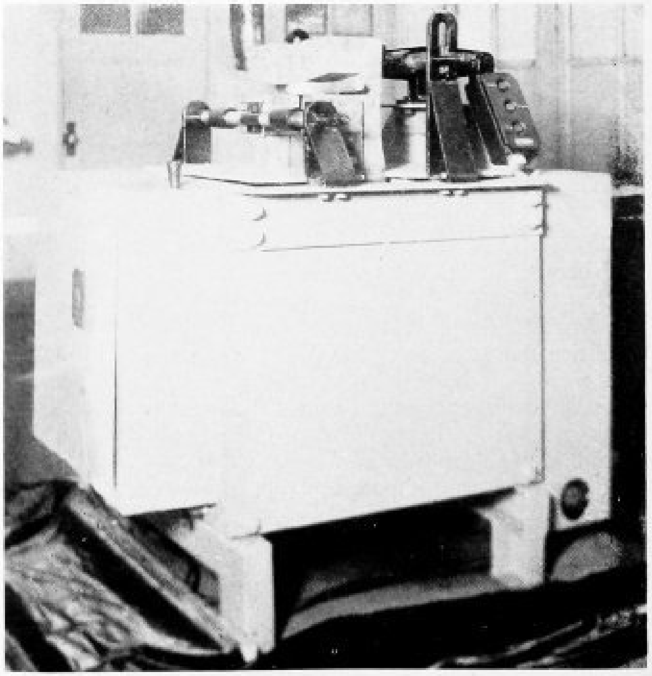
The above described process provides full hollow stays at a reasonable cost to the consumer, and I submit it to the most serious consideration of all officials interested in the performance and maintenance of locomotive boilers.

Berwick Electric Metal Heater

The American Car & Foundry Company, New York, recently added to its line of products a heater built along the same general lines as the Berwick electric rivet heater, the new product differing in the fact that instead of having one path or two metal points for the current, there are two paths with four metal points. Two of the contact points form the lower electrode on which rests the piece to be heated. The lower electrode is in the same plane as the upper electrode, which has overhanging lips that press down on the upper portion of the periphery of the piece being heated, holding it in position during the heating process. The upper electrode, is in two halves, of horseshoe shape, and set as close as possible to a core of silicon steel.

The heater is constructed with the electrode in open view, thus permitting the operator to see clearly the piece of steel heating. It can be designed to specifications to obtain end heating, and also any desired length of heat at any spot on the bar or rod.

The time of heating depends entirely upon the size of transformer, the diameter of the stock to be heated, and the length of heat. A 1-inch steel bar, with a 6-inch length of heat, takes 1¼ minutes per electrode. If a heater were furnished with three electrodes, there should be three of these pieces per minute; if a heater were furnished with five electrodes, there should be five pieces per minute. Small sizes would be heated in less time, while larger pieces would take longer.



Heater with piece of round stock heating between the electrodes

Locomotive Boiler ▲ ▲ ▲ Strength Formulas

By C. J. Zusy and G. M. Davies

Locomotive boiler calculations necessarily must be based upon the rulings of the Interstate Commerce Commission and the American Society of Mechanical Engineers boiler code. The majority of locomotive boilers come under the jurisdiction of the Interstate Commerce Commission. The following formulas and rules therefore have been based upon the Interstate Commerce Commission's rulings wherever possible.

P-1.— $$FS = \frac{S}{s}$$

where FS = Factor of safety.
S = Strength of material.
s = Stress on material.

P-2.—The minimum factor of safety allowed by the I. C. C. is 4. (Authority I. C. C. rule No. 2).

P-3.—The I. C. C. specifies that on all locomotives constructed after January 1, 1915, the maximum allowable stress on firebox and combustion-chamber stays shall not exceed 7500 pounds per square inch and on round, rectangular and gusset braces 9000 pounds per square inch. (Authority I. C. C. rule No. 3 a).

P-4.—For locomotives constructed prior to January 1, 1915, the maximum allowable stress on stays and braces shall be based on a minimum factor of safety of 4, except that when a new firebox and wrapper sheet are supplied to such locomotives they shall be altered so as not to exceed stresses shown in the above paragraph. (Authority I. C. C. rule No. 3 b).

Table 1—Tensile Strength Per Square Inch

Material	Strength	Authority
Steel plates (boiler steel)	50,000 pounds (assumed maximum)	I.C.C. rule No. 4
Wrought Iron plates	45,000 pounds (assumed maximum)	I.C.C. rule No. 4
Steel plates (firebox steel)	50,000 pounds (assumed maximum)	I.C.C. rule No. 4
Steel rivets	45,000-55,000 pounds (assumed maximum)	A.S.M.E.
Wrought iron	48,000-52,000 pounds (assumed maximum)	A.S.M.E.
Structural shapes	50,000 pounds (assumed maximum)	U.S.R.A. Spec. R-33
Steel castings	60,000 pounds (assumed maximum)	U.S.R.A. Spec. R-11
Cast iron	15,000 pounds (assumed maximum)	*Machinery*

Table 2—Shearing Strength Per Square Inch

Material	Strength	Authority
Steel rivets (single)	44,000 pounds (assumed maximum)	I.C.C. rule No. 5
Steel rivets (double)	88,000 pounds (assumed maximum)	I.C.C. rule No. 5
Iron rivets (single)	38,000 pounds (assumed maximum)	I.C.C. rule No. 5
Iron rivets (double)	76,000 pounds (assumed maximum)	I.C.C. rule No. 5
Structural steel	50,000 pounds (ultimate)	*Machinery*
Cast steel	60,000 pounds (ultimate)	*Machinery*
Cast iron	18,000 pounds (ultimate)	*Machinery*
Wrought iron	40,000 pounds (ultimate)	*Machinery*

Table 3—Crushing Strength Per Square Inch

Material	Strength	Authority
Steel plates	95,000 pounds	A.S.M.E. page 3 P-15
Wrought iron plates	85,000 pounds	Ratioed with tensile
Steel rivets	95,000 pounds	*Machinery*

P-5.—The efficiency of a riveted seam is the ratio of the strength of a unit length of the seam to the strength of the same unit length of the solid plate and should be calculated as illustrated in the following examples.

P-6.—The distance between the center lines of any two adjacent rows of rivets, or the back pitch measured at right angles to the direction of the joint, shall have the following minimum values:

(a).—If $\frac{p}{d}$ is 4 or less, the minimum value shall be

$$1.75\ d.$$

(b).—If $\frac{p}{d}$ is over 4, the minimum value shall be

$$1.75d + 0.1\ (p - 4d)$$

where

p = pitch of rivets in the outer row where a rivet in the inner row comes midway between two rivets in the outer row, inches.

p = pitch of rivets in the outer row less the pitch of rivets in the inner row where two rivets in the inner row come between two rivets in the outer row, inches. (It is assumed here that the joints are of the usual construction where the rivets are symmetrically spaced.)

d = diameter of the rivet holes, inches.

P-7.—On longitudinal joints the distance from the centers of rivet holes to the edges of the plates, except rivet holes in the ends of butt straps, shall be not less than one and one-third times the diameter of the rivet holes.

P-8.—The strength of circumferential joints of boilers shall be at least 50 percent of that required for the longitudinal joints of the same structure.

P-9.—With butt and double-strap construction, longitudinal joints of any length may be used, provided the tension test specimens are so cut from shell plates and butt-strap plates that their lengthwise direction is parallel with the circumferential seams of the boiler, and the tests meet the standards prescribed in the specifications for boiler-plate steel.

P-10.—Butt straps and the ends of shell plates forming the longitudinal joints shall be rolled or formed by pressure, not blows, to the proper curvature.

P-11.—The ultimate strength of a joint which has been properly welded by the forging process, shall be taken as 28,500 pounds per square inch, with steel plates having a range in tensile strength of 45,000 to 55,000 pounds per square inch. Autogenous welding may be used in boilers in cases where the strain is carried by other construction which conforms to the requirements of the code and where the safety of the structure is not dependent upon the strength of the weld.

P-12.—In the following methods of calculating efficiency of seams, let

TS = tensile strength of plate, pounds per square inch.
t = thickness of shell plate, inches.
B = thickness of welt strips, inches.
P = pitch of rivets, inches, on row having greatest pitch.
D = diameter of rivet after driving, inches, or diameter of rivet hole.
A = cross sectional area of rivet after driving, square inches.
s = shearing strength of rivet in single shear, pounds per square inch.
S = shearing strength of rivet in double shear, pounds per square inch.

C = Crushing strength of plate, pounds per square inch.

P-13.—The method of calculating the seam efficiency of a single-riveted lap joint is as follows:

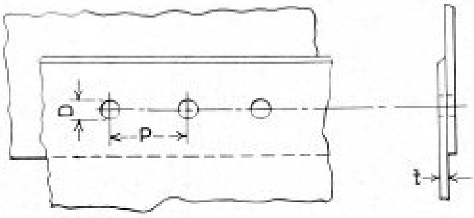


Fig. 1.—Single-riveted longitudinal or circumferential lap joint

This joint may fail in the following ways:
1.—Tearing of plate between rivet holes.
2.—Shearing of one rivet in single shear.
3.—Crushing of plate in front of one rivet hole.

Resistance to Failure

$$1.\text{—}\ \frac{(P-D)\times t\times TS}{P\times t\times TS}\ \text{or}\ \frac{P-D}{P}$$

$$2.\text{—}\ \frac{A\times s}{P\times t\times TS}$$

$$3.\text{—}\ \frac{D\times t\times C}{P\times t\times TS}$$

Efficiency = Least value obtained in 1, 2 or 3.

Example.—Assuming TS = 55,000 pounds.

t = ¼ inch = .25 inch. A = .3712 square inches.
P = 1⅝ inches = 1.625 inches. s = 44,000 pounds.
C = 95,000 pounds.
D = $\frac{11}{16}$ inch = .6875 inch.

$$1.\text{—}\ \frac{(1.625-.6875)\times .25\times 55{,}000}{1.625\times .25\times 55{,}000}=57.6$$

$$2.\text{—}\ \frac{.3712\times 44{,}000}{1.625\times .25\times 55{,}000}=73.$$

$$3.\text{—}\ \frac{.6875\times .25\times 95{,}000}{1.625\times .25\times 55{,}000}=73.$$

Efficiency = 57.6 percent.

P-14.—The method of calculating the seam efficiency of a double-riveted lap joint is as follows:

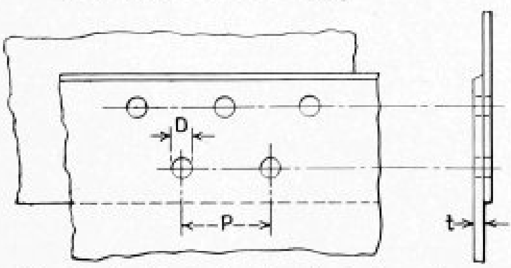


Fig. 2.—Double-riveted longitudinal or circumferential lap joint with staggered riveting

This joint may fail in the following ways:
1.—Tearing of plate between rivet holes.
2.—Shearing of two rivets in single shear.
3.—Crushing of plate in front of two rivet holes.

Resistance to Failure

$$1.\text{—}\ \frac{(P-D)\times t\times TS}{P\times t\times TS}\ \text{or}\ \frac{P-D}{P}$$

$$2.\text{—}\ \frac{2A\times s}{P\times t\times TS}$$

$$3.\text{—}\ \frac{2D\times t\times C}{P\times t\times TS}$$

Efficiency = Least value obtained in 1, 2 or 3.

Example.—Assuming TS = 55,000 pounds.

t = $\frac{5}{16}$ inch = .3125 inch. A = .4418 square inch.
P = 2⅞ inches = 2.875 inches. s = 44,000 pounds.
C = 95,000 pounds.
D = ¾ inch = .75 inch.

$$1.\text{—}\ \frac{(2.875-.75)\times .3125\times 55{,}000}{2.875\times .3125\times 55{,}000}=73.91$$

$$2.\text{—}\ \frac{2\times .4418\times 44{,}000}{2.875\times .3125\times 55{,}000}=78.6$$

$$3.\text{—}\ \frac{2\times .75\times .3125\times 95{,}000}{2.875\times .3125\times 55{,}000}=90.1$$

Efficiency = 73.91 percent.

P-15.—The method of calculating the seam efficiency of a triple-riveted lap joint is as follows:

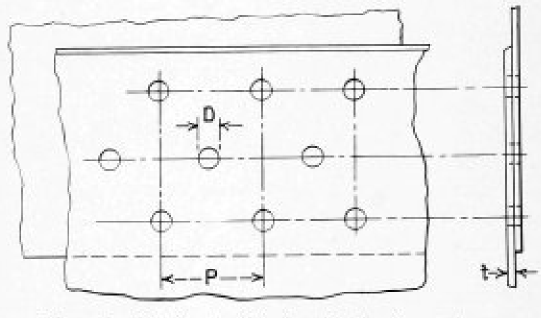


Fig. 3.—Triple-riveted longitudinal or circumferential lap joint with staggered riveting

This joint may fail in the following ways:
1.—Tearing of plate between rivet holes in outside row.
2.—Shearing of three rivets in shingle shear.
3.—Crushing of plate in front of three rivet holes.

Resistance to Failure

$$1.\text{—}\ \frac{(P-D)\times t\times TS}{P\times t\times TS}=\frac{P-D}{P}$$

$$2.\text{—}\ \frac{3A\times s}{P\times t\times TS}$$

$$3.\text{—}\ \frac{3D\times t\times C}{P\times t\times TS}$$

Efficiency = Least value obtained in 1, 2 or 3.

Example.—Assuming TS = 55,000.

t = ⅜ inch = .375 inch. A = .51849 square inches.
P = 3 inches. s = 44,000 pounds.
D = $\frac{13}{16}$ inch = .8125 inch. C = 95,000 pounds.

$$1.\text{—}\ \frac{(3-.8125)\times .375\times 55{,}000}{3\times .375\times 55{,}000}=72.9$$

$$2.\text{—}\ \frac{3\times .51849\times 44{,}000}{3\times .375\times 55{,}000}=110$$

$$3.\text{—}\ \frac{3\times .8125\times .375\times 95{,}000}{3\times .375\times 55{,}000}=140$$

Efficiency = 72.9 percent.

(To be continued)

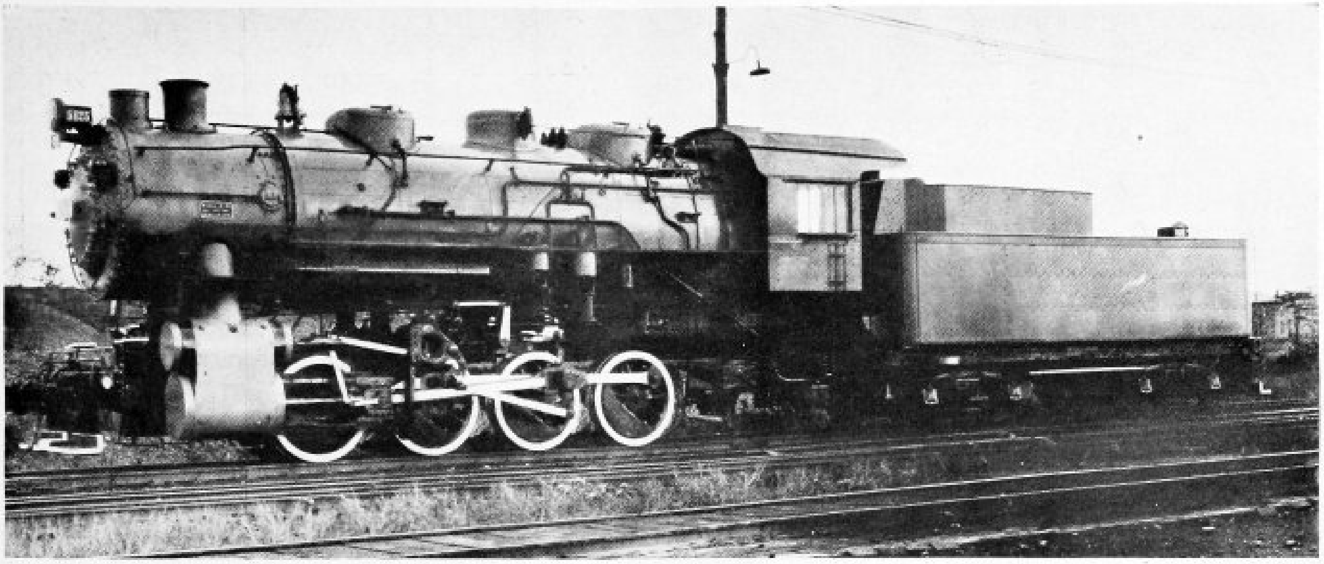


Fig. 8.—Switching engine equipped with Euduro A firebox steel and syphon of same material

Thermal Expansion of ▲ ▲ ▲ the Locomotive Boiler*

By H. L. Miller†

What is the scientist doing to help the railroad man along in this battle of expansion and contraction?

Fig. 9 shows the relative amounts of expansion of various metals when heated up to various temperatures. Brass and copper expand the most. Enduro KA2, an alloy of the stainless type with 18 percent chromium and 8 percent nickel added to the iron is next in expansion. Wrought iron, mild steel and cast iron are quite close together, and down below this point we have Enduro A which is an alloy of iron with 18 percent chromium and about 1 percent silicon. The ratio of expansion between Enduro A and common firebox steel is approximately about 10 to 14 or about 28 percent less expansion and would build up less strain in itself.

The laboratory tests, Fig. 10, tell us that the creep limit of Enduro A from 500 degrees F. to 900 degrees F. is between two and three times that of ordinary steel. That is, it will carry two to three times the load without stretching or distortion. We have also found that while mild steel becomes "blue brittle" when heated between 600 degrees F. and 1000 degrees F., Enduro A remains exceedingly tough throughout this range of temperature. It is not very much affected by blue brittleness as is common steel.

Fig. 11 shows the load limit lines for Enduro A and common steel up to 900 degrees F. The expansional stress lines are theoretical and would vary with the design of the parts and the distribution of heat in the plates, but given the same temperatures the stress due to expansion in Enduro A will always be less than in common steel. The ability to resist this stress is so much greater that the result would be to give the Enduro A, a much higher range of temperature for service than common steel. This alloy is practically noncorrodable in any boiler water and another feature in its favor caused by its low expansion was discovered in service tests on the Nickel Plate Railroad and that is the boiler scale falls off from the plate when the boiler is washed out. When cooling down, the plate and scale both shrink but the scale shrinks more than the plate and peels off when the water washes down the plate.

Out in Ohio we have some very hard water. Engine No. 5125, Fig. 8, on the Wheeling & Lake Erie Railroad was built in the railroad's shops at Brewster in September of last year. It was equipped with a complete firebox and two syphons of Enduro A. This job is all welded, not a rivet in the firebox. It is washed out every 7 days. We are expecting a long life for this firebox which is operating on a very hard water. The limit on the flues in this district is 25,000 miles. Locomotives then must be stripped and cleaned of scale, so you can see we picked a good spot to test this material.

Now there is one other great difference in temperature in a boiler to which I wish to call your attention and that is the difference between top and bottom water and resultant differences in plate temperatures. The top part of the shell in contact with steam at a constant temperature of 388 degrees F. for 200 pounds per square inch pressure will be quite close to 375 degrees F. for the top part of the shell. The bottom parts will be in contact and take their temperature from the colder water in the bottom. This difference in temperature and its resultant stress due to unequal expansion tend to put heavy strains on the shell and rivets and are one of the contributing causes to so-called caustic embrittlement. The answer to this problem is circulation. Keep the water moving. The Nicholson

* Second instalment of a paper presented at a recent meeting of the New England Railroad Club held in Boston. The first installment appeared on page 41 of the February issue.

† Metallurgist Republic Steel Corporation, Youngstown, O.

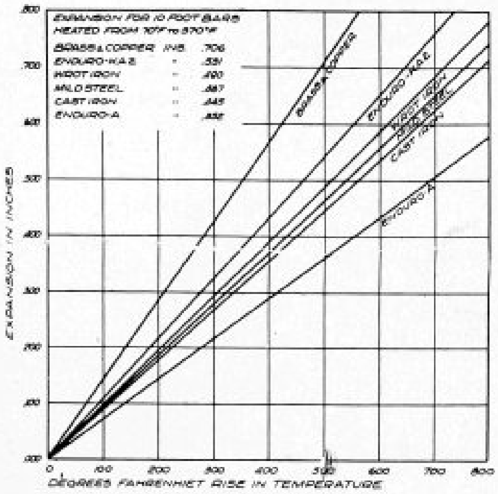


Fig. 9.—Expansion of various metals

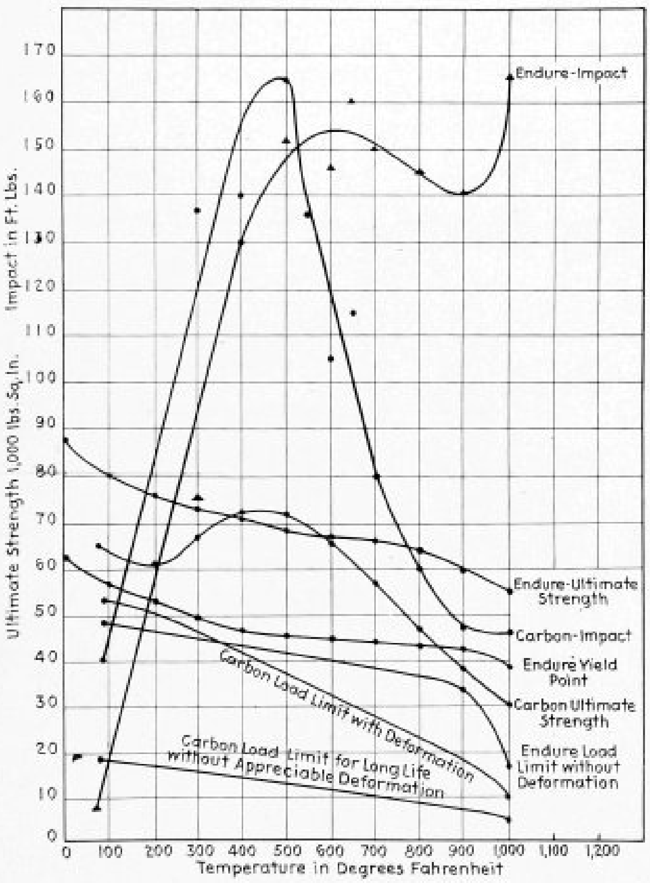


Fig. 10.—Comparison of Enduro A with common steel

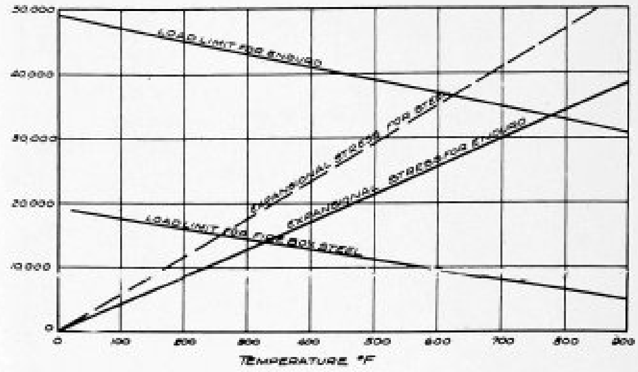


Fig. 11.—Load limits and theoretical stress lines

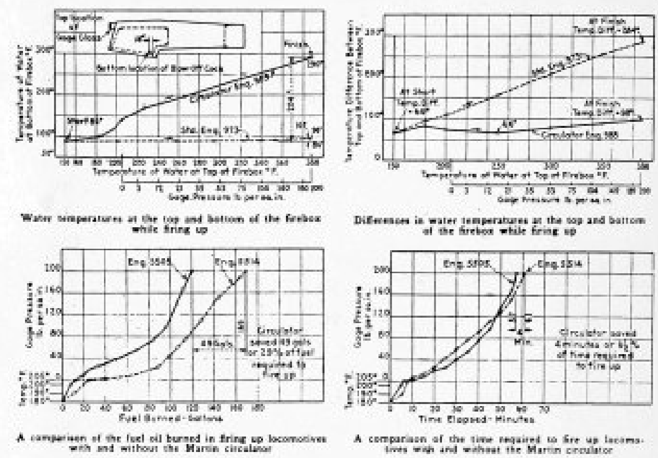
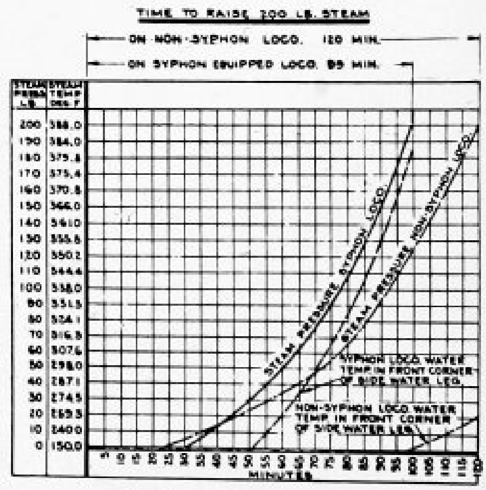


Fig. 12.—Test results with Martin water tables on the Texas & Pacific



TO RAISE 200 LB. OF STEAM

TIME USED	COAL USED
NON-SYPHON LOCO.....120. MIN.	NON-SYPHON LOCO.....2265. LB.
SYPHON EQUIPPED LOCO.....99. MIN.	SYPHON EQUIPPED LOCO.....2042. LB.
TIME SAVED.....21. MIN.	COAL SAVED.....223. LB.
SAVING OF TIME.....17.5 %	SAVING IN FUEL.....10 %

Fig. 13.—Firing-up test on mountain type locomotive (Courtesy Locomotive Firebox Company)

thermic syphon, Martin water tables, and watertube fireboxes are the best relievers of strains due to unequal heating.

Oil-burning locomotives are especially subjected to sudden changes of temperatures in the fireboxes and resultant stresses and strains. The Martin water tables give added heating surface and rapid circulation in the boilers. Fig. 12 shows that on firing up, the temperature on a Martin-equipped engine was up to 290 degrees F. at the bottom corner of the firebox, while a standard engine of the same class was only up to 96 degrees F. in the bottom corner with water on top of the crown sheet at 388 degrees F. The temperature difference in the Martin-equipped boiler was only 98 degrees F. and in the regular boiler it was 284 degrees F. A temperature difference of 275 degrees F. between the top and bottom of the shell on a B. & A. class A-1 boiler would mean a difference of 0.972 inch or nearly one inch in expansion and would tend to hump up the boiler in the middle and strain the rivets between courses of the shell.

This chart, Fig. 13, shows a firing-up test on a syphon-equipped boiler and a standard boiler of the same class. This test showed that the water in the bottom corner of the water leg was within 8 degrees of the steam temperature when the boiler popped, while the standard boiler showed only 260 degrees F. at the time the boiler popped or 120 degrees difference in this case. The oil-fired engines with Martin circulators popped in about an hour's time. The coal-fired engines required 1⅔ hours for the syphon boiler and two hours for the non-syphon. Fuel savings also were shown.

In conclusion, we have tried to show you the magnitude of these temperature and expansional stresses which are causing the heavy repairs found necessary on some of our large boilers and to throw what light we could on remedies to counteract or relieve these conditions. The men of the railroad world are making great strides in the improvement of transportation and lowering its cost and as a steel man I would feel very glad indeed if any suggestion or discovery that I should make, would be of any help to the railroad men.

Proposed Specifications ▲ ▲ ▲ for Fusion Welding

The following proposed revisions, which are now under the joint consideration of the American Welding Society and the Boiler Code Committee of the American Society of Mechanical Engineers, are for embodiment in the Code for Unfired Pressure Vessels and for embodiment in the Code for Power Boilers.

The Boiler Code Committee invites communications from those who approve the specifications, as well as from those who wish to suggest changes. Communications should reach the Secretary of the Boiler Code Committee, 29 West 39th St., New York, not later than April 6, 1931, in order that they may be presented to the committee for consideration.

Proposed Revisions and Additions to Code for Unfired Pressure Vessels for Fusion-Welded Construction

Pressure vessels may be fabricated by means of fusion welding provided the construction is in accordance with the requirements for material and design as required by this Code and the fusion welding process used conforms to the specifications for the grade of welding indicated for each class of vessel.

Fusion-welded pressure vessels shall be classified according to the following schedule. The grade of welding required for each class shall be as indicated.

Class 1. All vessels covered by this Code, constructed in accordance with the rules for this class, may be used for any purpose. This class includes vessels containing noxious, poisonous, or inflammable liquids or gases. These vessels shall be welded with Grade A welding. The allowable working stress shall be 18 percent (⅕ of 90 percent) of the minimum of the specified tensile range of the plate used.

Class 2. All vessels covered by this Code are included in this class, excepting those containing noxious or poisonous gases or liquids, provided the plate thickness does not exceed 1¼ in. These vessels may be welded with either Grade B or Grade C welding. When Grade B welding is used, the allowable stress shall be 16 percent (⅕ of 80 percent) of the minimum of the specified tensile range of the plate used. When Grade C welding is used, the allowable stress shall be 14 percent (⅕ of 70 percent) of the minimum of the specified tensile range of the plate used.

Class 3. All vessels covered by this Code not exceeding ⅜ in. plate thickness and used for the storage of gases or liquids at temperatures not exceeding their boiling temperature at atmospheric pressure, may be included in this class, except those containing noxious, poisonous, or inflammable liquids or gases. These vessels may be welded with Grade D welding. The allowable working stress shall be 12 percent (⅕ of 60 percent) of the minimum of the specified tensile range of the plate used for butt joints, and 10 percent (⅕ of 50 percent) for double-fillet-welded lap joints.

The allowable working stresses on the joints in pounds per square inch for different temperatures are given in Table 1.

Note: It does not follow that any vessel in which the plate thickness does not exceed ⅜ in. necessarily falls in Class 3, since if welded with Grade A welding it would fall in Class 1, and if welded with Grade B or C welding it would fall in Class 2.

The above classification gives the general features governing the classes into which the various vessels will be placed. The Boiler Code Committee will prepare a list indicating the classes into which the vessels for various uses shall be grouped. It is proposed to stamp each vessel to designate its class and the grade of welding used

Plate Material. The materials used in the fabrication of any fusion-welded pressure vessel covered by this Code shall conform to Specifications S-1 for Steel Boiler Plate and S-2 for Steel Plates of Flange Quality for Forge Welding, of Section II (1930 Edition) of the Code.

Longitudinal Joints. Longitudinal joints on Class 1 and Class 2 vessels shall be of the butt type and shall be reinforced at the center of the weld on each side of the plate in accordance with Par. U-71. This reinforcement may be machined off, if so desired. The longitudinal joints of Class 3 vessels may be of the butt or lap type. If of the lap type the throat dimension of the weld shall not be less than 1¼ T, where T represents the thickness of the plate. Both edges of the lap shall be welded and the overlap of the plate shall not be less than $4T$.

Circular Joints. Circular joints on Class 1 and Class 2 vessels shall be of the butt type and shall conform to the requirements for longitudinal joints. Circular joints on Class 3 vessels may be of the butt or lap type, either of which shall conform to the requirements for longitudinal joints.

Dished Heads. Dished heads concave to the pressure when used on Class 3 vessels may be inserted in shells with a driving fit and fillet welded inside and outside, except that on vessels 20 in. in diameter or less the heads may be welded on the outside only.

Qualified Welders. All welding on vessels covered by this Code shall be done by "qualified welders." A "qualified welder" is one who has demonstrated his ability to produce welds which will meet the required tests for the grade of welding for which he is to qualify.

Each qualified welder shall be assigned by the manufacturer an identifying number, letter, or symbol which shall be stamped on all vessels adjacent to and at intervals of not more than 3 ft. along the welds which he makes either by hand or by machine.

The manufacturer shall maintain a record of the qualified welders in his employ, showing the date and result of the qualification tests and the identification mark assigned to each. These records shall be accessible to the inspector at all times.

A welder's qualification shall be effective for a period of 6 months only, at the end of which time a repetition of the qualification tests shall be made.

Stress Relieving. All Class 1 fusion-welded vessels shall be stress relieved. Class 2 fusion-welded vessels shall be stress relieved in accordance with the following:

Longitudinal welds shall be stress relieved where the wall thickness is greater than 0.55 in. and the shell diameter less than 20 in.

Transverse or girth welds shall be stress relieved where the wall thickness is greater than 0.7 in. and the shell diameter less than 40 in.

For other wall thicknesses and shell diameters, stress relieving shall be required for all welds where the ratio of the diameter to the cube of the shell thickness is less than 118.

Where stress relieving is required, it shall be done in accordance with the rules given in Par. 4 of the Proposed Specifications for Fusion Welding of Unfired Pressure Vessels.

Holes. No unreinforced holes shall be located in a welded joint. When an unreinforced hole in the plate is located near a welded joint, the minimum distance between the edge of a hole and the edge of a joint shall be equal to the thickness of the plate when the plate thickness is from 1 in. to 2 in. With plates less than 1 in. thick, this minimum distance shall be 1 in. With plates over 2 in. in thickness, the minimum distance shall be 2 in.

Inspection. An inspector may designate stages of the work at which he wishes to inspect the welded joints of a Class 1 vessel, and the manufacturer shall either submit the drum for inspection in such partly completed condition, or as an alternative he may permit the inspector to witness stages of the welding operation at such times as the inspector may select.

NOTE: The X-ray examination required for the joints for Class 1 vessels provides a greater safeguard than any shop inspection.

Class 2 pressure vessels shall be inspected at least twice, and every Class 3 pressure vessel shall be inspected at least once, during construction.

For Class 2 vessels the first inspection shall be made during the welding of the longitudinal joint. At this time the inspector shall inspect the plate material and the fit-up of the work, and observe the workmen to see that only qualified welders are employed on the work of welding. A second inspection shall be made during the welding of the circumferential joints. At this time the inspector shall check any new material being used which may not have been examined at the time of the first inspection, also the fit-up of the vessel at this stage of construction, and again observe the welding operators to see that only qualified welders are employed on the work of welding.

For Class 3 vessels one inspection shall be made during the welding of the longitudinal joint. At this time the inspector shall check the plate material and the fit-up of the work, and observe the workmen to see that only qualified welders are employed on welding work.

Every pressure vessel covered by this Code shall be inspected while under the hydrostatic-pressure test.

The manufacturer shall certify that only qualified welders, as designated by their qualification symbols, have been employed on the work of welding.

Hydrostatic and Hammer Tests. All fusion-welded pressure vessels which are not stress relieved shall be subjected to a hydrostatic pressure of sufficient intensity to stress the longitudinal welded joints to 1½ times the maximum allowable working stress for the grade of welding used in the tank in question, and while subject to this hydrostatic pressure a thorough hammer test shall be applied. This test shall consist of striking the sheet on both sides of the welded joint a sharp blow with a long-handled hammer which shall be 10 percent of the weight of 1 sq. ft. of the wall of the vessel and not less than 2 lb. The blows shall be struck 2 to 3 in. apart along the joints, as rapidly as a man can conveniently strike a sharp, swinging blow, and as hard as can be struck without indenting the metal of the sheet. After the hammer test, the pressure shall be raised to a point which will stress the longitudinal joint to 2¼ times the maximum allowable working stress, and held at this pressure for three minutes.

All vessels which have been stress relieved shall be subjected to a hydrostatic pressure of sufficient intensity to stress the longitudinal joints to 2¼ times the maximum allowable working stress, and held at this pressure for three minutes.

Specifications for the Various Grades of Welding

Grade A Welding. The specifications for Grade A welding shall be the Proposed Specifications for Fusion Welding of Unfired Pressure Vessels, with the exception that Par. 8, Impact Tests, is to be omitted and Pars. 12, Hydrostatic and Hammer Tests, 13, Holes, and 14, Allowable Working Stress, are to be revised as herein set forth.

(Continued on page 84)

TABLE 1. ALLOWABLE STRESSES AT DIFFERENT TEMPERATURES FOR THE THREE CLASSES OF VESSELS AND FOR THE FOUR GRADES OF WELDING FOR STEEL SHELL PLATES COVERED BY THE SPECIFICATIONS

Class	Grade of welding	Longitudinal joint efficiency, percent	Minimum tensile strength, lb. per sq. in.	Temperature, Degrees Fahrenheit 60	650	700	750	800	850	900	950
			55,000	9900	9900	9900	9000	7200	6100	4950	3600
1	A	90	50,000	9000	9000	9000	8200	6600	5450	4350	3250
			45,000	8100	8100	8100	7400	5900	4900	3900	2900
			55,000	8800	8800	8800	8000	6400	5400	4400	3200
	B	80	50,000	8000	8000	8000	7300	5800	4850	3850	2900
2			45,000	7200	7200	7200	6550	5250	4350	3450	2550
			55,000	7700	7700	7700	7000	5600	4750	3850	2800
	C	70	50,000	7000	7000	7000	6350	5100	4250	3400	2500
			45,000	6300	6300	6300	5700	4550	3800	3000	2300
	D		55,000	6600a	....	....	....	....	....	....	....
	Butt-weded	60	50,000	6000a	....	....	....	....	....	....	....
3	joints		45,000	5400a	....	....	....	....	....	....	....
	D		55,000	5500a	....	....	....	....	....	....	....
	Lap-welded	50	50,000	5000a	....	....	....	....	....	....	....
	joints		45,000	4500a	....	....	....	....	....	....	....

a These values may be employed for all conditions for which Class 3 vessels may be used.

The Boiler Maker

VOLUME XXXI NUMBER 3

PUBLISHED Monthly by the Simmons-Boardman Publishing Company, 34 North Crystal Street, East Stroudsburg, Pa., with Executive Offices at 30 Church Street, New York City.

Edward A. Simmons, President. Henry Lee, Vice-President. C. R. Mills, Vice-President. L. B. Sherman, Vice-President. Samuel O. Dunn, Vice-President. F. H. Thompson, Vice-President. Roy V. Wright, Secretary. John T. De Mott, Treasurer. George Slate, Business Manager.

Chicago: 105 W. Adams Street. Washington, D. C.: 17th and H Streets, N. W. Cleveland: Terminal Tower. San Francisco, Cal.: 215 Market Street.

Subscription Price: United States, Canada and Mexico, $2.00, Foreign Countries, $3.00 a Year. Single Copies, 35 Cents.

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THE BOILER MAKER is a member of the Associated Business Papers, Inc. (A. B. P.), and the Audit Bureau of Circulation (A. B. C.)

EDITORIAL STAFF: H. H. Brown, Editor. L. S. Blodgett, Managing Editor. W. Lombard, Associate Editor.

Contents

Communications

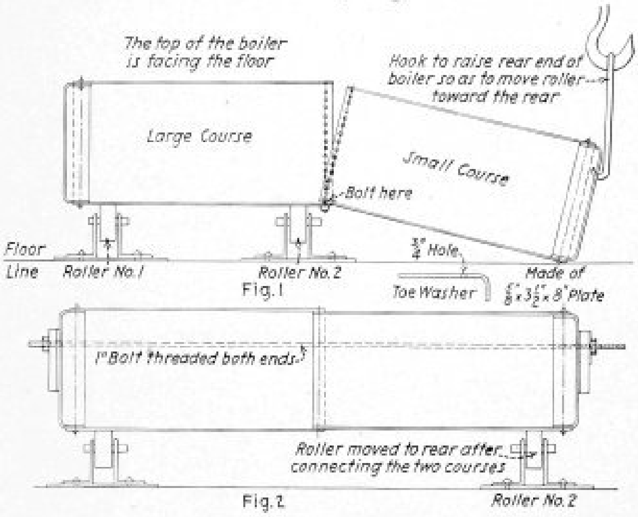
Fitting Boiler Courses

TO THE EDITOR:

After reading what Mr. Gardner had to say in the February issue of THE BOILER MAKER, I would like to submit my idea of coursing a return tubular boiler between the diameters 36 inches and 84 inches.

First, place the large course on two sets of rolls with the center of the top of the boiler facing the floor. Mark your center hole on the inside of the large course plainly. Have the center line of the small course toward the floor, as in the large course; mark the center hole, then lift the small course with a chain through the tube hole and through the inside of the small course with the crane and carry toward the large course.

Put one helper inside the large course with a long taper pin or a wrench that has a long tapered end, so that when the crane operator lets the small course down he puts his wrench in the center hole of the small course and draws it to meet the center hole of the large course. After these two courses have been brought together, and while the boiler maker is steadying the small course on the crane, the helper pulls out the wrench



Method of assembling boiler courses

and replaces it with a good bolt from the inside, connecting both courses. The boiler maker will then apply a nut and tighten the same from the outside.

The crane man will let the small course down and catch hold of the back head with a small pair of hooks or a chain, raising the rear end so that roller No. 2 can be moved within 4 inches of the rear seam. This will cause the courses to come toward each other.

The boiler maker then orders the helper, who is inside, to put bolts through certain holes where connection is to be made to allow him to fasten toe washers on the large course so that when tightened down it will separate the two plates.

Then put a 1-inch bolt, about 2 feet longer than the boiler and threaded and nutted on both ends, through a straightening bar then through tube holes and through the bar at the far end, Fig. 2.

As the boiler maker hammers the sides and top (that portion which is really the bottom of the boiler but which happens to be in a reversed position), the second helper tightens the nut on the long bolt with a long handle wrench.

As the small course enters the large course, the boiler maker removes the toe washers so the small course can enter freely.

London, Ont. EDGAR COOK.

Our Front Cover

The illustration on the front cover of this issue shows an interesting kink in use at the Huntington, W. Va., shops of the Chesapeake & Ohio Railroad. This device, a tube and a flue puller, is of the winch type and is clamped to the front end of the locomotive. It is simply made of a round bar, to which a chain is attached, extending across the front end of the locomotive and held in place by bearings at each side. At one end of this rod is a square shank to which an air motor is attached for operation.

Questions and Answers Pertaining to Boilers

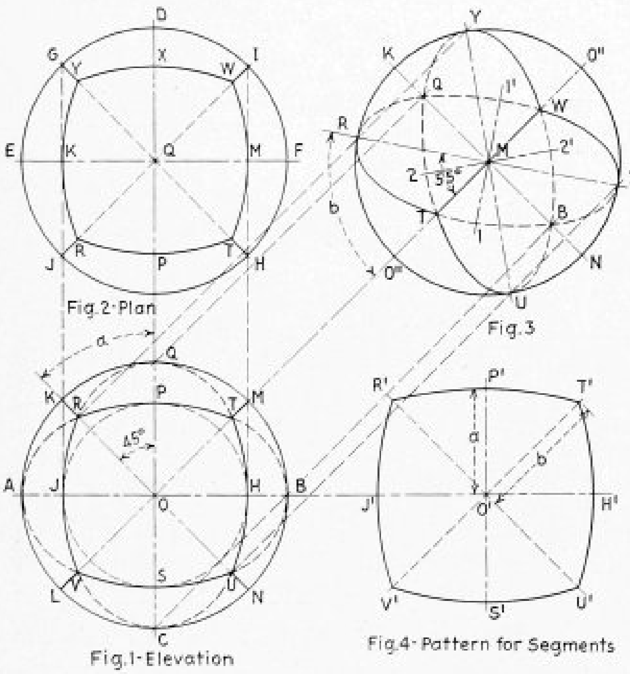
This department is maintained for the purpose of helping those who desire assistance on practical boiler shop problems. Inquiries should bear the name and address of the writer. Anonymous communications will not be considered. The identity of the writer, however, will not be disclosed unless the editor is given special permission to do so.

By George M. Davies

Layout of a Sphere

In the February, 1931, issue of The Boiler Maker, T. M. P. asked for a description of the method for laying out the shell of a sphere in six equal parts the shape of which would be roughly rectangular instead of being shaped like a piece of an orange peel. Such a solution is given as follows:

The development of a spherical head is accomplished by making a template of one of the segments and duplicating this six times to complete the sphere. With the



Method of laying out a sphere with six similar segments

point *O* in the elevation, Fig. 1, as a center, describe a circle with a radius taken from the center of the sphere to the neutral thickness of the metal. Draw the corresponding circle in the plan view.

In the plan view, Fig. 2, draw the diagonal lines *G-H* and *I-J* at an angle of 45 degrees to the line *E-F*. Draw lines through points *G, J, I* and *H* parallel to line *D-C* intersecting the circumference of the elevation at *K* and *M* and cutting the line *A-B* at *J* and *H*. With *O* as a center and *J-O* as a radius scribe a circle intersecting line *C-D* at *P* and *S*. Thus the points *J, P, H* and *S* on the boundary of the segment are located.

The next step is to locate the points *R, T, U* and *V*. Since each boundary line drawn on the surface of the sphere is the arc of a great circle, any great circle other than the circumference of the elevation will appear as a true ellipse. Then with *Q-O* as a major axis and *J-O* as a minor axis, draw the ellipse *J-R-Q-T-H-U-C-V*. With *A-O* as a major axis and *P-O* as a minor axis draw the ellipse *P-T-B-U-S-V-A-R*. Thus the intersections of the two ellipses locate the points *R, T, U* and *V*. The sides of the segment *P-T-H-U-S-V-J-R* are sections of the ellipses.

The lines *K-R, T-M, U-N* and *V-L*, Fig. 1, are taken at an angle of 45 degrees to the line *A-B* and indicate the intersections of the other segments. Thus *K-R*, Fig. 1, is the elevation of line *R-K-Y* in the plan view, Fig. 2; *T-M*, Fig. 1, is the elevation of *T-M-W* in the plan, Fig. 2, and *R-P-T* is reproduced at *R-P-T* in the plan.

The true length of lines *J-O-H* and *P-O-S* is indicated by the length of arc *K-Q-M*, Fig. 1. In order to obtain the true length of line *R-O-U*, a view taken perpendicular to *R-O-U* must be developed. Thus line *O″-O″* is produced perpendicular to *R-O-U* and at any point *M* a circle is drawn having the same radius as the sphere. Parallel to line *K-O-N* in the elevation the line *K-M-N* is drawn through *M*, Fig. 3.

Lines are now drawn parallel to *O″-O″* through points *R* and *U*, Fig. 1, intersecting the circumference of the circle, Fig. 3, at *R, Y, U* and *Z*. Lines are drawn parallel to line *O″-O″* through points *Q* and *B*, Fig. 1, intersecting line *K-M-N* at *Q* and *B*, Fig. 3.

Draw the lines *R-M-Z* and *Y-M-U* and draw the lines *1-M-1′* and *2-M-2′* respectively perpendicular to the lines *R-M-Z* and *Y-M-U*.

Now with *Y-M* as a major axis and *M-2* as a minor axis and the point *Q* as one point on the ellipse, draw the ellipse *2-Q-Y-W-2′-B-U-T*. In the same manner draw the ellipse *R-Q-1′-W-Z-B-1-T* and the intersections at points *W* and *T* locate the intersections of the segments.

The arc *R-O″-U* in Fig. 3 is the true length of the line *R-O-U*, Fig. 1.

To develop the pattern for the segments, draw the horizontal, vertical and 45-degree diagonal lines through point *O′*, Fig. 4. On the horizontal and vertical lines set off *P′-O′, H′-O′, S′-O′* and *J′-O′* equal to *K-Q*, Fig. 1. On the diagonals, set off *T′-O′, U′-O′, V′-O′* and *R′-O′* equal to *R-O″*, Fig. 3.

With the points *R′, P′* and *T′* located, strike an arc through these points, completing one side of the segment. Duplicate this method for the three remaining sides. The pattern thus formed must of course, be bumped out to the true curvature of the sphere. Allowance must be made for laps, if riveted.

A simple mathematical method of obtaining the true lengths of the segments without the necessity of laying out the circles is as follows:

Let, D = neutral diameter of the sphere
a = true length of arc *K-Q*, Fig. 1
b = true length of arc *R-O′*, Fig. 3

Then,

$$a = \pi D \times \frac{45}{360} = .125 \quad \pi D = .3927D$$

$$b = \pi D \times \frac{55}{360} = .1528 \quad \pi D = .4799D$$

With the dimensions a and b, layout the pattern as previously described.

Flat Plate Size for Forming a Flanged Head

Q.—Being a reader of THE BOILER MAKER I would like to receive information regarding the following:

In increasing or estimating the flat size circle required to make a flanged and dished or plain flanged head, is there a set rule to follow to determine the correct size? This is to apply on spun and pressed heads.

Also, is there a book or index published that will give the rise of arcs on circles say from 10 inches diameter to 132 inches diameter? These arcs scribed at any place across the circle. R. S. M.

A.—The diameters of flat plates, for flanged and dished heads, where the thickness of the metal does not change, should be the exact developed size, taken along the neutral axis of the sheet, as shown in Fig. 1.

Where the metal is drawn while flanging as in the case of the pressed steel dome shown in Fig. 2, the size

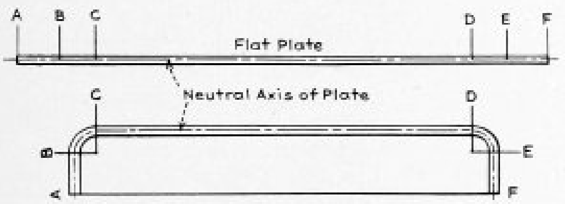


Fig. 1.—Flanged plate where thickness does not change

of the flat plate is usually determined by test or by the results of previous experience.

The rise of arcs where the diameter of the circle and length of the arc is known, can be determined by multiplying the radius of the circle by the versed-sine of one-

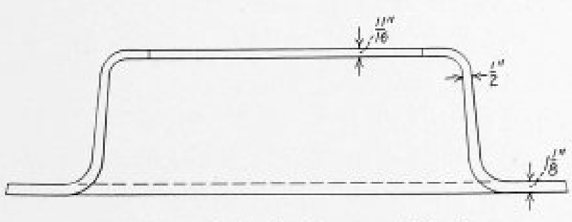


Fig. 2.—Flanged head where metal is drawn

half of the angle formed by the arc. The versed-sine for the various angles can be found in any engineering handbook.

Example:

Given—Diameter of circle = 60 inches.
Length of arc = 30 inches.

To find—Rise of Arc

$$\frac{30}{60 \times 3.1416} \times 360 = 57^\circ - 17'$$

Versed-sine of angle $\frac{57^\circ - 17'}{2}$ is 0.112236

$30 \times 0.112236 = 3.367$ inches, rise of arc.

Span of Self-Supporting Tank

Q.—What is the formula for figuring the length of span on which a tank will be self-supporting when full of water? Such a tank would have a 5-foot diameter, made up of ¼-inch steel in 6-foot sections. The joints would have an efficiency of 60 percent.

To state the problem in a different way, what is the maximum distance for placing supports for a 60-inch diameter pipe line with the above specifications?

Would the formula for obtaining the moment of inertia of a cylinder apply? What part do the longitudinal and circumferential joints play in the problem? H. A. B.

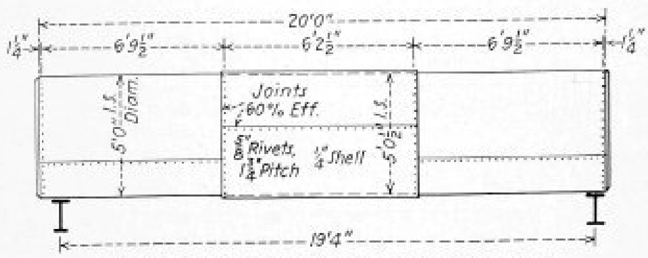


Fig. 1.—Tank supported by beams near ends

A.—A formula for thin hollow tubes loaded with a concentrated weight in the center and supported at the ends, given by D. H. Clark is as follows:

$$W = \frac{3.14\ D^2 \times t \times S}{L}$$

where

W = Breaking weight in the center, in pounds.
D = Diameter of the tank in inches.
t = Thickness of shell plate in inches.
S = Stress in pounds per square inch due to W.

In the case of a tank, when the load is uniformly distributed, as the one illustrated in the question, the re-

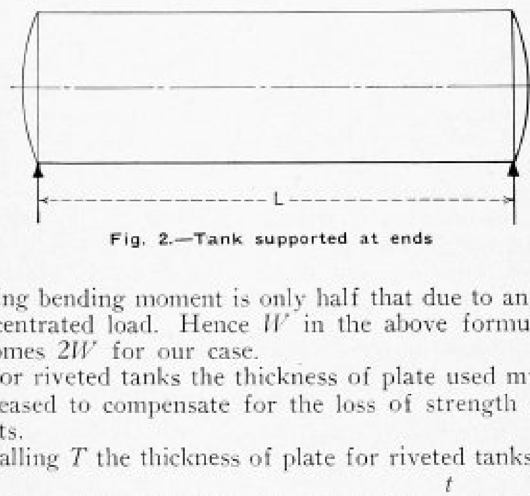


Fig. 2.—Tank supported at ends

sulting bending moment is only half that due to an equal concentrated load. Hence W in the above formula be-becomes $2W$ for our case.

For riveted tanks the thickness of plate used must be increased to compensate for the loss of strength at the joints.

Calling T the thickness of plate for riveted tanks to be equal to a solid plate t, we must take $T = \frac{t}{e}$, e being the efficiency of the circumferential joint.

Therefore for t in the above formula we substitute $7 \times e$. For Fig. 2, the formula will then be revised to:—

$$W = \frac{6.28 \times D^2 \times T \times e \times S}{L}$$

For Fig. 3, being differently supported the formula becomes:

$$W = \frac{36.61 \times D^2 \times T \times e \times S}{l}$$

provided $l = 0.207L$, which position of the supports gives the greatest strength.

When working out the weight W care must be taken to include the weight of the tank as well as the weight of the contents, as it will usually be found that the tank itself will weigh at least as much as if not more than its contents.

The weight of any piping or other impediments that may hang upon the tank must also be considered. The

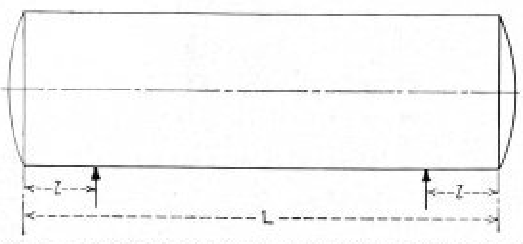


Fig. 3.—Tank with supports not located at the ends

working stress should not exceed 11,000 pounds per square inch.

Transposing the formula:—

$$W = \frac{6.28 \times D^2 \times T \times e \times S}{L}$$

we have:

$$S = \frac{W \times L}{6.28 \times D^2 \times T \times e}$$

Substituting the conditions of the tank in the problem, in this formula, we have:

Approximate weight of water = 24,597 pounds.
Approximate weight of tank = 4,036 pounds

Total = 28,633 pounds

$$S = \frac{28,633 \times 232}{6.28 \times (60.5)^2 \times .25 \times .60}$$

S = 1926 pounds per square inch.

The stress is well within the allowable stress of 11,000 pounds per square inch.

The longitudinal seams do not need to be considered when computing the tank as a beam.

The circumferential seams must be taken into consideration as already explained.

The formula for obtaining the moment of inertia of a cylinder would not apply when using Clark's formula, however, the problem could be worked out by the standard formulas for beams, taken from any engineering handbook.

In a beam uniformly loaded and supported at both ends,

$$S = \frac{W \times l}{8 \times Z}$$

where

S = Maximum stress in pounds per square inch
W = Total load in pounds.

Z = Section modulus = $\frac{I}{c}$

where

I = Moment of inertia
c = The distance to the fiber carrying the greatest stress.

l = Length in inches.

$$Z = \frac{I}{c} = .098 \frac{D^4 - d^4}{D}$$

where

D = Outside diameter in inches.
d = Inside diameter in inches.

The stress obtained using the above formulas would be for solid plate and the necessary correction for the thickness of plate to compensate for the circumferential seam would have to be made.

Proposed Specifications for Fusion Welding

(Continued from page 80)

Grade B Welding. The requirements for Grade B welding are the same as for Grade A, except that no X-ray tests are required for the joints of the completed vessels, stress relieving is not required in all cases, and the ductility requirement by the free-bend-test method is reduced from 30 to 20 percent.

Prior to, but not exceeding six months, before beginning the construction of vessels with Grade B welding as covered by this Code, the manufacturer shall have tested samples of welding of the thickness of plate used in the vessels which he is to build in order to qualify the process which he employs. The requirements for these qualification tests shall include an X-ray examination of the welds, as well as the other tests designated for Grade A welding.

Grade C Welding. This applies to welding that must of necessity be done in other than a horizontal position. The requirements are as given for Grade B welding, except that the samples shall be welded in the position encountered in the manufacture of the vessel and the required ductility by the free-bend-test method is reduced from 20 to 12 percent.

Grade D Welding. Prior to the construction of any vessels covered by this Code requiring Grade D welding, the manufacturer shall have tested samples of welding of plates approximately ¼ in. and ⅜ in. thick in order to qualify the process which he employs. The test specimens shall be the same as for Grade A welding and shall meet the following requirements:

Tensile Test: The ultimate tensile strength shall not be less than the minimum of the range stamped on the plate.

Ductility Test: The percentage of ductility as shown by the free bend test shall not be less than 10 percent.

Proposed Specifications for Fusion Welding of Drums or Shells of Power Boilers

It is proposed to make the Proposed Specifications for Fusion Welding of Drums or Shells of Power Boilers, conform with those under the heading of "Proposed Specifications for Fusion Welding of Unfired Pressure Vessels," except in the following particulars:

Par. 8—Impact Tests. Omit.

Par. 12—Hydrostatic and Hammer Tests. Change to read as follows:

Hydrostatic Test. The vessel shall be subjected to a hydrostatic pressure of sufficient intensity to stress the longitudinal joints to 2¼ times the maximum allowable stress, and held at this pressure for three minutes.

Par. 13—Holes. Change to read as follows:

Holes. No unreinforced holes shall be located in a welded joint. When an unreinforced hole in the plate is located near a welded joint, the minimum distance between the edge of a hole and the edge of a joint shall be equal to the thickness of the plate when the plate thickness is from 1 to 2 in. With plates less than 1 in. thick, this minimum distance shall be 1 in. With plates over 2 in. in thickness, the minimum distance shall be 2 in.

Par. 16. Add a new paragraph to read as follows:

Inspection. An inspector may designate stages of the work at which he wishes to inspect the welded joints of a vessel, and the manufacturer shall either submit the drum for inspection in such partly completed condition, or as an alternative he may permit the inspector to witness stages of the welding operation at such times as the inspector may select.

NOTE: The X-ray examination provides a greater safeguard than any shop inspection.

Associations

Bureau of Locomotive Inspection of the Interstate Commerce Commission

Chief Inspector—A. G. Pack, Washington, D. C.

Assistant Chief Inspectors—J. M. Hall, Washington, D. C.; J. A. Shirley, Washington, D. C.

Steamboat Inspection Service of the Department of Commerce

Supervising Inspector General—D. N. Hoover, Jr., Washington, D. C.

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Assistant International President—William Atkinson, suite 522, Brotherhood Block, Kansas City, Kansas.

International Secretary-Treasurer—Chas. F. Scott, suite 506, Brotherhood Block, Kansas City, Kansas.

Editor-Manager of Journal—John J. Barry, suite 524, Brotherhood Block, Kansas City, Kansas.

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States and Cities That Have Adopted the A.S.M.E. Boiler Code

States

Arkansas	Missouri	Rhode Island
California	New Jersey	Utah
Delaware	New York	Washington
Indiana	Ohio	Wisconsin
Maryland	Oklahoma	District of Columbia
Michigan	Oregon	Panama Canal Zone
Minnesota	Pennsylvania	Territory of Hawaii

Cities

Chicago, Ill.	St. Joseph, Mo.	Memphis, Tenn.
Detroit, Mich.	St. Louis, Mo.	Nashville, Tenn.
Erie, Pa.	Scranton, Pa.	Omaha, Neb.
Kansas City, Mo.	Seattle, Wash.	Parkersburg, W. Va.
Los Angeles, Cal.	Tampa, Fla.	Philadelphia, Pa.
	Evanston, Ill.	

States and Cities Accepting Stamp of the National Board of Boiler and Pressure Vessel Inspectors

States

Arkansas	Missouri	Pennsylvania
California	New Jersey	Rhode Island
Delaware	New York	Utah
Indiana	Ohio	Washington
Maryland	Oklahoma	Wisconsin
Minnesota	Oregon	

Cities

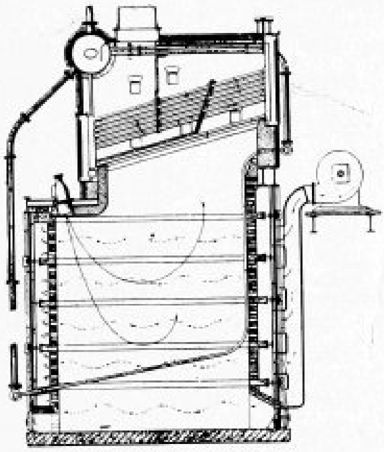
Chicago, Ill.	St. Louis, Mo.	Nashville, Tenn.
Kansas City, Mo.	Scranton, Pa.	Omaha, Neb.
Memphis, Tenn.	Seattle, Wash.	Parkersburg, W. Va.
Erie, Pa.	Tampa, Fla.	Philadelphia, Pa.

Selected Boiler Patents

Compiled by Dwight B. Galt, Patent Attorney, Washington Loan and Trust Building, Washington, D. C. Readers wishing copies of patents or any further information regarding any patent described, should correspond directly with Mr. Galt.

1,720,958. AIR-COOLED FURNACE WALL. DAVID S. JACOBUS, OF MONTCLAIR, NEW JERSEY, ASSIGNOR, BY MESNE ASSIGNMENTS TO FULLER LEHIGH COMPANY, A CORPORATION OF DELAWARE.

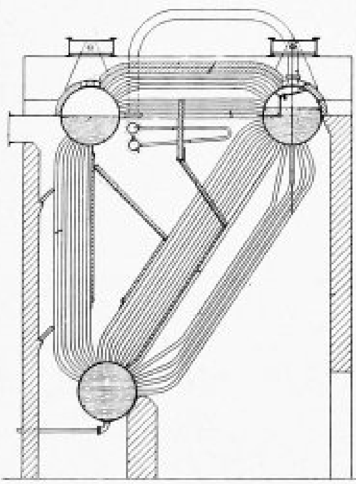
Claim.—In a furnace, a wall of refractory material having on its outer side material substantially impervious to air, a casing outside of said wall and spaced therefrom, and means to connect said walls and



casing constructed and arranged to permit relative movement between said wall and said casing in their respective planes, and means for introducing air into the space between said wall and said casing. Seven claims.

1,739,502. STEAM BOILER. CARL T. CARLSON, OF ERIE, PA., ASSIGNOR TO ERIE CITY IRON WORKS, OF ERIE, PA., A CORPORATION OF PENNSYLVANIA.

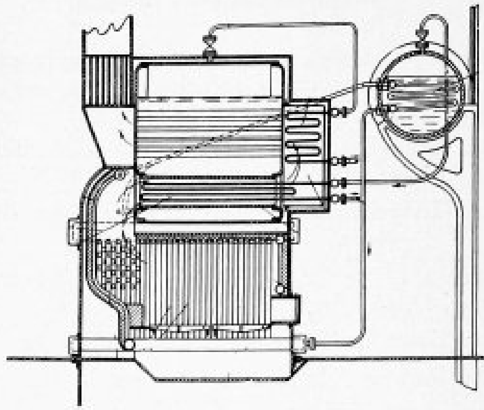
Claim.—In a steam boiler, the combination of a front drum; a rear drum; an upper bank of steaming watertubes connecting said drums; a lower circulating system connecting said drums; a steam chamber in the



upper part of the front drum; steam tubes leading from the rear drum to said steam chamber; and a drainage pipe leading from the steam chamber into said upper bank of tubes and discharging in a direction to be subjected to the ejector effect of the circulation.

1,740,239. CYLINDRICAL MARINE BOILER WITH SUPERHEATER. SIMON HOFFMANN, OF KASSEL-WILHELMSHOHE, GERMANY, ASSIGNOR TO SCHMIDT'SCHE HEISSDAMPF-GESELLSCHAFT MIT BESCHRANKTER HAFTUNG, OF KASSEL-WILHELMSHOHE, GERMANY, A CORPORATION OF GERMANY.

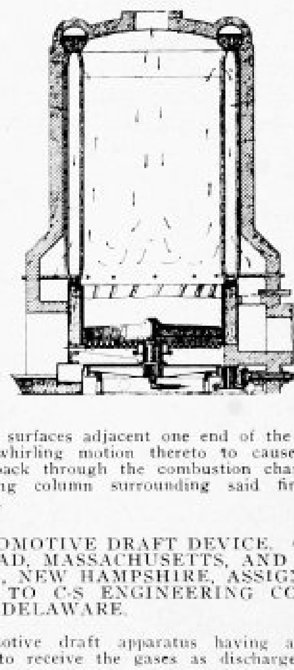
Claim.—A cylindrical marine boiler with two working pressures and superheaters for the high-pressure and the low-pressure part having a furnace chamber forming a first hot gas passage, a flue within the boiler forming a second gas passage, smoke tubes forming a third gas passage, a first return chamber between the first and the second gas passage, a second return chamber between the second and the third gas passage, a



superheater for the high-pressure part of the boiler arranged in said second gas passage and a superheater for the low-pressure part of the boiler arranged in said second return chamber.

1,722,496. BOILER AND METHOD OF OPERATING THE SAME. WILLIAM B. CHAPMAN, OF JACKSON HEIGHTS, NEW YORK.

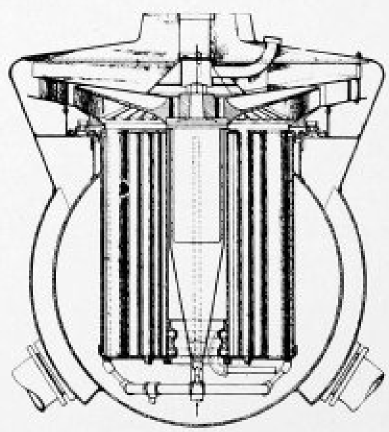
Claim.—The method of operating a boiler having a combination chamber and boiler heating surfaces surrounding the same, which comprises projecting a central stream of finely divided fuel longitudinally through the central portion of said combustion chamber, deflecting said stream



toward the heating surfaces adjacent one end of the combustion chamber, and imparting a whirling motion thereto to cause the gases of combustion to travel back through the combustion chamber in the form of an annular whirling column surrounding said first-mentioned stream. Twenty-five claims.

1,722,060. LOCOMOTIVE DRAFT DEVICE. C. A. SCHELLENS, OF MARBLEHEAD, MASSACHUSETTS, AND JOEL S. COFFIN, JR., OF LISBON, NEW HAMPSHIRE, ASSIGNORS, BY MESNE ASSIGNMENTS, TO C-S ENGINEERING COMPANY, A CORPORATION OF DELAWARE.

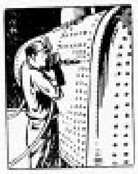
Claim.—A locomotive draft apparatus having a revolving fan and vanes in position to receive the gases as discharged from the fan and



set at a substantial angle relative to the direction of discharge of said gases, together with means positioned to exhaust the discharged gases axially of the fan. Fifteen claims.

The Boiler Maker

Reg. U. S. Pat. Off.



Nickel Steel for Locomotive Boilers

One of the most interesting contributions of metallurgists to the locomotive boiler has been in the form of nickel steel plates and tubes which have been adopted by several railroads in the construction of its locomotives during the past few years. The Canadian Pacific has, since 1926, practically established this material as a standard. The designs of forty 4-6-4 type, fast passenger and freight locomotives, recently built and described in this issue, were based on the qualities of nickel steel.

The primary object in utilizing this alloy was to increase the capacity of a locomotive without increasing its weight. This was accomplished, in the case of the Canadian Pacific locomotives cited above, by obtaining the required tensile strength, with the same thickness plates, which was necessary to increase the working pressure of the boiler design, if they had been built with carbon steel, from 200 to 250 pounds per square inch.

In addition to its high tensile strength, which for 3 percent nickel content gives a minimum of 70,000 pounds per square inch, its physical characteristics at high temperatures also make it attractive as a boiler material. Other qualities in its favor are its high impact values, its resistance to embrittlement in service and its uniformity.

The National Board of Inspectors

In view of the present condition of industry in general and of the boiler manufacturing industry in particular, some question has arisen as to the possibility of holding the annual meeting of the National Board of Boiler and Pressure Vessel Inspectors. This organization depends largely for its financial support on the fees obtained through the registration of boilers built according to A.S.M.E. Boiler Code requirements, for use in states accepting the stamp of the Board as authority for the conformance of that boiler to the code.

The National Board, which is composed of chief inspectors of states, cities and districts whose boiler requirements are those of the A.S.M.E. Code, has since its formation performed the function of assuring uniformity in the construction of boilers and pressure vessels in all parts of the country coming under its jurisdiction. It has been enabled to fulfill its object advantageously through a close personal contact of its members. Its meetings, once a year, have served the purpose of clearing up difficulties in interpretation of code rules and of establishing definite policies of inspection procedure.

In another way the annual sessions of the board have made possible the presentation of information by authorities on the latest developments in the art of boiler design and construction which could not be made available to the members in any other way.

It is to be hoped that some means will be developed for the Board to meet this Spring in order that its work may in no way be disrupted. This is especially important because of the necessity of establishing workable rules for putting into effect the welding requirements of the unfired pressure vessel code now being prepared.

Qualified Welders of Pressure Vessels

With the enactment, in the near future, of the welding code for unfired pressure vessels now under consideration by the American Society of Mechanical Engineers, Boiler Code Committee, several practical problems concerning its application have occurred. At the recent meeting of the American Boiler Manufacturers' Association in Cleveland, considerable discussion of the functioning of certain provisions of the code occurred.

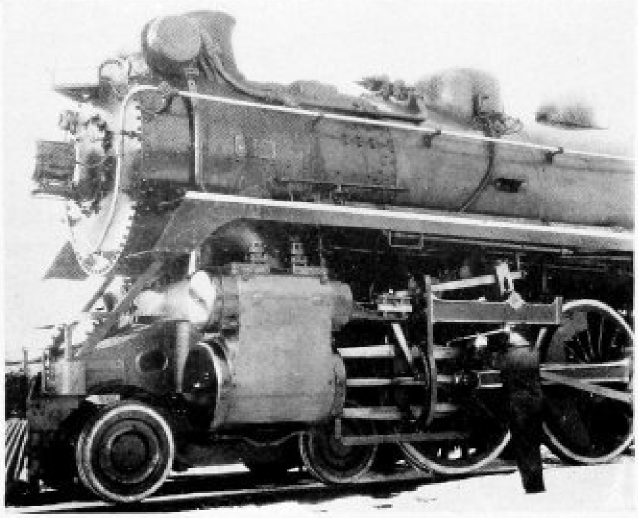
The State of Oregon has enacted a law requiring all welding work coming into the state to be done by welders licensed by that state. Requirements of this nature, if literally interpreted, would make it extremely difficult for manufacturers outside the state to build welded pressure vessels for use in that territory coming under the jurisdiction of the state laws.

Fortunately, in the case of Oregon, the National Board of Boiler and Pressure Vessel Inspectors undoubtedly will be able to establish a policy by which construction performed by welders who have been qualified by the board will be acceptable in A.S.M.E. Code states and political sub-divisions.

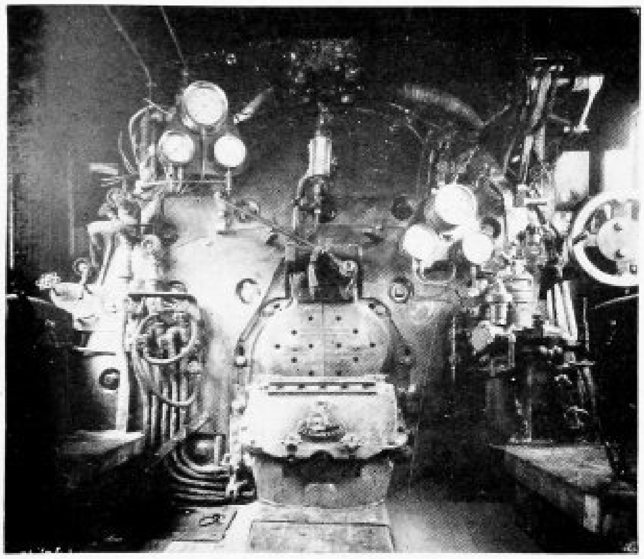
At present, the board is developing requirements for such qualifications of welders. Working closely, as it does, with the Boiler Code Committee and the American Boiler Manufacturers' Association, it is certain that the regulations which it will adopt will conform, to the best possible advantage, with the needs of these groups.

When the code is finally adopted by the states, the terms of enforcement will be such as to work no greater hardship on those affected by it than is now the case with the enforcement of the A.S.M.E. Codes now in effect. At the same time every effort by individuals or groups interested in the provisions and ramifications of the welding specifications should express their views on the matter while the details are yet under consideration by communicating with the Secretary of the American Society of Mechanical Engineers, Boiler Code Committee, 29 West 39th street, New York

Nickel Steel Boilers for New Canadian Pacific Locomotives



Front-end view of new power



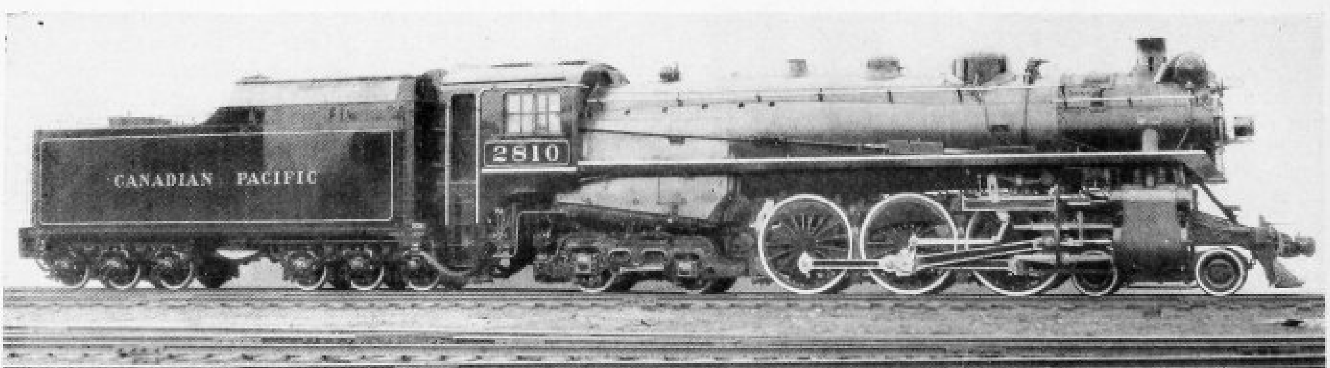
Interior of the cab showing the back-head arrangement

Since 1926 the Canadian Pacific has been operating successfully Pacific and Mikado-type locomotives with boilers constructed of 3 percent nickel steel plate. This material in the course of the period since then has virtually been made standard with the railroad. As a result, the recent addition of twenty 4-6-4 locomotives to passenger service of the company incorporates this material in the boilers as a means of weight-saving and to make possible the 275 pounds per square inch working pressure under which they operate.

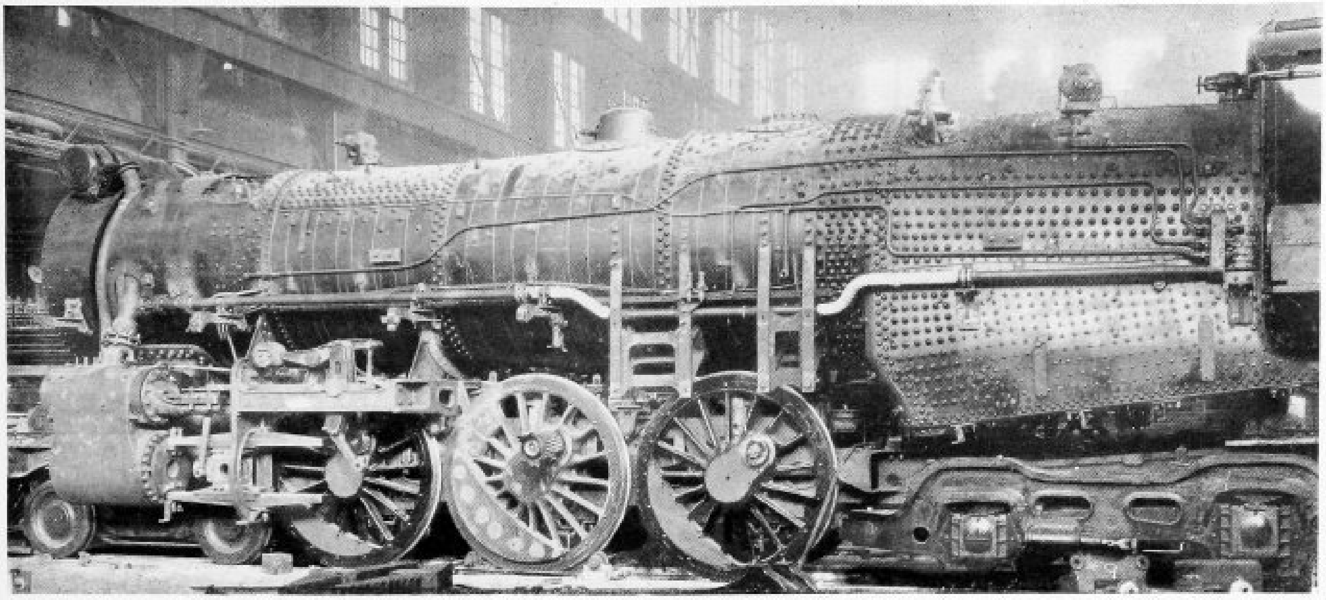
All of the locomotives were built by the Montreal Locomotive Works, Ltd., ten of them, known as the H1a type, have been in service since November, 1929. The second ten, the H1b type, were delivered during the last two months of 1930 and in January, 1931. The designs for this power were furnished by the mechanical engineering department of the railroad.

At this point it might be well to note the experience of the Canadian Pacific with nickel steel as a boiler material, to indicate the reasons for its adoption as a standard. The steps leading to its use in 1926 were the need of improving the capacity and efficiency of heavy passenger and general freight service locomotives without increasing the weight beyond a rather narrow range. Mikado and Pacific type locomotives, which had been built in 1919 and subsequently operated at 200 pounds per square inch boiler pressure were in general selected as the basis of new power with such changes incorporated as would accompiish the savings necessary. In order to do this and still remain within a total locomotive weight increase of 2 percent led to an investigation of boiler materials having a higher tensile strength than that of the customary steel. Nickel steel having a minimum tensile strength of 70,000 pounds per square inch was decided upon as the logical solution to the weight problem, for with it the increased pressure could be obtained without any change in the thickness of the barrel course plates. It was discovered at that time that a saving of 27 percent in the weight of these courses could be obtained as compared with carbon steel boiler plate.

The boilers of the present 4-6-4 type locomotives, as previously noted carry a still higher pressure than the



Canadian Pacific 4-6-4 type locomotive built by the Montreal Locomotive Works, Ltd.



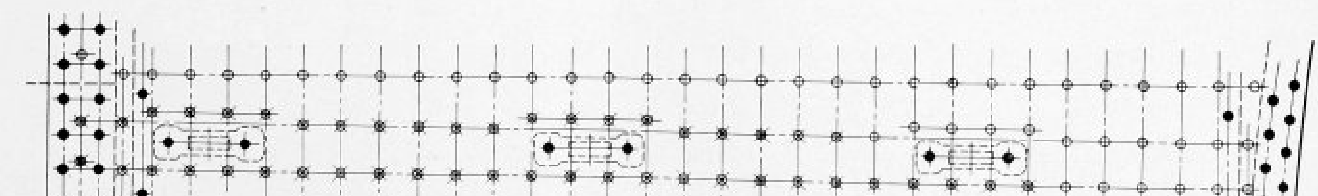
One of the Canadian Pacific 4-6-4 type locomotives under construction in the shops of the builders

locomotives built in 1926; namely, 275 pounds per square inch. The boilers are of the conical type, the outside diameter of the front ring being 80⅛ inches. The firebox has a width of 87⅞ inches and a length of 131 1/16 inches, while the grate area is 80.8 square feet. There are 62—2¼-inch tubes and 171—3½-inch superheater flues, all having a length over tube sheets of 18 feet 3 inches. The firebox and combustion chamber have a heating surface of 313.5 square feet; the arch tubes, 38.5 square feet; the tubes and flues, 3509 square feet, making a total evaporative surface of 3861 square feet. The superheating surface is 1640 square feet, while the combined evaporative and superheating surfaces total 5501 square feet.

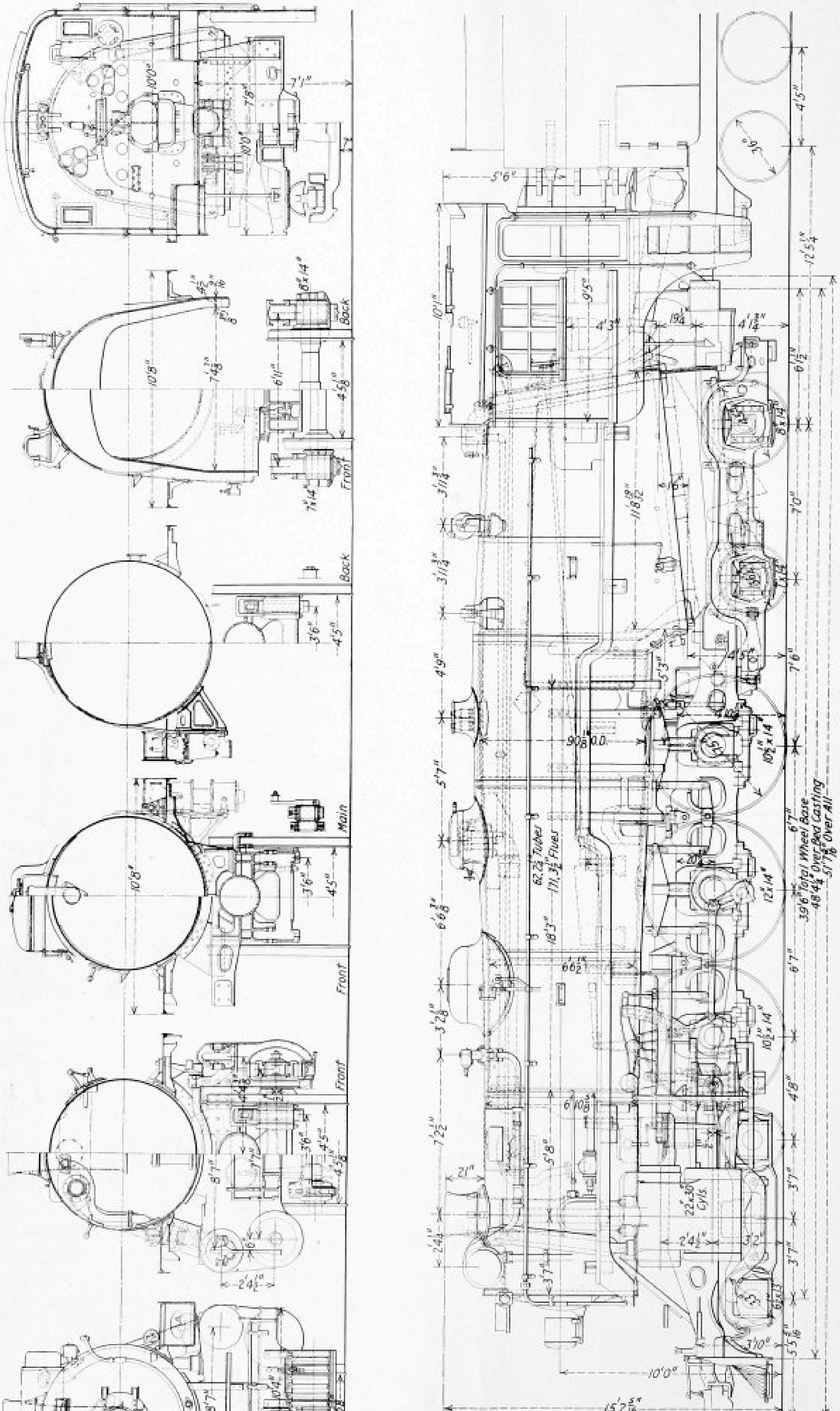
A special feature of the firebox on the H1b class of locomotives is that owing to the strength of the nickel steel plates. Two "weak sections," which are designed to fail before any other portion of the firebox fails in case of low water in the boiler, are incorporated. This safety feature, illustrated on page 89, tends to localize the danger should there develop a condition in the boiler which might cause a serious explosion. The "weak sections" are supported by parallel threaded staybolts and are surrounded by a zone of staybolts having tapered threads, extending from the front to the back of the crown sheet. All staybolts used are of 2 percent nickel steel. The tubes and flues are electrically welded with a special low-carbon wire (not fluxed) around the bead at the rear flue sheet. This practice has been standard on the Canadian Pacific for the past nine years. The railroad has been getting an average of 130,000 miles flue service and has had practically no trouble with leaky flues. Tubes and flues are renewed during general repairs every eighteen months to two years. During the year's operation of the first ten locomotives, no external leaks in the barrels of the boilers have been encountered.

The grates are of the Rosebud or pinhole type with an air opening of about 14 percent. Two baffle or deflector walls have been applied underneath the mud ring between the under side of the grates and above the ash pan which extend the entire length of the grates. These baffles deflect the air as it enters the side of the ash pan, downward and then up through the center of the grate area. In addition, the arch tubes are spaced to provide a wide arch-brick span through the center of the firebox and a narrow span at the sides. The deep center arch causes the gases to flow toward the center of the firebox and away from the side sheets.

The combination of baffle walls and the arrangement of arch brick prevents the cool air from circulating along the side sheets and because of the more uniform



Section of crown sheet showing the "weak section"



Elevation and cross-sections of the Canadian Pacific 4-6-4 type locomotives class H1

Table of Dimensions, Weights and Proportions of the Canadian Pacific 4-6-4 Type Locomotives

Railroad	Canadian Pacific
Builders	Montreal Locomotive Works, Ltd.
Type of locomotive	4-6-4
Railroad class	H-1
Service	Passenger
Cylinders, diameter and stroke	22 in. by 30 in.
Valve gear, type	Walschaert
Valves, piston type, size	14 in.
Maximum travel	7 in.
Steam lap	1⅛ in.
Exhaust clearance	⅝ in.
Lead in full gear	¼ in.
Weights in working order:	
On drivers	185,000 lb.
On front truck	62,800 lb.
On trailing truck	103,000 lb.
Total engine	350,900 lb.
Tender	292,000 **lb.**
Total engine and tender	642,900 lb.
Wheel bases:	
Driving	13 ft. 2 in.
Total engine	39 ft. 6 in.
Total engine and tender	80 ft. 6¼ in.
Wheels diameter outside tires:	
Driving	75 in.
Front truck	33 in.
Trailing truck, front	36¼ in.
Trailing truck, rear	45 in.
Journals, diameter and length:	
Driving, main	12 in. by 14 in.
Driving, others	10½ in. by 14 in.
Front truck	6½ in. by 13 in.
Trailing truck, front	7 in. by 14 in.
Trailing truck, rear	8 in. by 14 in.
Boiler:	
Type	Conical
Steam pressure	275 lb.
Fuel, kind	Soft coal
Diameter, front ring, outside	80⅝ in.
Firebox, length and width	131 1/16 in. by 88⅜ in.
Tubes, number and diameter	62—2¼ in.
Flues, number and diameter	171—3½ in.
Length over tube sheets	18 ft. 3 in.
Grate area	80.8 sq. ft.
Heating surfaces:	
Firebox and combustion chamber	313.5 sq. ft.
Arch tubes	38.5 sq. ft.
Tubes and flues	3,509 sq. ft.
Total evaporative	3,861 sq. ft.
Superheating surface	1,640 sq. ft.
Combined evaporative and superheat	5,501 sq. ft.
Tender:	
Style	Rectangular
Water capacity	12,000 Imperial gal. (14,400 U. S. gal.)
Fuel capacity	21 tons.
Wheels, diameter outside tires	36¼ in.
Maximum rated tractive force	45,250 lb.
Weight proportions:	
Weight on drivers ÷ total weight engine, percent	52.7
Weight on drivers ÷ tractive force	4.08
Total weight engine ÷ comb. heating surface	63.7
Boiler proportions:	
Tractive force ÷ comb. heating surface	8.21
Tractive force × dia. drivers ÷ comb. heating surface	616
Firebox heat. surface ÷ grate area	4.36
Firebox heat. surface, percent of evap. heat. surface	9.12
Superheat. surface, percent of evap. heat. surface	42.4

temperature, practically eliminates warping and cracking of the sheets and leakage of the staybolts. As it is to be expected with such an arrangement of baffle walls and arch brick, the fuel burns more rapidly at the center of the grates than around the sides. This is an ideal condition. The arch tubes are secured at the front sheet in arch tube sleeves which permit expansion and contraction without injury to the tubes or sheets. In addition, the firemen are instructed not to allow the fire to die down when drifting or standing in order to avoid subjecting the firebox sheets to a wide range of temperatures.

It is interesting to note the records which some of these locomotives have made since they were placed in service, when it was decided that the schedule time of passenger trains could be reduced, as was contemplated when the locomotives were ordered. These locomotives are capable of handling trains at extremely high maximum speeds, and have demonstrated their ability to travel at average speeds of from 90 to 95 miles per hour.

The first locomotives delivered have made a mileage of nearly 140,000 miles. Practically no maintenance, except the usual engine terminal attention, has been required up to the present time.

The locomotives were designed primarily for economical operation and maintenance and to meet the sustained speeds required in through passenger service. The cabs are of the railroad's standard vestibule type entirely inclosed, which is necessary on account of the severe weather conditions encountered in Canada. They are illuminated at night by a single electric bulb placed in a sheet metal case, which is attached to the roof of the cab directly above the center of the tender deck. Two holes in the front side of the shade throw beams of light on the two groups of three gages located on the fireman's and engineman's side of the boiler head respectively. Reflections from the beams of light enable both men to observe the water glass, which is located on the boiler head over the fire door.

Recent Cases of Caustic Cracking

Such factors as local stresses and seam tightness play so important a part in governing the rate at which caustic action takes place in a boiler that, even when the exact carbonate-to-sulphate ratio of an embrittling feed water is known, it is impossible to predict with any degree of accuracy how long the boiler will operate before cracks appear.

The finding of embrittlement cracks in two cross-drum boilers in January came more than five years after the Hartford Steam Boiler Inspection and Insurance Company warned the owners that an analysis of feed water showed it to be of a kind that would produce embrittlement. Thus warned, the owners installed a system of treatment designed to overcome the unfavorable carbonate-sulphate ratio of the deep-well water they were using, but the caustic that had concentrated in the boiler seams during the period before the water treatment was started proved sufficient to keep the embrittlement action going. As a result rivet heads eventually commenced to snap off under light blows of the inspector's hammer, and an examination with a Hartford Rivet-Hole Magniscope revealed cracks radiating from the rivet holes.

In the case cited above the boilers had been under close observation for five years for the first signs that the plate had been affected, so the discovery of cracks came as no surprise. However, in another case of caustic cracking encountered a few weeks ago in a horizontal tubular boiler the fact that the boiler was connected to a closed heating system and used nothing but condensate from radiators and heating coils as feed water, made difficult, for a time, all attempts to explain how caustic could have entered the boiler. An examination of the piping system dispelled the mystery, for it was found that steam from the boiler passed through coils in tanks used for heating a strong alkali solution. From time to time these coils developed leaks, and although it was impossible for the contents of the tank to pass into the coil while the latter contained steam at boiler pressure, such leakage did take place at night when the steam was shut off. At that time some of the caustic solution would seep into the coil and reach the hot well from which it would be forced into the boiler when the feed pump was started in the morning. —*The Locomotive.*

* * *

The Lincoln Electric Company, Cleveland, Ohio, has issued a 20-page catalog under the title of "Arc Welding Supplies." In this pamphlet are described the Fleetweld process and various welding electrodes, electrode holders, cables, protective shields and other supplies.

Prevention of Boiler Corrosion in Storage ▲ ▲ ▲

This article is an abstract of a report on the protection of boilers and boiler materials from corrosion and deterioration while in storage; prepared by a committee consisting of D. A. Steel, chairman, Armstrong Chinn, J. H. Davidson, R. L. Holmes, P. M. LaBach; J. J. Laudig, E. M. Miller, O. T. Rees and R. A. Tanner; presented at the March, 1931, convention of the American Railway Engineering Association, held in Chicago, Ill. This report was submitted as an appendix to the report of the committee on water service and sanitation.

Practically all boiler materials with the exception of staybolts and crown bolts, which some roads make in their own shops, are purchased in finished form. Their protection from corrosion or injuries likely to promote corrosion should, therefore, begin at the factory. Most roads have taken the precaution to guard against irregularities in thickness or size, or defects in composition likely to affect the strength of the materials, by appropriate clauses in their specifications, but those conditions or methods of handling that have a bearing on corrosion have not been emphasized. Railroads should expect manufacturers and other dealers to so handle and care for boiler plate, firebox steel, boiler tubes and other boiler materials as to protect them from rust or other injury, not only up to the time of inspection, but up to the point of shipment.

The committee has investigated the question of coating these materials to protect them from rust, preparatory to shipment. Some roads do not favor the practice on the ground that coatings hide surface imperfections. Other roads require manufacturers to apply a coating, particularly in the case of boiler tubes. The committee endorses the opposition to the use of any coatings that will prevent the proper inspection of the material. It should also be known that some coatings, such as kerosene, accelerate corrosion in themselves and that the use of heavy oils, by reason of their heat-insulating properties or tendency to emulsify in the boiler, are likely to cause a variety of boiler troubles unless removed before the materials are used. Where the atmospheric or other conditions are such as to favor the use of coatings, a paint reducing oil properly thinned or approved protective coating should be applied.

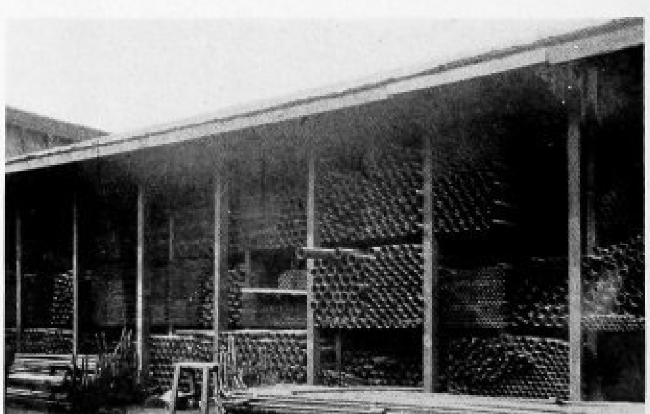
When oil or other coating of boiler materials is prescribed, the specifications should withhold its application as far as practicable until after inspection of the boiler materials, and the composition of the coating should also be tested.

The rapidity with which deliveries are usually made at present reduces the risk of injuries to boiler materials during transit. The possibility of rust and other damage while in transit should be kept in mind, however, and guarded against. With the exception of staybolts and crown bolts, such materials, for the sake of convenience in loading, are usually shipped in open cars. Where the conditions of the shipments are likely to result in considerable rusting, the use of oil free from corrosive qualities and which can be subsequently removed without undue expense may be advisable. Shippers and freight handlers should be advised against subjecting the materials to sharp blows that may bend or cut, and, in all instances, the receivers of such freight should observe the loads for evidences of such injury and lay the damaged material aside for examination. This inspection should particularly be assured where the material in transit has been wrecked, and the use of boiler tubes as levers, etc., should be avoided.

The committee particularly desires to stress the importance of protecting boiler materials from corrosion or other injury while in storage or awaiting application. The cost of boiler materials to railroads has been needlessly increased and the life of boiler materials prematurely shortened by a failure to appreciate this. The committee has been more impressed with the attention given by

Typical tube storage

Tubes stored under cover



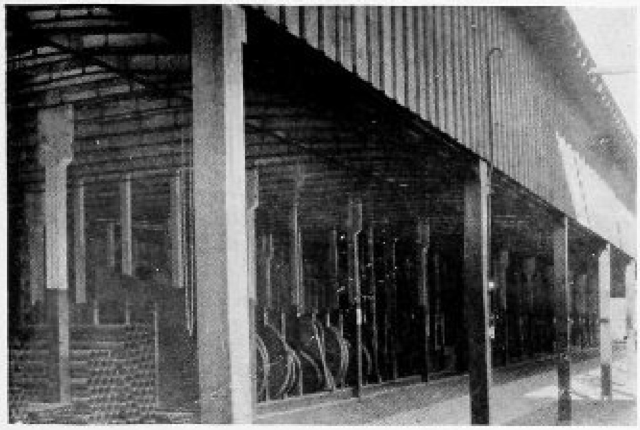
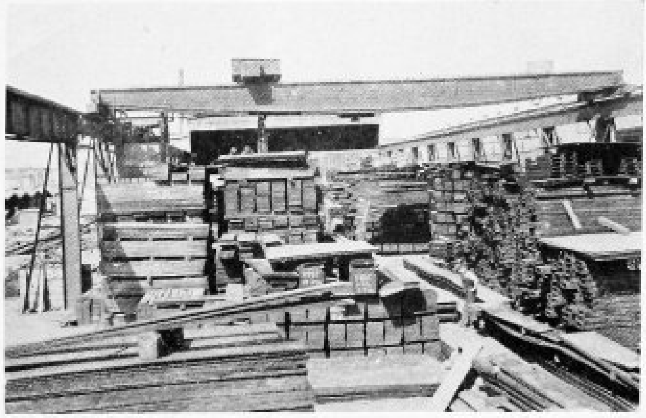


Plate protected from corrosion by sheds



Unprotected plate and shape storage

custodians to the arrangements made for convenient and economical handling of boiler materials and to their orderly and presentable appearance than to their protection. Deplorable rusting has been observed in exposed stocks, and this rusting has not been confined to uncoated stocks but is commonly found in the lower sections of piles which have been painted on top, apparently for the sake of appearance. In meeting the corrosion problem, the existence of these conditions should be recognized where found and avoided as far as practicable.

Store departments should order, and purchasing departments contract for, the smallest quantity of boiler materials consistent with current needs and economical purchasing and loading in order to avoid accumulations that cannot be adequately sheltered and to avoid exposure over long periods.

As far as possible, adequate shelter should be provided for all boiler materials. Heavy investments are not necessary, but such shelter should have a watertight roof and should preferably be completely enclosed, and the interior of the buildings should be free from dampness.

Where shelter is out of the question, all boiler materials should be stored so as to shed water and to allow the free circulation of air over all surfaces. In the case of boiler steel, this can be accomplished without interfering with convenient handling by setting rows of rails vertically in concrete so that the boiler plate can be set on edge above the ground. A modified form of such a rack is equally suitable for storing tubes in sets, where they will drain and can also be lifted bodily by crane. It is particularly important that all tubes and plates should be stored to permit using the oldest stock first. A high rate of turnover may mean little in handling boiler materials from the corrosion standpoint and may even be misleading unless the average rate truly represents the actual movement of units. Where rains are frequent, the layers of tubes should preferably be separated by non-metal strips to facilitate drainage.

Where unsheltered tubes may be in stock over extended periods and much wetting is unavoidable and the region one where boiler corrosion is encountered, they should also be protected by coating. A non-corrosive oil is preferred to varnish. Excessive applications should be avoided, and the oil should be cleaned off before the materials are used.

In regions subject to boiler corrosion, boiler forces should be given to understand that rust, pits, dents and other scoring of boiler materials, and also surface oils, may promote corrosion or other troubles in operation and should be removed before the power is placed in service. Boiler plate and tubes should be inspected for pits and the precaution taken to assure that all deposits in these pits are removed and the cavities filled. This is usually accomplished in a satisfactory manner by spotwelding. Since the punching of bolt holes in boiler plate has been found to promote corrosion as a consequence of strains set up in the physical structure of the metal, the practice of drilling holes should be followed as far as practicable. It is also important from corrosion standpoints, as well as from renewal considerations, to avoid as far as practicable mixing second-hand tubes with new tubes, and particular care should be exercised to remove from the interior of the boiler, nails, bolts or other loose pieces of metal because of their effect in promoting corrosion at points of contact with the boiler metal.

Where boiler tubes have been varnished or oiled in storage and such coatings have not been removed before application, cleaning should be insisted upon in territories of troublesome waters before the power is released for service. The total amount of this oil on a set of tubes is large. In scaling waters, a common effect is to increase the tenacity with which the scale adheres to the tubes and, even where it is eventually removed under boiler operation, the tendency is to cause overheating of the metal by preventing the water from coming in contact with the steel. The oil may also combine with foreign matter in the water to form a scum which promotes boiler foaming or collects in steam outlets while compositions which disintegrate under the heat are likely to promote corrosion. Troubles of this character may usually be avoided by washing the boiler with soda-ash.

The soda-ash should first be dissolved in warm water and applied by removing a plug from the top of the boiler and pouring in the mixture through a funnel. This is preferably done in connection with the preparations for steam testing. The boiler should be fired up and the steam pressure raised to the allowable working pressure. The boiler should then be blown down and cooled and then thoroughly washed to remove any sediment caused by the use of soda-ash.

No report on the protection of stored boiler materials from corrosion covers the problem without taking into account the stored or out-of-service locomotive and power plant boiler. The stored locomotive is usually overlooked, but it is probably the greatest of all sources of corrosion occurring under atmospheric conditions. Stored boilers containing corrosive water are less subject to the water when cold than when it is hot, but other conditions necessary to corrosive action are unchanged and may even be accentuated as by the lack of periodic cleaning to remove corrosive deposits.

After the boiler is emptied, it may still be damp and difficult to dry because of its enclosed condition. Under such conditions, rusting can take place and be aggravated by sweating during warm weather. Any corrosion taking place, moreover, is quite likely to proceed unhindered because it is not detected, as would be the case if the surfaces were exposed to view. As a result of these conditions, it is not uncommon to find progressive deterioration in boilers that were in good shape when stored. Instances have come to light where the tubes in many boilers have been completely ruined during the storage period.

There is no universally accepted method at present of protecting stored boilers from corrosion. This results from the fact that the form and intensity of corrosion, as well as climatic conditions, vary in different sections. The ideal precaution is to empty the boiler while the surfaces are still hot and remove all plugs to permit the boiler to dry thoroughly. Where a dry boiler cannot be assured because of atmospheric or other conditions, it has been suggested that powdered soda-ash be blown into the boiler until all surfaces have been dusted with it. One road reports satisfactory results from this practice. Boilers cannot be left filled with water during storage where freezing temperatures are encountered, but in the warmer climates it may prove more convenient and equally satisfactory, where corrosion is feared, to give the water in the boiler a heavy dosage of soda-ash or other inhibitor using about 50 pounds to the boiler. In all cases, stored locomotives should be inspected periodically and should be thoroughly washed with water containing soda-ash before the equipment is again placed in service.

Boiler Code Legislation

By Charles E. Gorton*

Code bills have been presented to four State legislatures, during the period of 1929-1930, looking to the adoption of the A. S. M. E. Boiler Code as their state standard. It has been necessary in several instances, to have bills amended after their introduction, in order to meet certain requirements and suggestions. Owing to the unsettled condition of affairs at the present time, we are unable to say what the result of this legislation will be, as the several legislatures where these bills are introduced, are still in session.

In all probability, Code legislation will be introduced in one or possibly two more states during this legislative season, and we feel that it will be a question as to what the final action may be.

Some nine or ten bills have been introduced in the different legislatures, which members of our society felt were not progressive legislation and were against the best interests of industries. It has been necessary and will continue to be necessary until the end of the present legislative sessions, to keep in close touch with what is being done in the several capitols with this class of legislation. We are compelled to feel at times, that the country and industry should not be burdened with some of the legislation that has been introduced.

We find that the tendency in some localities is to create new bureaus or offices which of necessity call for new or additional appropriations. This is usually contrary to the feeling of retrenchment, and this at times naturally reverts against bills, the object of which suggests a better class of legislation.

The Uniform Boiler Law Society has been in close and constant touch with the authorities having the administration of the boiler code in hand, and we wish to state that in the main, uniformity of administration has been pretty well observed during the past year, although there have been one or two instances which might have changed this somewhat.

We have had cooperation from the different sections and members of our society during the past year, and we wish to emphasize again that in unity there is strength, especially when it applies to the class of work represented by our membership. We sincerely trust that the same support may be forthcoming in the future.

*Chairman of the Uniform Boiler Law Society, New York.

A.S.M.E. Boiler Code Committee Work

The Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St, New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and published.

Below are given records of the interpretations of the Committee in Cases Nos. 607 (reopened), 674-679, inclusive, as formulated at the meeting on January 23, 1931, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

Case No. 607 (Reopened) *Inquiry:* Is it permissible, under the Code for Unfired Pressure Vessels, to construct a spherical shell with lap joints, or is it required that butt strap joints be used?

Reply: While there is nothing in the present Code applying to the construction of spherical vessels, it is the opinion of the Committee that lap joints may be safely used in the construction thereof provided that if the plates exceed 3/8 in. in thickness, they shall be hot formed to the proper curvature, and each vessel shall be carefully and completely fitted together in the shop before shipment.

Case No. 674 (In the hands of the Committee).

Case No. 675 *Inquiry:* Does the reply to section *a* of Case No. 661 permit the use of fusion welding of plain and wholly unstayed boiler furnaces under the conditions set forth?

Reply: The reply is intended to refer to the particular furnace under consideration and does not apply to plain and wholly unstayed boiler furnaces. Pending the time when the Proposed Specifications for Fusion Welding of Drums or Shells of Power Boilers are adopted, the Committee would recommend that requirements of these specifications or of the Proposed Specifications for Fusion Welding of Unfired Pressure Vessels for stress relief and free bend tests be followed for the particular furnace under consideration.

Case No. 676 (In the hands of the Committee).

Applying Diamond Patches to Locomotive Boilers ▲ ▲ ▲

By C. M. House*

It is our privilege to present in this article which was prepared by a leading mechanical official, practical suggestions of boiler maintenance, with particular reference to diamond boiler patches. The methods explained, while primarily developed for Chicago & Alton shops, constitute good boiler practice and, as such, offer a course of procedure that might well be adapted to the requirements of any shop. Furthermore the explanation is given in such a way that our readers will undoubtedly gain a clearer understanding of the problems entering into the design and application of diamond patches. *The Editors.*

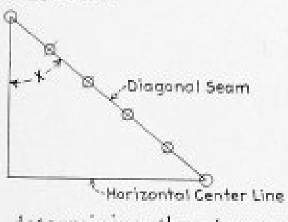
In preparing the shell of a locomotive boiler for inspection on the Chicago & Alton Railroad after the flues are removed, the interior of the boiler shell is sand blasted thoroughly with wet sand. The boiler is then cleaned clear of sand, scale, and all foreign material. This work is done at night, and the interior of the boiler is ready for inspection the next morning. The boiler is then given a thorough inspection, particular attention being given to the condition of the belly for pitting, and especially around the rivet heads and girth seams, where pitting and grooving generally appear more prominently. Also, points where the boiler rides on the waist sheet angle iron are given particular attention to develop whether or not there are cracks.

If defects are found they are then passed on by the general boiler foreman, who makes a decision as to whether or not a patch, new belly, or an entire course is required. When the defective area covers approximately 25 percent of the surface of the course, patches are not applied, but a new belly is required, or sometimes a new course. The mechanical engineer's office is then notified and a representative sent to the shops to check up the defects. If there happens to be a design for an existing patch that will be suitable for the defect in question insofar as the size of the patch and strength of the boiler is concerned, it is used; otherwise, a new patch is designed for that particular purpose.

Diamond patches only are used on the C. & A., and the resultant stress of the diagonal seam is based on the factor evolved from the formula.

$$\frac{2}{\sqrt{(\text{Sin. Angle } X^2 \times 3) + 1}}$$

Some of these various factors for the following angles are as follows:



Angle X	Factor
30 degrees	1.51
35 degrees	1.42
40 degrees	1.34
45 degrees	1.27
50 degrees	1.20
55 degrees	1.15
60 degrees	1.11
65 degrees	1.08

In determining the stress of this diagonal seam, the strength of the seam is first determined by the common method of calculating the efficiency by dividing the net section of plate by the distance between centers being considered. The efficiency thus found multiplied by the factor secured from the above formula gives the resultant efficiency of the diagonal seam in question. The efficiency of the seam referred to, it must be understood, is taken from the shell of the boiler and not the patch.

Consideration should be given to the enclosed area of the diamond, in order that the rivets may be spaced properly so as not to weaken the diamond itself. In other words, if the rivets are scattered around promiscuously on the diamond, and are placed too close together, the weakest part of the shell will be in these rivets and not in the diagonal seam. The weakest part of the patch should be in the diagonal seam, and attention should be given to space the rivets in the patch so that they reinforce the diamond rather than decrease its strength.

After the diamond is properly designed and calculated in the shell, the base of the diamond should be given proper consideration so that in case the defective part of the shell should let go, the base of the diamond would be of sufficient strength to hold the weakened shell. In other words, in the design of a patch special consideration should be given to the shell insofar as the diagonal seam is concerned, and then the same consideration should be given the patch insofar as the base of the diagonal seam is concerned. After the efficiency of the weakest part of the seam is determined, then this efficiency is used to determine the tension on net section of plate by the following formula:

$$\frac{P \times D}{2 \times T \times R} = \text{Tension on net section of plate}$$

P = Maximum boiler pressure
D = Largest diameter of course under consideration
T = Thickness of plate
R = Resultant efficiency

In the designing of a patch, a factor of safety should in all cases be provided equal to the factor of safety of the original seam. The shearing stress of the rivets in the diamond patch should provide a factor of safety equal to or greater than the factor of safety of the tension on the net section of plate. The space between the rivets across the base of the diamond should be watched, to see that the efficiency of the plate at the base of the diamond is equal to the efficiency of the diamond itself as mentioned above.

A sufficient number of rivets should be placed in the diagonal seam and within the diamond, to protect the distance between the extreme vertical center lines of the

* Superintendent of motive power and equipment, Chicago & Alton Railroad Company, Bloomington, Ill.

patch. Only one welt is used in the diamond patch, that being applied to the outside of the shell. When it is found necessary to apply a patch or reinforcement to the boiler check hole, or on account of a slight crack or check around a hole, a diamond patch is designed properly to reinforce this hole after the hole has been cleaned out free of checks. In other words, the original shell surrounding such a hole can be assumed to carry its proportion of the stress, and the design of the patch is only necessary to reinforce this hole properly.

After the patch has been laid out in the shops it is punched, drilled, and the edges beveled. It is then rolled to as nearly the contour of the shell as possible. Holes in the patch are punched ⅛ inch smaller in diameter than the cold rivet that is to be used. The patch is then put up in place on the boiler, and starting from the center line of the patch a drill the same diameter as a cold rivet is run through the patch and shell. Through every fourth or fifth hole a bolt is inserted, and the patch is pulled up tight to the shell. After the entire patch is drawn on the boiler and pulled up, it is then released from the shell and the pipe is thoroughly cleaned of burrs, chips, and all foreign material.

The patch is again fitted to the shell and ready for reaming. A reamer 1/16 inch in diameter larger than the drill hole is run through the patch and shell, and the bolts are again applied to each fourth or fifth hole starting at the center of the patch. The patch is then riveted with steeple-head rivets. After riveting, the patch and the rivets are calked and the patch is then ready for test.

There are no standard patches on the C. & A., and most patches are made to suit the individual defect. However, when an epidemic of cracks takes place in boilers of the same class in identical locations, the patches as designed may be used on several engines. On the C. & A. a patch is applied to the belly of the boiler over the waist sheet, this acts not only as a wearing pad but as a boiler reinforcement. The waist sheet angles are let float free from the boiler. When new bellies are applied, a seam similar to the original seam is used except in a boiler that has diamond seams, and in that case a quadruple riveted, or quintuple riveted double-welt butt strap seam is used.

Considerable interest has been manifest on the C. & A. regarding the application of waist sheet angles. Some railroads let these waist sheet angles float on the boiler, and some rivet same to the boiler; while other railroads have riveted the waist sheet angles to a liner applied to the boiler. By some it has been contended that when freeing the waist sheet from the boiler, a considerable number of cracks have been found in the frames, and I understand that some railroads have gone back to riveting the waist sheet angles to the boiler after once having freed them.

However, after giving this consideration on the C. & A., we, as stated above, concluded that the proper method of application of waist sheet angles was to free them from the boiler. The primary function of a boiler is to furnish the necessary power for moving the locomotive, and the locomotive boiler has been mounted on a frame which was designed and intended to support the boiler. However, in a great many instances, we have found that the boiler is actually supporting the frame instead of the frame supporting the boiler. It is our contention that a boiler never was intended to support the frame, but that the primary function of the frame was to support the boiler.

Therefore, we feel that if after freeing our waist sheets from the boiler, we have cracked frames, it indicates the weakness in the frames, and the frames of course should have been designed properly to be self-supporting, and also to lend the necessary aid in supporting the boiler.

Another point that should be given consideration particularly in the shops regarding not only boiler work, but erecting work: The locomotive designer in designing a boiler is particularly careful to see that a seam of proper strength is designed to withstand the boiler pressure. The designer is also very careful in locating the boiler braces, various holes, and other boiler parts to maintain this strength in the seam. Attention is also given to the location of the various appurtenances to see that there should be sufficient space between the rivets and studs to provide the strength required in the boiler shell.

However, after an engine is once built and turned back into the locomotive shops for repairs, the boiler makers are cautioned regarding the proper spacing of rivets in applying patches, and also in the application of bellies and courses. The boiler maker is also required to see that these rivets are spaced accurately, and that no holes are applied intervening. However, when the boiler is once placed over on the pit side and is mounted on the frame, it is not an uncommon sight to see mechanics promiscuously locate studs for air pump brackets, power reverse gear brackets, etc., with utter disregard to their proximity with reference to any boiler seam and patches that may be near such brackets, and also to apply them so close together that they actually weaken the original seam in the boiler.

Also, studs for these brackets are often applied so close to the rivets of a seam that in no time after the engine is in service a crack develops between this stud and the seam in the original shell, or in a patch. Good judgment should be used by the mechanics on the erecting side in the location of studs around boiler checks or seams; otherwise it would be just as well for the boiler designer and boiler maker to be very careless in the designing and application of boiler work. The designer and boiler maker work very close to the I.C.C. Laws on boilers, and I often wonder whether or not the mechanics on the erecting side appreciate the pains that have been taken in the design and construction of a locomotive boiler.

Chairman of Hartford Company Dies

Charles Spafford Blake, chairman of the board of directors of the Hartford Steam Boiler Inspection & Insurance Company, died on March 31. Born in Windsor Locks, Ontario, on October 25, 1860, Mr. Blake was educated in the public schools of Springfield, Mass., and Jersey City, N. J. He served his apprenticeship at the Central Iron Works, Jersey City. Before he had reached his 21st year he was licensed as an engineer on small vessels. Shortly afterward he was certified as chief engineer of ocean-going steamers. Mr. Blake entered the boiler insurance field in 1884 as an inspector for the American Steam Boiler Insurance Company. Within three years, he had become chief inspector at the company's Philadelphia office and subsequently was made adjuster for its Chicago agency. He went with the Hartford Steam Boiler Inspection & Insurance Company on June 1, 1898, as its general agent in Hartford. In 1916, he was made a director of the company and at the same time elected to the presidency. He was made chairman of the board of directors on February 8, 1927.

Erie Railroad Standards of Locomotive Boiler Practice

▲ ▲ ▲

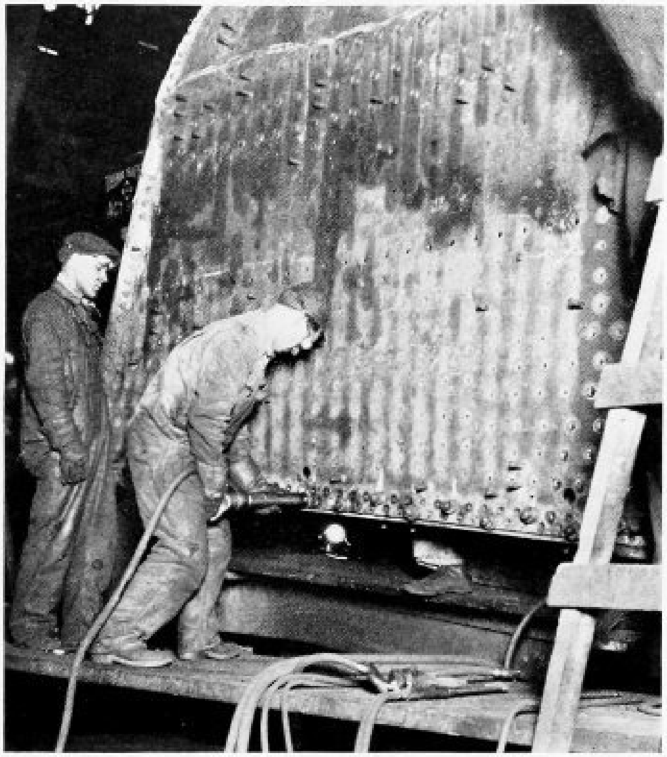


Fig. 7.—Driving the mud ring rivets

Flexible staybolts are to be applied in the combustion chamber, throat sheets and in the breaking zones of side and roof sheets and back heads, Fig. 9. All bolts should be released slightly from close contact with the sleeve seat before riveting up, as the riveting operation has a tendency to draw up the bolt.

The following table gives the approximate clearance between flexible staybolt head and sleeve by turning back after it has touched the sleeve:

1/8 turn backward—1/64 inch scant, 1/4 turn backward—1/64 inch full, 3/8 turn backward—1/32 inch full, 1/2 turn backward—3/64 inch scant, 5/8 turn backward—3/64 inch full, 3/4 turn backward—1/16 inch full, 7/8 turn backward—5/64 inch scant, 1 turn backward—5/64 inch full.

Flexible staybolts should be threaded so as to give a good running fit in firebox sheets. A tight fit is objectionable as it does not permit of proper seating of the bolt to the sleeve; while the loose fit has a tendency to turn while riveting.

When riveting up flexible staybolts, the holder-on should be held securely against the head of the bolt and kept central in the line of the riveting blow. Care should be exercised to protect the face of sleeves from burrs, jams, etc., which will tend to injure the cap seat.

The firebox end of all flexible staybolts, after riveted over (except in full installations) shall be marked with a deep center-punch mark.

Flexible staybolt caps should have threads coated with a mixture of graphite and oil before screwing onto sleeves. A copper gasket is to be used with all caps of Flannery welded-type sleeves.

Jacket and lagging shall not be applied until engines have been fired up, where such engines have received firebox repairs or complete removal of caps has been made for the two-year inspection. Following fire-up or break-in test, caps should be retightened as it will frequently be found they can be given an additional one-quarter to one-half turn.

Gasket seat and threads of flexible caps must be thoroughly cleaned out before applying. This is easily accomplished with an air hose and medium pressure.

Flexible Expansion Bolts.—Flexible radial bolts of the taper-head type of iron to conform to the railroad company specification are to be applied to the first four rows back of the flue sheet. When new fireboxes are applied, expansion bolts shall be 1 inch diameter.

The holes in the outer and inner sheets should be reamed at the same time to insure perfect alinement. The hole in the wrapper sheet is to be reamed to 1½ inches and the hole in the crown sheet is to be 1 1/16 inches.

The hole in the wrapper sheet is then countersunk with a ball joint reamer having an extension shank, which extends through the crown sheet hole as a guide. Counterboring of the ball seat is not to be over 1/8 inch deep at the low side. The shank or guide shall not be less than 1/16 inch smaller in diameter than the hole in the crown sheet.

All scale, oil, grease or any other foreign substance must be cleaned off the wrapper sheet around the sleeve seat and sleeve before application of sleeve. Sleeves are to be held in place by an applicator, while welding. Only sufficient metal to prevent leakage should be applied around the sleeve.

The hole in the crown sheet is required to be tapped out by using a tapered tap having a long guide stem, extending through a guide nut screwed into the sleeve. The guide stem on top must be not less than 1/16 inch smaller in diameter than the hole in the guide nut.

Expansion stay is to be screwed into place in the crown sheet and a "KN" nut screwed onto the outer end, being seated to sleeve and then turned back slightly to release from contact with the sleeve. (See table under flexible staybolts.) Care must be exercised to see that the bolt does not extend through the nut far enough to strike the cap and interfere with proper seating.

Second instalment of article on boiler shop practice. The first appeared on page 60 of the March issue.

Fig. 8.—Operations incidental to fitting up the back end assembly at one of the Erie shops

The bottom end of expansion stay is riveted to the crown sheet using a holder-on held securely against the top head of the bolt and centrally in line with the riveting. After riveting, the "KN" nut is to be screwed to its seat and cap applied.

Testing Flexible Staybolts with Caps.—All staybolts having caps over the outer end shall have the caps removed at least once every two years, except those drilled with telltale holes as provided below, and the bolts and sleeves examined for breakage. Each time the hydrostatic test is applied, the hammer test provided for rigid bolts shall be made, while the boiler is under hydrostatic pressure not less than the allowed working pressure.

When all flexible staybolts with which any boiler is equipped are provided with a telltale hole not less than 3/16 inch in diameter nor more than 7/32 inch in diameter, extending the entire length of the bolt and into the head not less than 1/3 of its diameter and these holes are protected from becoming closed by rust and corrosion by copper plating or other approved method, and are opened and tested, each time the hydrostatic test is applied, with an electrical or other instrument approved by the Bureau of Locomotive Inspection, that will positively indicate when the telltale holes are open their entire length, the caps will not be required to be removed. When this test is completed, the hydrostatic test must be applied and all staybolts removed which show leakage through the telltale holes.

The inner ends of the telltale holes must be kept closed with a fireproof porous material that will exclude foreign matter and permit leakage of steam or water, if the bolt is broken or fractured, into the telltale hole. When this test is completed, the ends of the telltale holes shall be closed with material of different color than that removed and a record kept of colors used.

The removal of flexible staybolt caps and other tests shall be reported on the Annual Locomotive Inspection and Repair Card.

Testing Flexible Staybolts without Caps.—Flexible staybolts, which do not have caps shall be tested once each month, the same as rigid bolts.

Each time a hydrostatic test is applied such staybolt test shall be made while the boiler is under hydrostatic pressure not less than the allowed working pressure and proper notation made on the Annual Locomotive Inspection and Repair Card.

Testing Rigid Staybolts.—All rigid staybolts must be tested once each month. They shall also be tested immediately after every hydrostatic test. The inspector must tap each bolt and determine the broken bolts from the sound or the vibration of the sheet. If staybolt tests are made when the boiler is filled with water, there must be not less than 50 pounds pressure on the boiler. Should the boiler not be under pressure, the test may be made after draining all water from the boiler, in which case the vibration of the sheet will indicate any unsoundness. The latter test is preferable.

Examining Sheets.—Firebox sheets must be carefully examined at least once every month for mud burn, bulging, and indication of broken staybolts.

Expansion Stays at Front End of Crown Sheet.—When engines receive Class 1, 2 or 3 repairs, all expansion stays of the sling stay or eyebolt type at the front end of the crown sheet must be examined closely and all stays loose or under compression must be removed and shortened, and reapplied under tension after flues are renewed.

When engines receive new back flue sheet, the crown sheet must be brought down to normal condition and sling stays lengthened if necessary to place under tension after flues are renewed.

Expansion stays of the eyebolt type are to be replaced when engines receive Class 1, 2 or 3 repairs by flexible expansion stays.

Fusible Plugs.—Fusible plugs shall be applied to the crown sheets of all locomotive boilers, except those equipped with low water alarms, and they are to be applied as near to the highest point of the crown sheet as the arrangement of crown bars or crown bolts will permit.

Fusible plugs are to be removed at every thirty-day washout period by the local boiler inspector and a new Banca tin disk applied regardless of the condition of the old disk. This is absolutely essential as the action of heat has a crystallizing effect on the disk tending to raise its fusing point.

Boiler inspectors shall exercise care in the application of fusible plugs to observe that the threads on the plug and in the sheet are in good condition and that the threads are not crossed or stripped when applying the plug. A mixture of flake graphite and heavy oil shall be coated on the threads of plug before application.

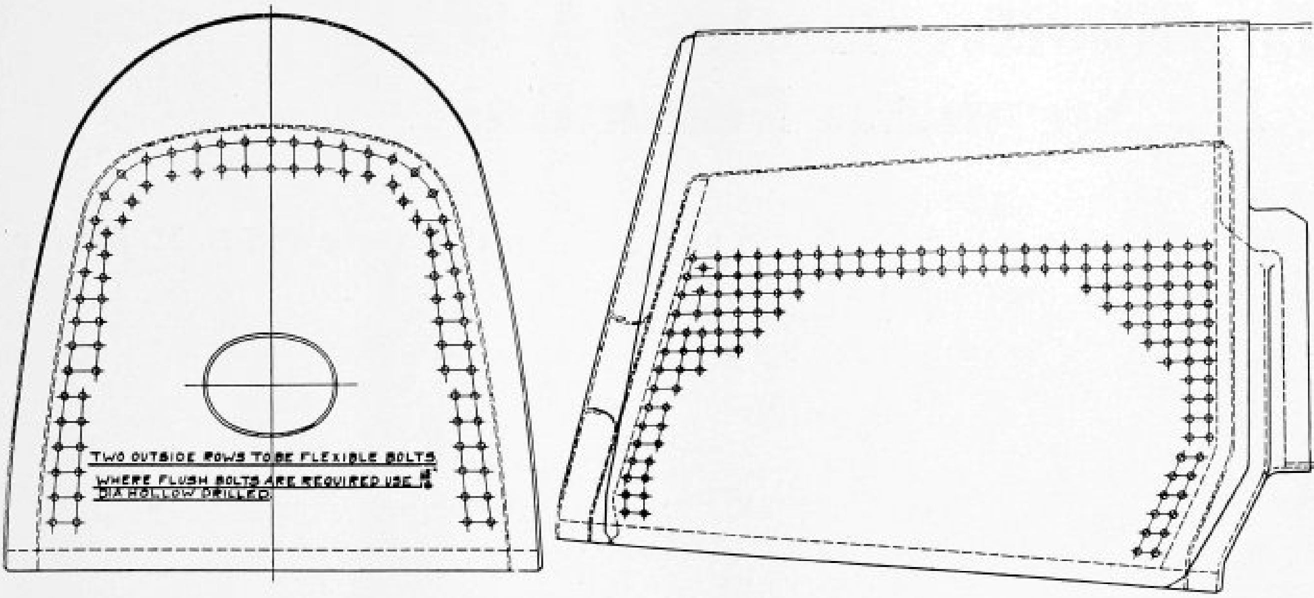


Fig. 9.—(Above) Flexible staybolt application in breaking zone of backhead, and in breaking zone of side sheets. Fig. 10. —(Right) Low water alarm and its parts

When holes in the crown sheet are found to be larger than 2 inches in diameter, such holes shall be electric welded shut, by first passing through the hole a plate, 3/16 inch thick, large enough to protect and lap on two sides of the hole. The welding metal should fuse with the plate. After the hole has been welded shut in this manner, the fusible plug hole is to be drilled in the center of its original position.

Low Water Alarms.—Low water alarms (Fig. 10) shall be located as near the highest point of the crown sheet as the arrangement of crown bars or expansion bolts will permit. Fusible plugs shall be omitted in fireboxes equipped with low water alarms.

Firebox plugs of low water alarms shall be removed by the local boiler inspector at each thirty-day washout inspection. The fusible plug shall then be removed, and where the improved type low water alarm is installed, that is not in direct contact with the water, it may be reapplied, if the tin element is undamaged. Fusible plugs of the type stated must, however, be renewed at the time of hydrostatic test. Fusible plugs of types coming in direct contact with the water in the boiler, shall be renewed at period of thirty-day washout.

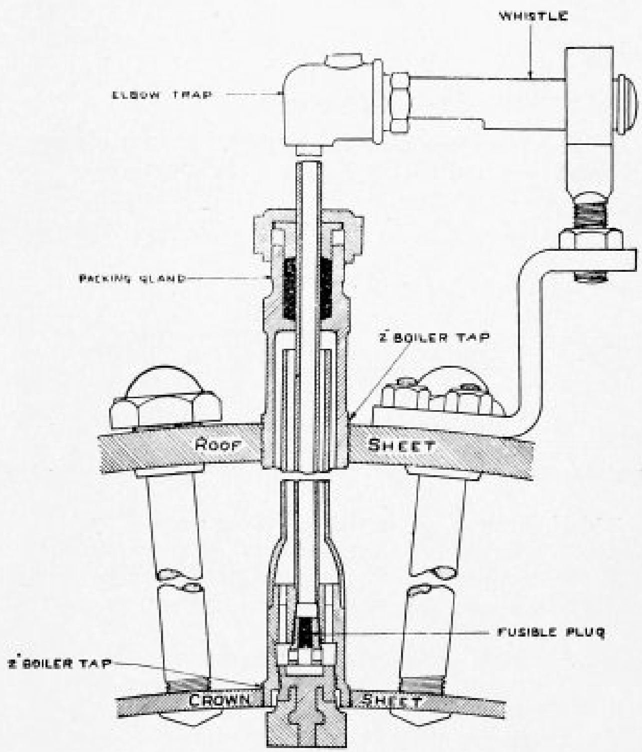
Fusible plug elements of low water alarms shall be sent to Meadville shops for re-filling with pure Banca tin.

Cages of low water alarms giving access of boiler water to the fusible plug must be carefully examined to see that all openings are free from scale.

The whistle of the low water alarm should be tested by inserting the nipple of an air hose in the fusible plug opening of the alarm cage before reassembling.

After inspection of fusible plug cage and whistle, the fusible plug and then the firebox plug shall be reapplied by the boiler inspector, after coating the threads with a mixture of graphite and oil.

The stuffing box of low water alarms located in the outside wrapper sheet must not be repacked with pressure in the boiler.



When steam or water is found escaping from the low water alarm whistle at terminals, draw the fire and blow off all steam pressure, remove whistle reducing elbow and clean the fused metal out of the trap provided in this elbow. The local boiler inspector should then test whistle as outlined above after which a new fusible plug can be applied.

Washout Plugs. All washout holes and plugs shall be carefully examined before applying and where necessary, holes must be retapped, plugs recut or new plugs applied. Where a shoulder of burnt graphite has formed on the plug, it shall be removed before re-applying. Coat all washout plugs before applying with graphite and oil.

(To be Continued)

Locomotive Boiler ▲▲▲ Strength Formulas*

By C. J. Zusy and G. M. Davies

P-16.—The minimum thickness of welt strips for joints with inside and outside welts, shall be as given in Table 4. Intermediate values shall be determined by interpolation. For plate thicknesses exceeding 1½ inches, the thickness of the welt strips shall be not less than two-thirds of the thickness of the plate.

TABLE 4—MINIMUM THICKNESS OF BUTT STRAPS

Thickness of shell plates, inches	Minimum thickness of welt strips inches	Thickness of shell plates, inches	Minimum thickness of welt strips inches
1/4	1/4	17/32	7/16
9/32	1/4	9/16	7/16
5/16	1/4	5/8	1/2
11/32	1/4	3/4	1/2
3/8	5/16	7/8	5/8
13/32	5/16	1	11/16
7/16	3/8	1-1/8	3/4
15/32	3/8	1-1/4	7/8
1/2	7/16	1-1/2	1

A.S.M.E. Boiler Code 1930, page 5.

P-17.—The method of calculating the seam efficiency of a double-riveted butt joint is as follows:

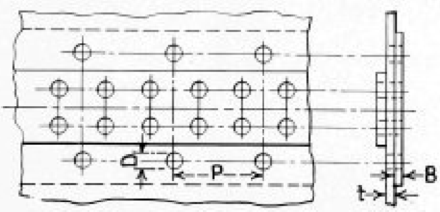


Fig. 4.—Double-riveted butt joint with inside and outside welts

This joint may fail in the following ways:

1.—Tearing of plate between rivet holes in outer row.

2.—Tearing of plate between rivet holes in the second row and shearing one rivet in single shear in the outside row.

3.—Shearing one rivet in single shear in the outside row and two rivets in double shear in the inside row.

4.—Tearing of plate between rivet holes in the second row and crushing welt strip in front of one rivet in the outside row.

5.—Crushing plate in front of two rivets in the inside row and in front of one rivet in welt strip in the outside row.

6.—Crushing plate in front of two rivets in the inside row and shearing one rivet in single shear in the outside row.

7.—Tearing of welt strips between rivet holes in the inside row. This method of failure is not possible for thicknesses of welt strips as required by Table 4 and the computation need only be made for old boilers in which thin butt straps have been used. For this reason this method of failure will not be considered in other butt joints with inside and outside welts.

RESISTANCE TO FAILURE

1.— $$\frac{(P - D) \times TS \times t}{P \times TS \times t}$$

2.— $$\frac{(P - 2D) \times TS \times t + A \times s}{P \times TS \times t}$$

3.— $$\frac{A \times s + 2A \times S}{P \times TS \times t}$$

4.— $$\frac{(P - 2D) \times TS \times t + D \times B \times C}{P \times TS \times t}$$

5.— $$\frac{2D \times t \times C + D \times B \times C}{P \times TS \times t}$$

6.— $$\frac{2D \times t \times C + A \times s}{P \times TS \times t}$$

Efficiency = Least value obtained in 1, 2, 3, 4, 5, or 6.

Example.—Assuming TS = 55,000 pounds.

t = ⅜ inch = .375 inch.
B = $\frac{5}{16}$ inch = .3125 inch.
P = 4⅞ inches = 4.875 inches.
D = ⅞ inch = .875 inch.
A = .6013 square inch.
s = 44,000 pounds.
S = 88,000 pounds.
C = 95,000 pounds.

1.— $$\frac{(4.875 - .875) \times 55{,}000 \times .375}{4.875 \times 55{,}000 \times .375} = 82.05$$

2.— $$\frac{(4.875 - 2 \times .875) \times 55{,}000 \times .375 + .6013 \times 44{,}000}{4.875 \times 55{,}000 \times .375} = 90.4$$

3.— $$\frac{.6013 \times 44{,}000 + 2 \times .6013 \times 88{,}000}{4.875 \times 55{,}000 \times .375} = 131.5$$

4.— $$\frac{(4.875 - 2 \times .875) \times 55{,}000 \times .375 + .875 \times .3125 \times 95{,}000}{4.875 \times 55{,}000 \times .375} = 89.9$$

5.— $$\frac{2 \times .875 \times .375 \times 95{,}000 + .875 \times .3125 \times 95{,}000}{4.875 \times 55{,}000 \times .375} = 87.8$$

6.— $$\frac{2 \times .875 \times .375 \times 95{,}000 + .6013 \times 44{,}000}{4.875 \times 55{,}000 \times .375} = 88.3$$

Efficiency = 82.05 percent.

P-18.—The method of calculating the seam efficiency of a triple-riveted butt joint is as follows:

This joint may fail in the following ways:

1.—Tearing of plate between rivet holes in the outer row.

2.—Tearing of plate between rivet holes in the second row and shearing one rivet in single shear in the outside row.

3.—Shearing one rivet in single shear in the outside row and four rivets in double shear in the second and third rows.

*This is the second of a series of articles entitled "Locomotive Boiler Strength Formulas." The first appeared in the March issue.

4.—Tearing of plate between rivet holes in the second row and crushing the welt strip in front of one rivet in the outside row.

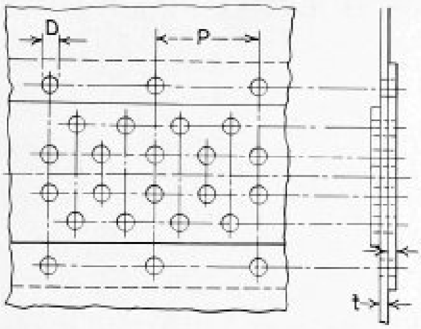


Fig. 5.—Triple-riveted butt joint with inside and outside welts

5.—Crushing the plate in front of four rivets in the second and third rows and in front of one rivet in the welt strip in the outside row.

6.—Crushing the plate in front of four rivets in the second and third rows and shearing one rivet in single shear in the outside row.

RESISTANCE TO FAILURE

1.— $$\frac{(P-D) \times TS \times t}{P \times TS \times t}$$

2.— $$\frac{(P-2D) \times TS \times t + A \times s}{P \times TS \times t}$$

3.— $$\frac{A \times s + 4A \times S}{P \times TS \times t}$$

4.— $$\frac{(P-2D) \times TS \times t + (D \times B \times C)}{P \times TS \times t}$$

5.— $$\frac{4D \times t \times C + D \times B \times C}{P \times TS \times t}$$

6.— $$\frac{4D \times t \times C + A \times s}{P \times TS \times t}$$

Efficiency = Least value obtained in 1, 2, 3, 4, 5, or 6.

Example.—Assuming TS = 55,000 pounds.

$t = \frac{3}{8}$ inch = .375 inch.
$B = \frac{5}{16}$ inch = .3125 inch.
$P = 6\frac{1}{2}$ inches = 6.5 inches.
$D = \frac{13}{16}$ inch = .8125 inch.
A = .5185 square inch.
s = 44,000 pounds.
S = 88,000 pounds.
C = 95,000 pounds.

1.— $$\frac{(6.5 - .8125) \times 55{,}000 \times .375}{6.5 \times 55{,}000 \times .375} = 87.4$$

2.— $$\frac{(6.5 - 2 \times .8125) \times 55{,}000 \times .375 + .5185 \times 44{,}000}{6.5 \times 55{,}000 \times .375} = 92.$$

3.— $$\frac{.5185 \times 44{,}000 + 4 \times .5185 \times 88{,}000}{6.5 \times 55{,}000 \times .375} = 153.1$$

4.— $$\frac{(6.5 - 2 \times .8125) \times 55{,}000 \times .375 + .8125 \times .3125 \times 95{,}000}{6.5 \times 55{,}000 \times .375} = 92.9$$

5.— $$\frac{4 \times .8125 \times .375 \times 95{,}000 + .8125 \times .3125 \times 95{,}000}{6.5 \times 55{,}000 \times .375} = 104.3$$

6.— $$\frac{4 \times .8125 \times .375 \times 95{,}000 + .5185 \times 44{,}000}{6.5 \times 55{,}000 \times .375} = 103.3$$

Efficiency = 87.4 percent.

P-19.—The method of calculating the seam efficiency of a triple-riveted butt joint is as follows:

This joint may fail in the following ways:

1.—Tearing of plate between rivet holes in outer row.

2.—Tearing of plate between rivet holes in the second row and shearing one rivet in single shear in the outside row.

3.—Tearing of plate between rivet holes in the third row and shearing three rivets in single shear in first and second rows.

4.—Shearing four rivets in double shear in the third row and three rivets in single shear in the first and second rows.

5.—Tearing of plate between rivet holes in the second row and crushing the welt strip in front of one rivet in the first row.

6.—Tearing of plate between rivet holes in the third row and crushing the welt strip in front of three rivets in the first and second rows.

7.—Crushing the plate in front of four rivets in the third row and crushing the welt strip in front of three rivets in the first and second rows.

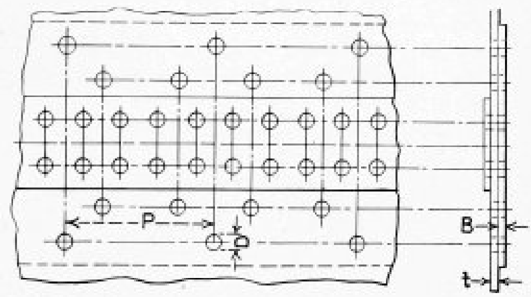


Fig. 6.—Triple-riveted butt joint with inside and outside welts

8.—Crushing the plate in front of four rivets in the third row and shearing three rivets in single shear in the first and second rows.

RESISTANCE TO FAILURE

1.— $$\frac{(P-D) \times t \times TS}{P \times t \times TS}$$

2.— $$\frac{(P \times 2D) \times t \times TS + A \times s}{P \times t \times TS}$$

3.— $$\frac{(P-4D) \times t \times TS + 3A \times s}{P \times t \times TS}$$

4.— $$\frac{4A \times S + 3A \times s}{P \times t \times TS}$$

5.— $$\frac{(P-2D) \times t \times TS + D \times B \times C}{P \times t \times TS}$$

6.— $$\frac{(P-4D) \times t \times TS + 3D \times B \times C}{P \times t \times TS}$$

7.— $$\frac{4D \times t \times C + 3D \times B \times C}{P \times t \times TS}$$

8.— $$\frac{4D \times t \times C + 3A \times s}{P \times t \times TS}$$

(Continued on page 109)

Revisions and Addenda to the Boiler Construction Code ▲ ▲ ▲

It is the policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the Rules and its Codes. Any suggestions for revisions or modifications that are approved by the committee will be recommended for addenda to the Code, to be included later on in the proper place in the Code.

The Boiler Code Committee has received and acted upon a number of suggested revisions which have been approved for publication as addenda to the Code. These are published below, with the corresponding paragraph numbers to identify their locations in the various sections of the Code, and are submitted for criticisms and comment thereon from any one interested therein. Discussions should be mailed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Committee for consideration.

After a suitable time has elapsed to afford full opportunity for such criticism and comment upon the revisions as approved by the Committee, it is the intention of the Committee to present the modified rules as finally agreed upon to the Council of the Society for approval as addenda to the Boiler Construction Code. Upon approval by the Council, the revisions will be published in the form of addenda data sheets, distinctly colored pink, and offered for general distribution to those interested, and included in the mailings to subscribers to the Boiler Code interpretation data sheets.

For the convenience of the reader in studying the revisions, all added matter appears in small capitals and all deleted matter in smaller type.

PREAMBLE—Insert the following:

The rules in Pars. P-193, P-260, P-261, and P-268, which bear on the reinforcement of openings, are under consideration for revision and as soon as a conclusion is reached they will be issued in amended form.

PAR. P-180. REVISE DEFINITION OF THE TERM *TS* UNDER THE FORMULA TO READ:

TS = ultimate tensile strength IN lb. per sq. in., stamped on THE shell plates OR SEAMLESS SHELLS as provided for in the MATERIAL specifications [for Steel Boiler Plate].

PAR. P-182. REVISED:

P-182. FOR LONGITUDINAL JOINTS the distance between the center lines of any two adjacent rows of rivets, or the "back pitch" measured at right angles to the direction of the joint, shall have the following minimum values:

a If $\frac{P}{d}$ is 4 or less, the minimum value shall be $2d$;

b If $\frac{P}{d}$ is over 4, the minimum value shall be:

$$2d + 0.1\,(P - 4d)$$

where

P = pitch of rivets in outer row where a rivet in the inner row comes midway between two rivets in the outer row, in.

P = pitch of rivets in the outer row less pitch of rivets in the inner row where two rivets in the inner row come between two rivets in the outer row, in. (It is here assumed that the joints are of the usual construction where the rivets are symmetrically spaced.)

d = diameter of the rivet holes in.

THE BACK PITCH OF CIRCUMFERENTIAL JOINTS MAY BE LESS THAN THAT CALLED FOR BY THE ABOVE FORMULAS PROVIDED THE LIGAMENTS BETWEEN RIVETS IN A CIRCUMFERENTIAL DIRECTION, AS WELL AS THOSE IN A DIAGONAL DIRECTION, AS DETERMINED BY THE RULES IN PAR. P-193 ARE SUFFICIENT TO WITHSTAND THE STRESS DUE TO PRESSURE, TOGETHER WITH ANY STRESS DUE TO WEIGHT COMPONENTS IN SUPPORT OF BOILER STRUCTURE, WITH A FACTOR OF SAFETY OF FIVE.

The back pitch of rivets shall be measured either on the flat plate before rolling, or on the median line after rolling, AND THE BACK PITCH AS THERE MEASURED SHALL GOVERN THE LOCATIONS OF RIVET HOLES IN THE BUTT STRAPS.

PAR. P-184. ADD THE FOLLOWING AS SECTION *e*:

e THE DISTANCE BETWEEN ANY TWO ROWS OF RIVETS IN A CIRCUMFERENTIAL JOINT OR "BACK PITCH" SHALL NOT BE LESS THAN $1.75d$.

PAR. P-186. REVISE THIRD SENTENCE OF FIRST SECTION TO READ:

Joints between the doorhole flanges of furnace and exterior sheets may be butt or lapwelded by the fusion process, provided these sheets are stayed or otherwise supported around the doorhole opening and provided the distance from the flange to the surrounding [row of] stays or other supports does not exceed the permissible staybolt pitch as per Par. P-199.

REVISE THE SECOND SECTION TO READ:

Where the entire area is welded simultaneously, electric resistance butt welding OR BUTT WELDING WHERE THERMIT IS EMPLOYED AS THE HEATING ELEMENT WITHOUT THE INTRODUCTION OF EXTRANEOUS METAL may be used and the ultimate strength of the joint taken as 35,000 lb. per sq. in. as in the case of forge welding. EITHER METHOD [it] may, upon the request of a manufacturer who submits proper scientific data and evidence, be given a higher rating by the Boiler Code Committee than for forge welding, provided that an authorized inspector may demand a test of any one of the welded articles he may select for the purpose, and if, after witnessing such a test, he shall doubt the advisability of using the assigned rating for the weld, the case shall be referred to the Boiler Code Committee for its decision.

PARS. P-195 AND U-36. REVISE DEFINITION OF THE TERM *TS* IN THE FORMULA TO READ:

TS = tensile strength, lb. per sq. in., ORIGINALLY STAMPED ON THE PLATE USED IN FORMING THE HEAD

REVISE THIRD SECTION TO READ:

When a head dished TO A SEGMENT OF A SPHERE has a manhole or access opening that exceeds 6 in. in any dimension, the thickness shall be increased by not less than 15 percent of the required thickness for a blank head computed by the above formula, but in no case less than 1/8 in. additional thickness over a blank head. Where SUCH a dished head has a flanged opening supported by an attached flue, an increase in thickness over that for a blank head is not required. If more than one manhole is inserted in a head, the thickness of which is calculated by this rule, the minimum distance between the openings shall not be less than one-fourth of the outside diameter of the head.

INSERT THE FOLLOWING AS THE SIXTH SECTION:

NO HEAD SHALL BE OF A LESSER THICKNESS THAN THAT REQUIRED FOR A SEAMLESS SHELL OF THE SAME DIAMETER.

REVISE PRESENT SIXTH SECTION TO READ:

A blank head of a semi-elliptical form in which half the minor axis or the depth of the head is at least equal to one-quarter of the inside diameter of the head shall be made at least as thick as the required thickness of a seamless shell of the same diameter. If a flanged-in manhole which meets the Code requirements is placed in an elliptical head, the thickness OF THE HEAD shall be the same as for a head dished TO A SEGMENT OF A SPHERE with a dish radius equal to 0.8 the diameter of the shell and with the added thickness for the manhole.

PARS. P-197 AND U-38, AND P-198 AND U-39. COMBINE AS SECTIONS *a* AND *b* OF PARS. P-197 AND U-38:

PARS. P-197*a* AND U-38*a*. REVISED:

a The corner radius of an unstayed dished head measured on the concave side of the head shall not be less than 3 times the thickness of the material in the head; but in no case less than 6 percent of the diameter of the shell. IN NO CASE SHALL THE THINNING DOWN AT THE CORNER RADIUS OF THE KNUCKLE OF ANY DISHED HEAD DUE TO THE PROCESS OF FORMING EXCEED 10 PERCENT OF THE THICKNESS REQUIRED BY THE FORMULA IN PAR. P-195.

PARS. P-198 AND U-39. INSERT THE FOLLOWING NEW PARAGRAPH:

FLAT HEADS

THE THICKNESS REQUIRED IN UNSTAYED FLAT HEADS, WHICH ARE UNPIERCED AND ARE RIGIDLY FIXED AND SUPPORTED AT THEIR BOUNDING EDGES BY RIVETED OR BOLTED ATTACHMENTS TO SHELLS OR SIDE PLATES, SHALL BE CALCULATED BY THE FOLLOWING FORMULA:

$$t = a\sqrt{\frac{0.162\,P}{S}}$$

WHERE

t = THICKNESS OF PLATE IN HEAD, IN.

a = DIAMETER, OR SHORT SIDE OF AREA MEASURED TO THE CENTER OF THE INSIDE ROW OF RIVETS OR BOLTS, IN.

P = MAXIMUM ALLOWABLE WORKING PRESSURE, LB. PER SQ. IN.

S = ALLOWABLE UNIT WORKING STRESS, LB. PER SQ. IN. $= \frac{TS}{5}$

TS = ULTIMATE TENSILE STRENGTH STAMPED ON THE PLATES, AS PROVIDED FOR IN THE SPECIFICATIONS FOR STEEL BOILER PLATE, LB. PER SQ. IN.

PAR. P-230*b*. IN THE THIRD LINE OF THE FINE-TYPE MATTER FOLLOWING THE FORMULA, REPLACE "p" BY "D_1", AND REVISE DEFINITION OF D_1 TO READ:

D_1 = longitudinal SPACING [pitch] of crown bar WHICH SHALL NOT EXCEED TWICE THE MAXIMUM ALLOWABLE STAYBOLT PITCH, in.

PAR. P-253. REVISED:

P-253. *Rivet and Staybolt Holes.* All holes in braces, lugs and sheets for rivets or staybolts shall be drilled [full size with plates, butt straps and heads bolted up in position], or they may be [drilled or] punched AT LEAST 1/8 IN. LESS THAN FULL DIAMETER FOR MATERIAL NOT MORE THAN 5/16 IN. THICK AND AT LEAST 1/4 IN. LESS THAN FULL DIAMETER FOR MATERIAL MORE THAN 5/16 IN. THICK [not to exceed 1/4 in. less than full size for plates over 5/16 in. in thickness and 1/8 in. less than full size for plates not exceeding 5/16 in. in thickness and then drilled or reamed to full size with plates, butt straps and heads bolted up in position.].

Such holes shall not be punched in material more than 5/8 in. thick.

FOR FINISHING THE RIVET HOLES, THE PLATES, BUTT STRAPS, BRACES, HEADS AND LUGS SHALL BE FIRMLY BOLTED IN POSITION BY TACK BOLTS FOR FINAL DRILLING OR REAMING TO FULL DIAMETER.

The finished holes must be true, clean and concentric.

PAR. P-257. ADD THE FOLLOWING PARAGRAPH AS SECTION *b*:

b FUSION WELDING MAY BE USED TO SEAL THE CALKING EDGES OF CIRCUMFERENTIAL-RIVETED LAP JOINTS OF POWER BOILERS PROVIDED THE PLATES DO NOT EXCEED 0.30 PERCENT CARBON AND THAT THEIR THICKNESS IS AT LEAST 1/8 IN. MORE THAN THAT REQUIRED FOR A SEAMLESS SHELL OF THE SAME DIAMETER, SAME WORKING PRESSURE AND SAME GRADE OF MATERIAL. FOR FIRETUBE BOILERS THE THICKNESS OF THE PLATES AT THE CALKING EDGES OF CIRCUMFERENTIAL SEAMS IF TO BE SEAL WELDED SHALL BE AT LEAST 1/8 IN. MORE THAN 60 PERCENT OF THAT REQUIRED FOR A SEAMLESS SHELL OF THE SAME DIAMETER, SAME WORKING PRESSURE, AND SAME GRADE OF MATERIAL. SUCH SEAL WELDING SHALL NOT BE APPLIED UNTIL AFTER THE BOILER IS MADE TIGHT AS EVIDENCED BY THE REGULAR HYDROSTATIC PRESSURE TEST PRESCRIBED IN PAR. P-329. SEAL WELDING MAY BE USED ON NOZZLES AND THEIR REINFORCING PLATES UNDER THE SAME CONDITIONS. ON UNSTAYED DISHED HEADS, SEAL WELDING SHALL NOT BE APPLIED CLOSER THAN 1/2 IN. TO THE POINT OF TANGENCY OF THE KNUCKLE OF THE FLANGE. SEAL WELDING MAY BE APPLIED ONLY WHEN THE WELD METAL IS DEPOSITED IN A SINGLE LAYER HAVING A THROAT THICKNESS OF NOT LESS THAN 3/16 IN., NOR MORE THAN 5/16 IN. THE HEAT FROM WELDING SHALL NOT DISTORT THE PLATE OR LOOSEN THE RIVETS IN SUCH A MANNER AS TO BREAK THE INITIAL BOND EFFECTED IN THE RIVETED JOINT. AFTER SEAL WELDING, THE VESSEL SHALL BE RESUBJECTED TO THE PRESCRIBED HYDROSTATIC TEST.

PAR. P-261*b*. ADD FOLLOWING SENTENCE:

THE REQUIRED STRENGTH OF THE RIVETS IN SHEAR IN THE FLANGE OF A NOZZLE MAY BE COMPUTED BY BOTH SECTIONS *a* AND *b*, AND THE LESSER OF THE TWO VALUES USED.

PAR. P-261. ADD THE FOLLOWING NEW SECTION:

e IN CASE A SHELL IS MADE THICKER THAN REQUIRED BY THE CODE IN ORDER TO ALLOW FOR CORROSION OR FOR ANY OTHER REASON, THE RULES IN THIS PARAGRAPH SHALL BE BASED ON THE REQUIRED THICKNESS OF THE SHELL.

PAR. P-269. REVISE FIRST SENTENCE TO READ:

P-269. *Safety-Valve Requirements.* Each boiler having more than [either] 500 sq. ft. of water-heating surface, or in which the generating capacity exceeds 2000 lb. per hour, shall have two or more safety valves.

PAR. P-274. REVISE SECOND SECTION TO READ:

The heating surface shall be computed for that side of the boiler surface exposed to the products of combustion, exclusive of the superheating surface. In computing the heating surface for this purpose, only the tubes, fireboxes, shells, tube sheets and the projected area of headers need be considered, EXCEPT THAT FOR VERTICAL FIRE-TUBE BOILERS, ONLY THAT PORTION OF THE TUBE SURFACE UP TO THE MIDDLE GAGE COCK IS TO BE COMPUTED. The minimum number and size of safety valves required shall be determined on the basis of the aggregate relieving capacity and the relieving capacity marked on the valves by the manufacturer. Where the operating conditions are changed, or additional heating surface such as water screens or water walls is connected to the boiler circulation, the safety-valve capacity shall be increased, if necessary, to meet the new conditions and be in accordance with Par. P-270. The additional valves required on account of changed conditions may be installed on the steam line between the boiler and the main stop valve except when the boiler is equipped with a superheater or other piece of apparatus, in which case they may be installed on the steam pipes between the boiler drum and the inlet TO THE SUPERHEATER OR [of the] other apparatus, provided that the steam main between the boiler and points where a safety valve or valves may be attached has a cross-sectional area at least 3 times the combined areas of the inlet connections to the safety valves applied to it.

PAR. P-291. REVISED:

P-291. *Water Glasses and Gage Cocks.* Each boiler shall have at least one water-gage glass, with connections not less than ½ in. pipe size. [The lowest visible part of the water glass shall be not less than 2 in. above the lowest permissible water level.] The water-gage glass shall be equipped with a valved drain.

THE LOWEST VISIBLE PART OF THE WATER GAGE GLASS SHALL BE AT LEAST 2 IN. ABOVE the lowest permissible water level, WHICH LEVEL shall be that at which there will be no danger of overheating any part of the boiler when IN OPERATION [it is operated with the water not lower than] AT that level. THE [this] LOWEST PERMISSIBLE WATER LEVEL for the usual types of boilers is given in Par. A-21 of the Appendix.

BOILERS OF THE HORIZONTAL FIRE-TUBE TYPE SHALL BE SO SET THAT WHEN THE WATER IS AT THE LOWEST READING IN THE WATER-GAGE GLASS THERE SHALL BE AT LEAST 3 IN. OF WATER OVER THE HIGHEST POINT OF THE TUBES, FLUES, OR CROWN SHEET.

PAR. P-296. REVISE FIRST PART TO READ:

P-296. *Steam Gages.* Each boiler shall have a steam gage connected to the steam space or to the water column or its steam connection. The steam gage shall be connected to a siphon or equivalent device of sufficient capacity to keep the gage tube filled with water and so arranged that the gage cannot be shut off from the boiler except by a cock placed near the gage and provided with a tee or lever handle arranged to be parallel to the pipe in which it is located when the cock is open; FOR BOILERS CARRYING 500 LB. PRESSURE OR OVER, VALVES MAY BE USED IN PLACE OF COCKS.

PAR. P-301. REVISED:

P-301. *Stop Valves.* Each steam-discharge outlet, except safety-valve and superheater connections, shall be fitted with a stop valve located at an accessible point in the steam delivery line and as near to the boiler nozzle as convenient and practicable. When such outlets are over 2-in. pipe size, the valve or valves used on the connection shall be of the outside-screw-and-yoke rising-spindle type SO AS TO INDICATE BY THE POSITION OF ITS SPINDLE WHETHER IT IS CLOSED OR OPEN, and the wheel may be carried either on the yoke or attached to the spindle.

PAR. P-308. REVISED:

P-308. Each boiler shall have a bottom blow-off pipe, fitted with a valve or cock, in direct connection with the lowest water space practicable; the minimum size of pipe and fittings shall be 1 in., and the maximum size shall be 2½ in., except that for boilers 24 in. or less in diameter the minimum size of pipe and fittings may be ¾ in. Straight-run globe valves of the ordinary type as shown in Fig. P-19, or valves of such type OR SO INSTALLED that dams or pockets can exist for the collection of sediment IN SUFFICIENT QUANTITIES TO OBSTRUCT THE FLOW, shall not be used on such connections. Return connections of the same size or larger than the size herein specified may be used, and the blow-off may be connected to them. In such case, the blow-off must be so located that the connection may be completely drained.

PAR. P-314. ADD THE FOLLOWING:

IN VERTICAL TUBULAR BOILERS, FEEDWATER SHALL BE INTRODUCED AT A POINT NOT LESS THAN ONE-FOURTH THE LENGTH OF THE TUBE ABOVE THE LOWER TUBE SHEET OR CROWN SHEET. IN VERTICAL BOILERS OF THE TUBELESS, STUB OR PORCUPINE TYPE, A DEFLECTION PLATE SHALL BE ATTACHED TO THE INNER SIDE OF THE OUTER SHELL DIRECTLY IN FRONT OF THE POINT OF INTRODUCTION OF FEEDWATER. THIS LATTER METHOD OF INTRODUCTION OF THE FEED MAY BE USED ON ALL TYPES OF VERTICAL BOILERS IF SO DESIRED.

PAR. P-318. REVISE LAST SENTENCE TO READ:

On boilers having more than 100 sq. ft. of heating surface, the feed pipe shall be not less than ¾ in. pipe size, BUT IN NO CASE SHALL THE FEED PIPE BE LESS THAN ½ IN. PIPE SIZE.

PAR. P-328. REVISE FIRST SENTENCE OF SECOND SECTION TO READ:

These latches or fastenings shall be of the automatic positive-locking type having a latch or bolt in a fixed bracket on the DOOR, door frame or furnace front.

PAR. P-332. REVISE FIRST SECTION TO READ:

P-332. Each boiler shall conform in every detail to these Rules, and shall be distinctly stamped with the symbol as shown in Fig. P-21, WHICH STAMPING IS A GUARANTEE BY THE MANUFACTURER THAT HE HAS COMPLIED WITH ALL THE REQUIREMENTS OF THE CODE [denoting that the boiler was constructed in accordance therewith.]

Section II—Revisions have been proposed in the following specifications which are either identical with or based on the specifications of the American Society for Testing Materials:

- Carbon-Steel and Alloy-Steel Forgings (Spec. S-10) —A.S.T.M. Spec. A 18-30
- Malleable Castings (Spec. S-15)—A.S.T.M. Spec. A 47-30
- Boiler Rivet, Staybolt, and Extra-Refined Bar Iron (Spec. S-16)—A.S.T.M. Spec. A 84-30
- Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (Spec. S-17)—A.S.T.M. Spec. A 83-30
- Welded and Seamless Steel Pipe (Spec. S-18)—A.S.T.M. Spec. A 53-30
- Welded Wrought-Iron Pipe (Spec. S-19)—A.S.T.M. Spec. A 72-30

The following new specifications have been added to Section II, and will be designated as Spec. S-25:

- Open-Hearth Iron Plate of Flange Quality—A.S.T.M. Spec. A 129-30T

For detail schedule concerning the above specifications communicate with Secretary of the Boiler Code Committee.

PAR. H-5. REVISED:

H-5. Specifications are given in [Pars. S-1 to S-263 of] Section II of the Code for the important materials used in the construction of boilers. Material for parts of low-pressure heating boilers [required to resist internal pressure] for which specifications have been provided, shall conform to those specifications except as otherwise specified herein.

PARS. H-40 AND H-93. REVISED:

WHEN A STOP VALVE IS USED IN THE SUPPLY PIPE CONNECTION OF A SINGLE BOILER, THERE SHALL BE ONE USED IN THE RETURN PIPE CONNECTION. IT IS RECOMMENDED THAT NO STOP VALVES BE PLACED IN THE SUPPLY AND RETURN PIPE CONNECTIONS OF A SINGLE BOILER INSTALLATION.

A STOP VALVE SHALL BE USED IN EACH SUPPLY AND RETURN PIPE CONNECTION OF TWO OR MORE BOILERS CONNECTED TO A COMMON SYSTEM.

IT IS RECOMMENDED THAT THE RETURN PIPE CONNECTION OF EACH BOILER SHALL BE SO ARRANGED AS TO

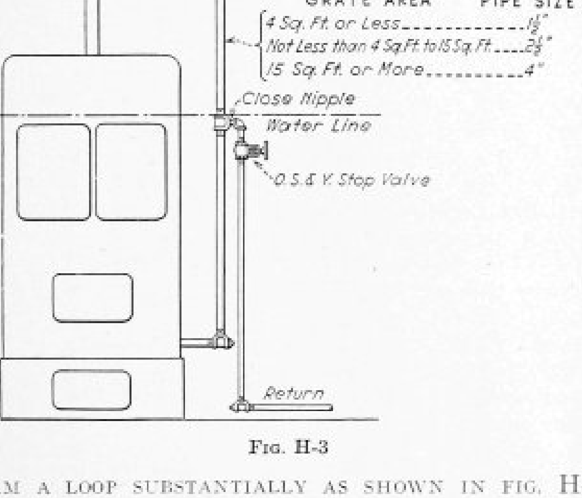


FIG. H-3

FORM A LOOP SUBSTANTIALLY AS SHOWN IN FIG. H-3 SO THAT THE WATER IN EACH BOILER CANNOT BE FORCED OUT BELOW THE SAFE WATER LEVEL.

PROVISION SHALL BE MADE FOR CLEANING THE INTERIOR OF THE RETURN PIPING AT OR CLOSE TO THE BOILER.

WHEN STOP VALVES OVER 2 IN. IN SIZE ARE USED THEY SHALL BE OF THE OUTSIDE SCREW-AND-YOKE TYPE.

WHEN STOP VALVES ARE USED THEY SHALL BE PROPERLY DESIGNATED SUBSTANTIALLY AS INDICATED BELOW BY TAGS OF METAL OR OTHER DURABLE MATERIAL FASTENED TO THEM.

[If valves are used in the supply and return mains

SUPPLY VALVE—NUMBER ( )
DO NOT CLOSE WITHOUT ALSO CLOSING
RETURN VALVE—NUMBER ( )

RETURN VALVE—NUMBER ( )
DO NOT CLOSE WITHOUT ALSO CLOSING
SUPPLY VALVE—NUMBER ( )

they shall be locked and sealed open and bear tags stating that provision must be made to prevent pressure from building up in the boiler whenever the valves are closed. It is recommended that no valves be placed in the supply and return mains of single boiler installations.]

PARS. H-44 AND H-97. REVISED:

Water-Relief Valves. AT LEAST ONE water-relief valve shall be connected to EACH [all] hot-water HEATING OR HOT-WATER SUPPLY boilers. The valve shall be of the diaphragm-operating type, without guide wings below the seat, set to open at or below the maximum allowable working pressure. No water-relief valve shall be smaller than ½ in. nor LARGER [greater] than 2 in. standard pipe size. [The outlets of water-relief valves shall have open discharges in plain sight.] THE VALVE SHALL BE PLACED ON A VERTICAL DEAD END PIPE ATTACHED TO THE COLD-WATER SUPPLY PIPE CONNECTION CLOSE TO THE BOILER OR DIRECTLY TO THE BOILER WITHOUT AN INTERVENING VALVE. THE VERTICAL DEAD END PIPE TO WHICH THE VALVE IS ATTACHED SHALL BE AT LEAST 1 IN. NOMINAL PIPE SIZE, AND THE VERTICAL DISTANCE FROM THE COLD-WATER SUPPLY PIPE OR FROM THE BOILER CONNECTION TO THE WATER-RELIEF VALVE SHALL BE AT LEAST 6 IN.

PARS. H-61 AND H-114. REVISED:

Water-Gage Glasses. Each steam boiler shall have [at least] one OR MORE water-gage glasses, WITH THE LOWER FITTING PROVIDED WITH A VALVE OR PET COCK TO FACILITATE CLEANING.

PARS. H-63 AND H-116. REVISE FOURTH SENTENCE OF PAR. H-63 AND THIRD SENTENCE OF PAR. H-116 TO READ:

No connections, except for combustion regulator, drain[s] or steam gage[s], shall be ATTACHED TO [placed on] the PIPING [pipes] connecting a water column to a boiler.

REVISE FIFTH SENTENCE OF PAR. H-63 AND FOURTH SENTENCE OF PAR. H-116 TO READ:

If the water column or gage glass is connected to the boiler by pipe and fittings, a cross[es or], tee[s] or EQUIVALENT, IN WHICH A DRAIN VALVE AND PIPING MAY BE ATTACHED, shall be PLACED IN [used on] the water PIPING connection AT EVERY RIGHT-ANGLE TURN to facilitate cleaning.

PAR. H-64. REVISED:

H-64. *Low-Water Fuel-Supply Cut-Off. a* IT IS RECOMMENDED THAT ON ALL AUTOMATICALLY FIRED STEAM OR VAPOR-SYSTEM BOILERS, A LOW-WATER FUEL-SUPPLY CUT-OFF BE INSTALLED IN SUCH LOCATION THAT IT AUTOMATICALLY CUTS OFF THE FUEL SUPPLY WHEN THE SURFACE OF THE WATER FALLS TO THE LOWEST SAFE WATER LINE.

Fusible Plugs. b. A fusible plug, if used, shall be placed at the lowest safe water line and in contact with the products of combustion.

PAR. H-74. REVISED:

H-74. *Material for Base Metal.* The base metal composing the plates of [autogenously] FUSION-WELDED heating boilers shall be of weldable flange or firebox quality conforming to the requirements of Pars. H-122 to H-136, inclusive, OR OF SPECIFICATIONS S-1 OR S-25 OF SECTION II OF THE CODE. IF DESIRED, STEEL OF LOWER TENSILE STRENGTH THAN SPECIFIED MAY BE USED, THE DESIRED TENSILE LIMITS TO BE SPECIFIED WITH A RANGE OF 10,000 LB. PER SQ. IN.

PAR. H-117. REVISED:

H-117. *Low-Water Fuel-Supply Cut-Off. a* IT IS RECOMMENDED THAT ON ALL AUTOMATICALLY FIRED STEAM OR VAPOR-SYSTEM BOILERS, A LOW-WATER FUEL-SUPPLY CUT-OFF BE INSTALLED IN SUCH LOCATION THAT IT AUTOMATICALLY CUTS OFF THE FUEL SUPPLY WHEN THE SURFACE OF THE WATER FALLS TO THE LOWEST SAFE WATER LINE.

Fusible Plugs. *b* A fusible plug, if used, shall be placed at an accessible point in the combustion chamber.

PAR. M-2. ADD THE FOLLOWING SECTION:

IF, IN THE DEVELOPMENT OF THE ART OF WELDING, OTHER MATERIALS THAN THOSE HEREIN DESCRIBED BECOME AVAILABLE, SPECIFICATIONS MAY BE SUBMITTED FOR CONSIDERATION.

PAR. M-3*a*. REVISED:

M-3*a*. Steel plate SUBJECT TO PRESSURE IN [when used for] any part of a miniature boiler of riveted construction [where under pressure] shall be of the firebox or flange grades. [but] FOR RIVETED SHELLS THE PLATES SHALL [in no case] NOT BE [shall steel of] less than 1/4 in. IN thickness AND FOR SEAMLESS [be used for riveted] shells SHALL BE NOT [or] less than 3/16 in. IN thickness [for seamless shells]. [The] Heads [if] used as tube sheets with tubes rolled in, shall be at least 5/16 in. thick.

PAR. M-4. ADD SECTIONS *b* AND *c* TO READ:

b MINIATURE BOILERS MAY BE FABRICATED BY MEANS OF FUSION WELDING PROVIDED THE MATERIALS USED CONFORM TO SPECIFICATIONS S-1 FOR STEEL BOILER PLATE, OR S-2 FOR STEEL PLATES OF FLANGE QUALITY FOR FORGE WELDING OF SECTION II OF THE CODE, OR TO THE REQUIREMENTS FOR PIPE MATERIAL SPECIFIED IN PAR. M-2.

BEFORE BEING PERMITTED TO WORK ON THE FABRICATION OF ANY MINIATURE BOILER UNDER THESE RULES, EACH WELDER IS REQUIRED TO QUALIFY UNDER THE QUALIFICATION TESTS FOR WELDERS IN THE CODE FOR UNFIRED PRESSURE VESSELS. THE INSPECTOR MAY AT ANY TIME CALL FOR THE QUALIFICATION TEST OF ANY OF THE WELDERS ENGAGED IN THE FABRICATION OF MINIATURE BOILERS.

Maximum Allowable Working Stress. *c* WHEN CONSTRUCTED IN ACCORDANCE WITH THESE RULES, THE MAXIMUM ALLOWABLE WORKING STRESS OF A WELDED JOINT, AT RIGHT ANGLES TO THE DIRECTION OF THE JOINT, SHALL BE THAT SPECIFIED IN THE CODE FOR UNFIRED PRESSURE VESSELS FOR THE GRADE OF FUSION WELDING USED.

PAR. M-7. REVISED:

M-7. Circumferential riveted joints, where used, shall conform to the requirements in Par. P-184 of Section I of the Code. [Autogenous welding may be used for joints in miniature boilers where the strain is carried by other construction which conforms to the requirements of the Code and where the safety of the structure is not dependent upon the strength of the weld.]

PAR. M-11. REVISED:

M-11. Every miniature boiler shall be fitted with not less than three brass washout plugs of 1 in. iron-pipe size, which shall be screwed into openings in the shell near the bottom. [reinforced to give four full threads.] IN A MINIATURE BOILER OF THE CLOSED-SYSTEM TYPE WHICH IS HEATED BY REMOVABLE INTERNAL ELECTRIC HEATING ELEMENTS AND WHERE THE OPENINGS FOR THE HEATING ELEMENTS MAY BE USED FOR CLEANING PURPOSES, SUCH OPENINGS MAY BE USED FOR WASHOUT OPENINGS. All threaded openings in the boiler [shell] shall be provided with a riveted or welded reinforcement if necessary, to give four full threads therein.

PAR. M-19. RENUMBER AS PAR. M-20 AND INSERT NEW PAR. M-19 TO READ:

M-19. *Hydrostatic and Hammer Tests for Welded Construction.* EACH BOILER OF WHOLLY OR PARTLY WELDED CONSTRUCTION SHALL BE SUBJECTED TO A HYDROSTATIC PRESSURE EQUAL TO 3 TIMES THE MAXIMUM ALLOWABLE WORKING PRESSURE, AND WHILE SUBJECT TO THIS HYDROSTATIC PRESSURE SHALL BE GIVEN A THOROUGH HAMMER OR IMPACT TEST. THIS IMPACT TEST SHALL CONSIST OF STRIKING THE SHEET SHARP BLOWS 2 TO 3 IN. APART ALONG BOTH SIDES OF THE WELDED SEAM WITH A LONG-HANDLED HAMMER. THE BLOWS SHALL BE AS RAPID AS A MAN CAN CONVENIENTLY STRIKE A SHARP, SWINGING BLOW, AND AS HARD AS CAN BE STRUCK WITHOUT BENDING THE SHEET. THE WEIGHT OF THE HAMMER SHALL BE EQUAL TO 10 PERCENT OF THE WEIGHT OF 1 SQ. FT. OF THE WALL OF THE VESSEL, BUT NOT LESS THAN 1 LB.

PAR. I-19. REVISE FIRST SECTION TO READ:

I-19. *Tube-Hole Tolerance and Use of Ferrules.* The INITIAL diameter of finished tube holes shall not exceed the nominal diameter of the tubes by an amount greater than shown in the following table:

PAR. I-21. REVISED:

I-21. *General Flanging.* The inspector shall see that in flanged sections there are no cracks due to the flanging operation, no deep hammer marks, burned sections, scars, or other injurious surface defects. It is to be noted that reduction in thickness is not below the designed thickness at the heel of the flange, and that the flanged section is practically true to form as designed. [When flanged manholes are used the corners shall be well rounded to a radius not less than that specified in the Code.] The manhole flange and reinforcing ring shall, when used, be installed in accordance with the requirements of the Code.

PAR. U-1. REVISED:

U-1. The Rules in this Section apply to CLOSED Unfired Pressure Vessels [over 6 in. in diameter, having a volume of more than 1.5 cu. ft. and] carrying a pressure of over 15 [30] lb. per sq. in., constructed of material herein specified.

PAR. U-12. REVISED:

U-12. ALL MATERIALS for the important PARTS [materials] used in the construction of [boilers and] UNFIRED pressure vessels, FOR WHICH specifications are given in [Specifications S-1 to S-24 of] Section II of the Code [and when such materials are used for the construction of unfired pressure vessels they] shall conform [there] to SUCH REQUIREMENTS.

PAR. U-17. REVISE THE TABLE IN THIS PARAGRAPH BY STRIKING OUT THE WORDS "TO 72 IN." IN THE NEXT TO THE LAST ITEM, AND BY STRIKING OUT THE WORDS "OVER 72 IN., 1/2 IN." IN THE LAST ITEM.

PAR. U-23. MODIFY REVISION AS PUBLISHED IN DECEMBER, 1930, ISSUE* TO READ:

U-23. Pressure vessels may be fabricated by means of fusion welding under the rules given in Pars. ——, provided the CONSTRUCTION [fabrication] is in accordance with the REQUIREMENTS FOR MATERIAL AND DESIGN AS REQUIRED BY THIS CODE AND THE FUSION WELDING PROCESS USED CONFORMS TO THE SPECIFICATIONS FOR THE GRADE OF WELDING INDICATED FOR EACH CLASS OF VESSEL [Recommended Procedure for Fusion Welding of Pressure Vessels given in the Appendix, as follows:

a Air vessels, when the inside diameter does not exceed 60 in., or the working pressure does not exceed 200 lb. per sq. in., or the temperature does not exceed 250 deg. fahr.

b Vessels, in which the circumferential joints only may be welded, when the inside diameter does not exceed 48 in., or 72 in., when at least 75 percent of the load on a flat head is supported by tubes or through stays extending from head to head.

All joints in vessels covered by this Code and of any dimensions may be fusion welded provided that in addition to meeting the requirements for material and de-

* *Mechanical Engineering.*

sign, they will conform to specifications now being prepared for inclusion in this Code, based on those which have been published under the heading, Proposed Specifications for Fusion Welding of Drums or Shells of Power Boilers.]

PAR. U-27. ADD THE FOLLOWING SECTIONS:

THE BACK PITCH OF CIRCUMFERENTIAL JOINTS MAY BE LESS THAN THAT CALLED FOR BY THE ABOVE FORMULAS PROVIDED THE LIGAMENTS BETWEEN RIVETS IN A CIRCUMFERENTIAL DIRECTION, AS WELL AS THOSE IN A DIAGONAL DIRECTION AS DETERMINED BY THE RULES IN PAR. U-59, ARE SUFFICIENT TO WITHSTAND THE STRESS DUE TO PRESSURE, TOGETHER WITH ANY STRESS DUE TO WEIGHT COMPONENTS IN SUPPORT OF THE BOILER STRUCTURE, WITH A FACTOR OF SAFETY OF FIVE.

THE BACK PITCH OF RIVETS SHALL BE MEASURED EITHER ON THE FLAT PLATE BEFORE ROLLING, OR ON THE MEDIAN LINE AFTER ROLLING, AND THE BACK PITCH AS THERE MEASURED SHALL GOVERN THE LOCATIONS OF RIVET HOLES IN THE BUTT STRAPS.

PAR. U-30. REVISED:

U-30. The riveted longitudinal joints of a shell which exceeds ½ IN. IN THICKNESS [48 in. in diameter], shall be of butt-and-double-strap construction. This rule does not apply to the portion of a shell which is staybolted to an inner sheet.

PAR. U-31. REVISE FIRST SECTION TO READ:

U-31. The longitudinal joints of a shell not more than ½ IN. IN THICKNESS [48 in. in diameter], with the exception given below, may be of lap-riveted construction; but the maximum allowable working pressure of such construction shall not exceed [nor] 200 lb. per sq. in. for vessels less than 24 in. in diameter, NOR 150 lb. per sq. in. FOR VESSELS 24 IN. IN DIAMETER OR OVER.

ADD THE FOLLOWING SECTION AT END OF PARAGRAPH.

THE SPHERICAL PORTION OF VESSELS OF ANY DIAMETER WHICH ARE WHOLLY SPHERICAL OR PARTLY HEMISPHERICAL, MAY BE CONSTRUCTED WITH LAP JOINTS PROVIDED THAT IF THE PLATE THICKNESS EXCEEDS ⅜ IN., THE SEVERAL SPHERICAL SECTIONS OF PLATE SHALL BE HOT PRESSED TO THE PROPER RADIUS OF CURVATURE. WHEN THE VESSEL CANNOT BE COMPLETED IN THE SHOP, THE WHOLE STRUCTURE SHALL BE CAREFULLY AND COMPLETELY FITTED UP READY FOR RIVETING BEFORE SHIPMENT.

PAR. U-52. ADD THE FOLLOWING AS SECTION *b*:

b FUSION WELDING MAY BE USED TO SEAL THE CALKING EDGES OF RIVETED JOINTS AND RIVET HEADS OF UNFIRED PRESSURE VESSELS, PROVIDED THE PLATES DO NOT EXCEED 0.30 PERCENT CARBON AND THAT THE THICKNESS OF THE PLATE OR HEAD AFFECTED BY THE WELDING IS AT LEAST ⅛ IN. MORE THAN THAT REQUIRED FOR A SEAMLESS SHELL OF THE SAME DIAMETER, THE SAME WORKING PRESSURE AND THE SAME GRADE OF MATERIAL. SUCH SEAL WELDING SHALL NOT BE APPLIED UNTIL AFTER THE VESSEL IS MADE TIGHT AS EVIDENCED BY THE REGULAR HYDROSTATIC PRESSURE TEST PRESCRIBED IN PAR. U-64. SEAL WELDING MAY BE USED ON NOZZLES AND THEIR REINFORCING PLATES UNDER THE SAME CONDITIONS. ON UNSTAYED DISHED HEADS, SEAL WELDING SHALL NOT BE APPLIED CLOSER THAN ½ IN. TO THE POINT OF TANGENCY OF THE KNUCKLE OF THE FLANGE. SEAL WELDING MAY BE APPLIED ONLY WHEN THE WELD METAL IS DEPOSITED IN A SINGLE LAYER HAVING A THROAT THICKNESS OF NOT LESS THAN 3/16 IN. NOR MORE THAN 5/16 IN. THE HEAT FROM WELDING SHALL NOT DISTORT THE PLATE OR LOOSEN THE RIVETS IN SUCH A MANNER AS TO BREAK THE INITIAL BOND EFFECTED IN THE RIVETED JOINT. AFTER SEAL WELDING, THE VESSEL SHALL BE RESUBJECTED TO THE PRESCRIBED HYDROSTATIC TEST.

PAR. U-53. REVISE FIRST SECTION TO READ:

U-53. All vessels for use with compressed air, OR SUBJECT TO INTERNAL CORROSION, 18 in. in diameter or over, and not exceeding 36 in. in diameter, shall have a hand hole in the shell or head, or a manhole or at least two plugged threaded openings of not less than 2 in. pipe size. When two threaded openings are used, they should be located in the heads or in the shell near the heads.

PAR. U-54. REVISED:

U-54. [All] Vessels for use with compressed air, OR SUBJECT TO INTERNAL CORROSION, over 36 in. in diameter, shall have a manhole, excepting those whose shape or use make it impracticable, IN WHICH CASE THEY SHALL HAVE A 4- BY 6-IN. HANDHOLE, OR ITS EQUIVALENT IN AREA, LOCATED AS NEAR EACH HEAD AS PRACTICABLE. An elliptical manhole opening shall be not less than 11 by 15 in., or 10 by 16 in. in size. A circular manhole opening shall be not less than 15 in. in diameter.

PAR. U-56. REVISED:

[U-56. Manhole frames in shells shall have the proper curvature and, when the diameter exceeds 48 in., shall be riveted to the shell with two rows of rivets.]

PAR. U-64. REVISED:

U-64. *Hydrostatic Test.* Each vessel constructed under these rules shall be tested under hydrostatic pressure to NOT LESS THAN [50 lb. in excess of the maximum allowable working pressure when same does not exceed 100 lb. and to] 1½ times the maximum allowable working pressure [above 100 lb.], except that FOR enameled vessels THE TEST PRESSURE NEED NOT EXCEED [shall not be tested in excess of] the working pressure. FOR VESSELS OF FUSION-WELDED CONSTRUCTION THE REQUIREMENTS OF PAR. U-0 SHALL APPLY.

PAR. U-75. REVISE THIRD SECTION TO READ:

When the heads are thicker than the shell, THE WELDING EDGES [they] shall be reduced in thickness BY MACHINING, CHIPPING OR GRINDING APPROXIMATELY as shown in Fig. [s]. U-7 [A or U-7B], TO WITHIN 20 PERCENT OF THE THICKNESS OF THE SHELL.

PAR. U-91. REVISED:

U-91. *Material.* Steel plates for the shells of brazed vessels shall be made by the open-hearth process and THE THICKNESS *shall not exceed* ⅜ in. [in thickness] EXCEPT WITH THE VARIATION PERMITTED BY PAR. 12 OF SPECIFICATIONS S-1 PLUS 0.01 IN. WHEN THE LONGITUDINAL SEAM IS OF THE LAP-JOINT TYPE, NOR 1 IN. PLUS 0.02 IN. WHEN THE LONGITUDINAL SEAM IS OF THE DOUBLE-STRAP BUTT-JOINT TYPE. Plates ¼ in. thick or heavier shall be of either flange or firebox quality as provided for in the Specifications for Steel Boiler Plate [as given in Pars. S-5 to S-17] of Section II of the Code. Sheets lighter than ¼ in. shall have the properties as provided for in [the] Specifications S-13 [for Steel Plate for Brazing as given in Pars. S-280 to S-285].

PAR. U-95. REVISED:

U-95. A longitudinal [seams] LAP-JOINT shall have the edges of the plate lapped a distance of not less than 8 times the thickness of the SHELL PLATE [metal]. FOR DOUBLE-STRAP BUTT-JOINT CONSTRUCTION, THE TOTAL AMOUNT OF LAP OF THE INNER AND OUTER STRAPS SHALL BE EQUAL TO AT LEAST 16 TIMES THE THICKNESS OF THE SHELL PLATE, ONE-HALF OF WHICH SHALL BE ON EACH SIDE OF THE ABUTTING EDGES. THE WIDTH OF THESE STRAPS SHALL NOT DIFFER MORE THAN 25 PERCENT OF THE WIDTH OF THE WIDER ONE. The laps shall be held closely in position substantially metal to metal, by stitch riveting or other sufficient means. The brazing shall be done by placing the flux and brazing material on one side of the joint and applying heat until this material comes entirely through the lap and shows uniformly along the seam on the other side. Sufficient flux must be used to cause the brazing material to so appear promptly after reaching the brazing temperature. The brazing material used shall be such as to give a joint which has a shearing strength of at least 10,000 lb. per sq. in.

PAR. U-96. REVISED:

U-96. *Head* AND GIRTH JOINTS. [Seams.] Heads shall be driven into the shells with a tight driving fit, and shall be thoroughly brazed in approximately the same manner as the longitudinal seam for a depth or distance from the end of the shell equal to at least 4 times the thickness of the shell metal. WHEN A VESSEL IS FABRICATED WITH MORE THAN ONE COURSE IN THE SHELL, THE GIRTH JOINT MAY BE OF EITHER THE LAP OR BUTT TYPE. IF OF THE LATTER TYPE, THE CIRCUMFERENCE OF THE ABUTTING COURSES SHALL NOT DIFFER BY MORE THAN 0.20 PERCENT, AND EITHER INSIDE OR OUTSIDE SLEEVES SHALL BE USED. IN EITHER CASE THE LAP OVER THE END OF EACH COURSE SHALL BE AT LEAST 4 TIMES THE SHELL THICKNESS.

SPECIFICATIONS FOR FUSION WELDING. In the rules published in the March, 1931, issue (page 230), an error appears in the fourth sentence of the paragraph headed "Longitudinal Joints" which should be corrected to read:

If of the lap type the throat dimension OF EACH of the TWO welds shall not be less than 5/8 [1¼] *T*, where *T* represents the thickness of the plate.

PAR. CA-5. REPLACE PRESENT PARAGRAPH BY THE FOLLOWING:

CA-5. Cracks in riveted, welded, or expanded joints are generally attributable to steel of unsuitable quality, to excessive internal stresses in the plates caused by high riveting pressure, imperfect thermal or mechanical treatment during fabrication, unskilful or abusive treatment during the repair of leaky seams, also, to extremely severe operating conditions. Cracks from such causes are in general transcrystalline (across the grains) in character and occur both internally and externally to any joint in any section of a boiler.

Cracks of a different character may occur in highly stressed portions of a boiler where dissolved salts concentrate. These cracks, which are generally intercrystalline (around the grain) in character can only occur within riveted or other joints in a boiler, and are usually termed embrittlement. These cracks generally take place below the normal water level, but have appeared above the water level.

In all embrittlement cases the analysis of the concentrated boiler waters show that the sulphates are low in proportion to the combined sodium hydroxide and sodium carbonate.

In cases of boiler failures from cracks, competent advice should be secured to determine the cause for such failure.

Operating evidence supplemented by laboratory research work indicates that if not less than the following ratios of sodium sulphate to total alkalinity as determined by methyl orange are maintained in the boiler concentrates, embrittlement will not take place:

Working Pressure of Boiler, Pounds Gage	Sodium Sulphate	to	Methyl Orange Alkalinity
0 to 150	1	to	1
150 to 250	2	to	1
250 and over	3	to	1

Extensive research work by a number of investigators has confirmed the necessity for the above ratios.*

Recent laboratory research work has indicated that there may be other means of preventing embrittlement. However, there are insufficient operating data available at the present time to prove the value of these preventative measures.

Pending further operating data from boilers in service, it is recommended that the requirements of Par. I-44 of Section VI of the Code be extended to all riveted, welded, or expanded joints, and that careful examination of all joints be made if leaks occur and do not remain tight after proper calking.

PAR. A-21*a*. REVISED:

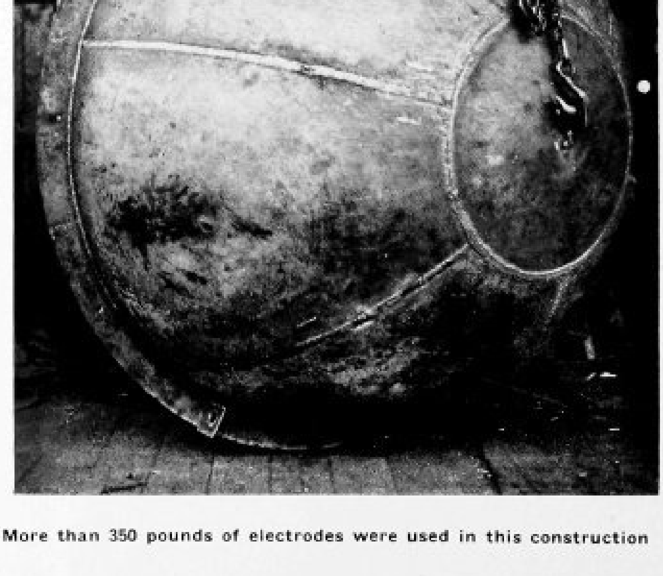
a In Horizontal-Return Tubular Boilers—in the rear head, not less than 1 [2] in. above the upper row of tubes, the measurement to be taken from the line of upper surface of tubes to the center of the plug, and projecting through the sheet not less than 1 in. When the distance between the uppermost line of tubes and the top of the steam space is 13 in. or less, the bottom of the fusible plug may come at a lesser distance than 1 [2] in. above the upper row of tubes, but in no case shall the plug be located below the level of the top of the uppermost row of tubes.

*See Bulletin No. 216 of the Engineering Experimental Station, University of Illinois, entitled "Embrittlement in Boilers."

Large Melting Pot Is Arc Welded

Some idea of the extent and rapidity with which arc-welded construction is taking the place of traditional methods of construction may be seen in the illustration of what is believed to be the first melting pot of its size in the world to be fabricated by this method.

This pot is 10 feet 2½ inches in diameter, is 5 feet 1½ inches deep, and weighs 6 tons. It is fabricated of



More than 350 pounds of electrodes were used in this construction

1-inch steel plate cut to shape, formed and fused together with the electric arc. The completed pot operates at a temperature of 980 degrees F., and has a capacity of 100 tons of lead.

This large pot is a product of the Steel Tank and Pipe Company, Berkeley, Cal., and was fabricated by use of the "Fleetweld" process of welding utilizing the shielded arc. Pots of this size are generally spun from a solid piece of steel, but by utilizing the shielded-arc welding process it was possible to save a great amount of time, yet secure the same homogenous construction as that of a spun pot.

The Fleetweld Process is a product of The Lincoln Electric Company, Cleveland, O., whose welders were also used in the construction of this large pot.

Locomotive Boiler Strength Formulas

(Continued from page 101)

Efficiency = Least value obtained in 1, 2, 3, 4, 5, 6, 7 or 8.

Example.—Assuming TS = 55,000 pounds.

$t = \frac{25}{32}$ inch = .78125 inch.

$B = \frac{11}{16}$ inch = .6875 inch.

P = 14 inches.

$D = 1\frac{1}{4}$ inches = 1.25 inches.

A = 1.2272 square inches.

s = 44,000 pounds.

S = 88,000 pounds.

C = 95,000 pounds.

1.— $$\frac{(14 - 1.25) \times .78125 \times 55{,}000}{14 \times .78125 \times 55{,}000} = 91.67$$

2.— $$\frac{(14 - 2 \times 1.25) \times .78125 \times 55{,}000 + 1.2272 \times 44{,}000}{14 \times .78125 \times 55{,}000} = 91.11$$

3.— $$\frac{14 - 4 \times 1.25 \times .78125 \times 55{,}000 + 3 \times 1.2272 \times 44{,}000}{14 \times .78125 \times 55{,}000} = 91.21$$

4.— $$\frac{4 \times 1.2272 \times 88{,}000 + 3 \times 1.2272 \times 44{,}000}{14 \times .78125 \times 55{,}000} = 98.73$$

5.— $$\frac{14 - (2 \times 1.25) \times .78125 \times 55{,}000 + 1.25 \times .6875 \times 95{,}000}{14 \times .78125 \times 55{,}000} = 95.71$$

6.— $$\frac{14 - (4 \times 1.25) \times .78125 \times 55{,}000 + 3 \times 1.25 \times .6875 \times 95{,}000}{14 \times .78125 \times 55{,}000} = 104.99$$

7.— $$\frac{4 \times 1.25 \times .78125 \times 95{,}000 + 3 \times 1.25 \times .6875 \times 95{,}000}{14 \times .78125 \times 55{,}000} = 102.4$$

8.— $$\frac{4 \times 1.25 \times .78125 \times 95{,}000 + 3 \times 1.2272 \times 44{,}000}{14 \times .78125 \times 55{,}000} = 88.61$$

Efficiency = 88.61 percent.

Foster Wheeler Enters Boiler Industry

The Foster Wheeler Corporation, 165 Broadway, New York, has entered the field of boiler manufacture and is prepared to furnish all types in the entire range of sizes and pressures. Acquisition of the plant and business of the D. Connelly Boiler Company, Cleveland, O., has placed the Foster Wheeler Corporation in a position to cover the boiler field.

The Connelly Company has been a progressive builder of boilers for more than 50 years. In that time, it has built up excellent shop facilities and organization. It has made notable installations among which may be cited both the largest boiler unit, and the boiler for highest pressure in public utility service in the United States.

The Foster Wheeler Corporation has been supplying complete steam generators for some time, and has produced the various parts in its own works, with the exception of the boiler proper. The combination of an old established boiler shop with the present Foster Wheeler plants and engineering aggressiveness will be of special interest in the industry.

The units to be produced include: Forged-steel, sectional-header, cross-drum boilers; four-drum and three-drum bent-tube boilers; three-drum low-head bent-tube and two-drum bent-tube boilers. For marine service there will be offered, as in the past, cross-drum steam generators of both box-header and sectional-header designs; three-drum A-type and two-drum low-head units.

With the addition of the boiler to its products, the Corporation can now undertake single contracts with undivided responsibility as to design, construction and operation for complete steam generators including pulverized-fuel equipment, water-cooled furnaces, superheaters, economizers and air heaters.

The possession of a boiler shop fully equipped for heavy work has the further advantage of enabling Foster Wheeler to meet all of its requirements for heater and evaporator shells as well as for fractionating and stabilizing towers, used extensively in its petroleum-refining and gasoline-recovery plants.

Business Notes

The Sidney Machine Tool Company, Sidney, O., manufacturers of engine lathes, will take over for the Ryerson Company full manufacturing responsibilities in the building of the former Kempsmith products. The former factory manager of Kempsmith, H. L. Livesay, has been placed in full charge of the production of milling machines at the Sidney plant.

The Lincoln Electric Company, Cleveland, O., announces the removal of its Chicago office from 53 West Jackson Blvd., to a new building at 1455 West 37th Street. This move is made to provide additional space for the sales and service of Lincoln Stable-Arc welders and Linc-Weld motors, and to provide additional storage space for a complete stock of welders, welding supplies and accessories.

The Lidgerwood Manufacturing Company, builders of hoist and derrick equipment, Elizabeth, N. J., has greatly strengthened its distributor organization. Among the distributors recently added are the Hedge & Mattheis Company, Boston; the Brown-Bevis Company, Los Angeles; the Edward R. Bacon Company, San Francisco; Funkhouser Equipment Company, Kansas City, and the Thorman W. Rosholt Company of Minneapolis. During the past year a number of new Lidgerwood products have been announced, among these being the Lidgerwood "A" crane.

The Claud S. Gordon Steel X-Ray Laboratory of Chicago, located at Western avenue and 15th Place, has recently been organized for the purpose of X-raying steel, iron and metal up to a thickness of 4½ inches. Inherent defects in this metal will be uncovered and this new service is available to all industries using steel in manufacturing. Metallurgical radiography is the scientific term applied to this new science and the new apparatus required for this huge laboratory was furnished by the General Electric X-Ray Corporation, Chicago (formerly the Victor X-Ray Laboratories). Patterns, tools, dies, casting, raw material and all shapes and sizes of steel and iron may be subjected to the microscopic scrunity of this most powerful of all X-ray equipment. General offices of the Gordon Company are located in Cleveland, O.

The Boiler Maker

VOLUME XXXI NUMBER 4

PUBLISHED Monthly by the Simmons-Boardman Publishing Company, 34 North Crystal Street, East Stroudsburg, Pa., with Executive Offices at 30 Church Street, New York City.

Edward A. Simmons, President. Henry Lee, Vice-President. C. R. Mills, Vice-President. L. B. Sherman, Vice-President. Samuel O. Dunn, Vice-President. F. H. Thompson, Vice-President. Roy V. Wright, Secretary. John T. De Mott. Treasurer. George Slate, Business Manager.

Chicago: 105 W. Adams Street. Washington, D. C.: 17th and H Streets, N. W. Cleveland: Terminal Tower. San Francisco, Cal.: 215 Market Street.

Subscription Price: United States, Canada and Mexico, $2.00, Foreign Countries, $3.00 a Year. Single Copies, 35 Cents.

Request for change of address should reach us on or before the 15th of the month preceding the issue with which it is to go into effect. It is difficult, and often impossible, to supply back numbers to replace those undelivered through failure to send advance notice. In sending us change of address, please be sure to send us your old address as well as the new one.

THE BOILER MAKER is a member of the Associated Business Papers, Inc. (A. B. P.), and the Audit Bureau of Circulation (A. B. C.)

EDITORIAL STAFF: H. H. Brown, Editor. L. S. Blodgett, Managing Editor. W. Lumbard, Associate Editor.

Contents

Communications

Patch Around Blow-Off Pipe Flange

TO THE EDITOR:

I cannot agree with the articles on applying a patch around the blow-off pipe flange, as outlined on page 301 of the November and page 328 of the December, 1930, issues of THE BOILER MAKER.

As the author states, he has a 72-inch boiler of 7/16-inch plate carrying a pressure of 125 pounds. Using 87.5 percent as the efficiency of the longitudinal joint, he is operating the boiler with the low factor of safety of 4.67.

According to the author, in the November issue he recommends a patch 30 inches longitudinally and 60 inches girthwise, which would give us a factor of 1.42 instead of 1.567 according to the A.S.M.E. Boiler Code.

I would like to know where the author of the December article gets the constants 1.26 and 1.62.

If the patch were properly applied, as I see it, it would be 30 inches longitudinally and 72 inches girthwise, giving us a factor of 1.567.

The pitch of rivet holes in the patch is 2⅛ inches and the diameter of rivet holes is 15/16 inch. Therefore, the efficiency of patch = 2.125 — .9375 ÷ 2.125 = 55.8 percent.

Efficiency of longitudinal joint = 87.5 percent.

87.5 ÷ 55.8 = 1.567 factor.

Using the A.S.M.E Code, 1.567 gives us 72 inches girthwise for the patch.

$$\frac{.4375 \times 55{,}000 \times 87.5}{36} = 584 \text{ pounds per square inch}$$

bursting pressure.

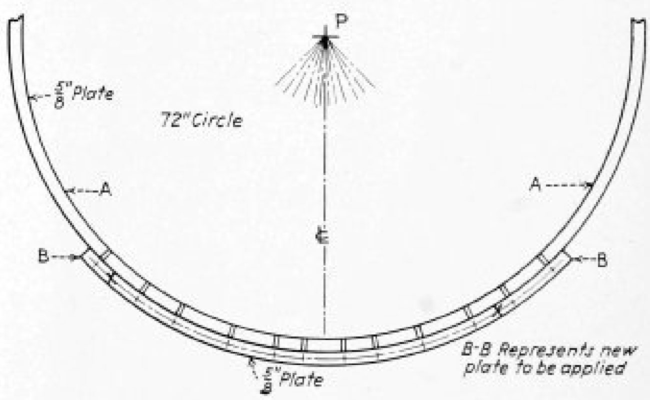
584 pounds ÷ 125 = 4.67, factor of safety, making the patch no weaker than the boiler.

Chicago, Ill. ROY P. MURPHY.

Layout of Irregular Rivet Holes

TO THE EDITOR:

In repair work, the boiler maker is often confronted with the problem of laying out plates where the original rivet holes could not be made with uniform pitch due to connections of other parts thereto.



Method of laying out irregular rivet holes

The accompanying drawing shows a section of a boiler which is 72 inches in diameter, made up of ⅝-inch plate. By close inspection it will be seen that the holes are of irregular pitch.

The method of laying out the plate is as follows: Draw a circle of whatever the diameter may be; then draw another circle with space between representing the thickness of the plate; then lift the rivet holes with a thin straight edge. The holes can be lifted on either the inside or outside whichever is most convenient. If lifted on the inside, when transferring to the sketch use line *A-A*. The two other circular lines marked *B-B*, represent the sheet to be developed. Midway between these lines is line *x-x*. Take a straight edge and draw lines from the center of circle *P*, then run these lines through to the center of the rivet holes to the line marked *x-x*.

With these points developed, the proposed plate can be laid out very accurately by using the exact distance on the stretchout as lifted off the line *x-x* on the sketch.

Jacksonville, Florida. C. S. HANDLEE.

Questions and Answers Pertaining to Boilers

This department is maintained for the purpose of helping those who desire assistance on practical boiler shop problems. Inquiries should bear the name and address of the writer. Anonymous communications will not be considered. The identity of the writer, however, will not be disclosed unless the editor is given special permission to do so.

By George M. Davies

Characteristics of Ellipses

Q.—I shall appreciate receiving an answer to the following questions, for which I am inclosing a sketch of an oval:

(1) How do you find the circumference? (2) What percent of the

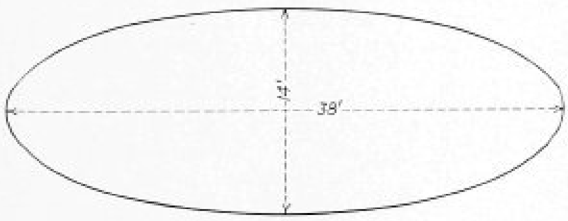


Fig. 1.—Typical ellipse

short and long diameter are radii, if any? (3) What are the methods of construction? (4) What is a perfect oval? I.A.M.

A.—The sketch submitted with the question shows an ellipse and does not illustrate what is termed an oval. An oval is an egg-shaped figure; an ellipse constructed with three axes, one of the minor axes being shorter than the other, as shown in Fig. 2.

To draw the egg-shaped oval shown in Fig. 2, draw the line *A-B*; using the distance *A-B* as the diameter, describe the circle *A-C-B-G*. Through the center *O* draw *O-C* perpendicular to *A-B* cutting the circumference *A-C-B-G* at *C*. Draw the straight lines *B-C-F* and *A-C-E*. With *B* and *A* as centers and the diameter *A-B*

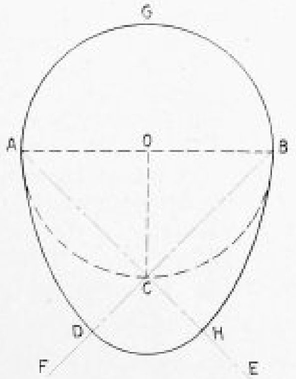


Fig. 2.—Construction of an oval

as a radius, describe arcs terminating with *B-F* and *A-E*. With *C* as a center and *C-D* as a radius, describe the arc *D-H*. The curve *A-D-H-B-G* is the required oval.

Fig. 2 clearly illustrates the difference between an oval and the ellipse as shown in Fig. 1. Assuming then that the four questions are relative to an ellipse rather than an oval

(1) An approximate formula for determining the perimeter of an ellipse is:

$$P = 3.1416\sqrt{2\,(a^2 + b^2)}$$

A closer approximation is:

$$P = 3.1416\sqrt{2\,(a^2 + b^2) - \frac{(a-b)^2}{2.2}}$$

where

P = perimeter in inches.
a = ½ major axis in inches.
b = ½ minor axis in inches.

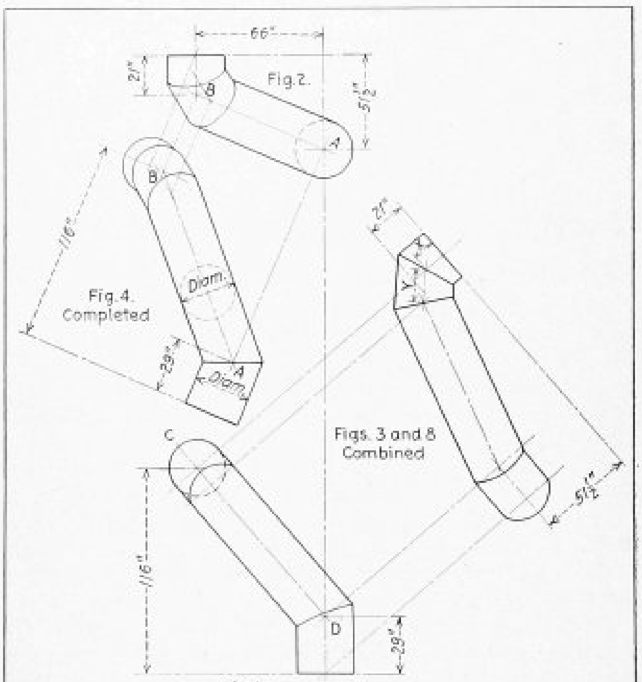
(2) No part of an ellipse is a part of a circle, therefore a true ellipse cannot be drawn with radii.

(3) The August, 1930, issue of The Boiler Maker shows two methods of constructing an ellipse.

(4) Any section of a right circular cone made by a plane which cuts all the elements of one nappe of the cone will be an ellipse; if the plane is perpendicular to the axis of the cone, the ellipse becomes a circle.

Layout of Pipe with Double Elbow

Q.—I have been reading The Boiler Maker and am particularly interested in the layout of a pipe with a double elbow. Please explain to me how you constructed Fig. 4 and Fig. 8 by preparing a sketch with dimensions for locating the center lines of the pipe. Is the distance from the center line of the pipe in Fig. 8 to the base of elbow 51½ inches? What dimensions are used in laying out to get the long and short side of pipe *A*, Fig. 4? G.W.M.



Diagrammatic layout of pipe with double elbow

A.—The accompanying sketch is a diagrammatic drawing of the layout of the pipe with double elbow as developed in the February issue.

Fig. 4 has been completed to show clearly the manner in which the center lines were obtained. This view is a projection of the pipe along the line *A-B*, Fig. 2, points *A* and *B* being projected from Fig. 2 to Fig. 4 as shown. This in turn determines the short and long sides of the pipe *A*, Fig. 4.

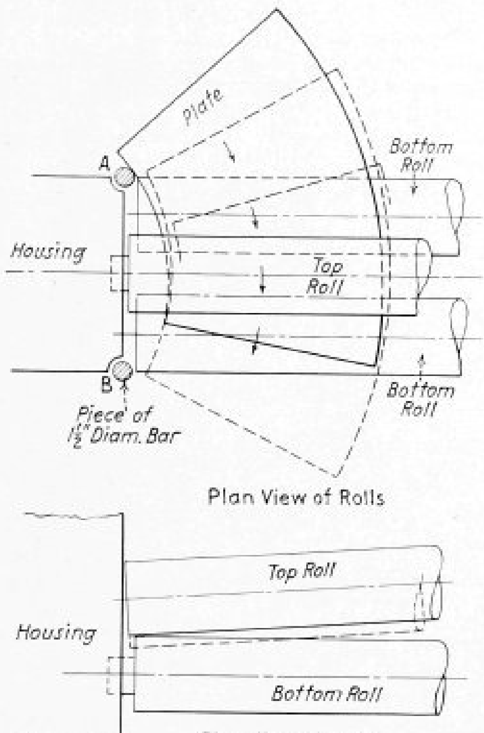
Fig. 8 has been combined with Fig. 3 and is a projection of the pipe along the line *C-D* of Fig. 1. The distances *x* and *y* were not given on the print submitted and for this reason were not shown on the layout, but were scaled from the print for the purpose of illustrating the development.

The distance from the center line of the pipe in Fig. 8 to the base of the elbow is 51½ inches as illustrated.

Fabricating Conical Shapes

Q.—As an interested reader of The Boiler Maker, I am taking the liberty of asking you whether you could refer me to any articles that have appeared in past issues on the subject of fabricating conical shapes out of boiler plate up to 5/8-inch thickness for use particularly in tank construction. We are called upon at times to produce cone tops or bottoms on welded tanks and these cones range from, say, 30 inches to 120 inches inside diameter and have depths from 20 inches to 60 inches. We produce our cones on our hydraulic presses or upon our bending rolls and I am particularly desirous of learning any short cuts that your contributors or subscribers may have discussed. W.R.G.

A.—The following discussion of the rolling or shaping



Rolling tapered plates

of tapered plates has been published in The Boiler Maker by James Crombie.

"The rolling or shaping of tapered plates that go to make up cones or tapered cylinders seems to many boilermakers to be a very formidable-looking job, yet it is not so difficult a matter.

"Plates forming complete cones in one piece, if not of too heavy material may be rolled right up without any lining up or shifting of the plates. Take for instance, a cone of 5/16 inch plate 48 inches in diameter at the bottom and 40 inches in diameter at the top, and about 36 inches high such as are used for reducers from the wagon top to shell of oil-country boilers. A one piece cone of this description takes about half an hour to roll.

"The plate is entered in the rolls and run right through, the narrow end of the plate is kept close up to the housings of the rolls, and a piece of round bar is placed between the housings and the plate for the plate to swing around on. It will be readily understood that when the plate starts to travel in the direction of the arrows in the illustration, it will hit and jam on the bar *A* and this will retard the narrow end, and the wide end of the plate will keep travelling through the rolls and gradually swinging around, while the narrow end travels more slowly. The plate will require possibly four or five passes through the rolls to come out right.

"If these bars are not used at *A* and *B*, the sharp edge of the plate will soon cut a groove in the housings of the rolls.

"With heavy plates it is customary to put lines on them radiating from the center to the circumference, and to keep these lines which we have put on the plate as nearly as possible parallel to the rolls and to roll a short piece at a time, then move the plate around a little at the bottom, so as to avoid flat spots. The bottom may have to be hammered out a little if the cone is very short and has a sharp taper. The rolls should be lowered only from the one end but like the rolling of any shell plate good judgment will be required. The illustration will show more clearly what is required.

"Cone sections of heavy plates are sometimes set up under the sectional flanges with formers and in one shop the writer saw them forming cones of ½-inch plate under the punch press with a pair of forming dies.

"When a number of plates are required to make a very large cone, it is sometimes cheaper to roll one plate to correct shape and lay it on a sand bed or bed it in the ground in front of the furnace, then heat the plates and set them hot into the plate already formed, using wooden mauls to beat them into shape."

Flue Leakage

Q.—Can you provide me with information in regard to hot work on locomotives, and of the general causes and some of the most modern methods of stopping flue leaks? What would cause flue leakage in a locomotive with flues two or three years old? I would appreciate this information very much because I am working with an old-time boiler maker. A. P.

A.—There are a number of conditions that will cause flues to leak, namely: The ends of the flues may not be properly expanded in the flue sheet. Frequent rolling or expanding causes the flue holes to become larger and to thin the metal of the flues. The flue sheets may be badly corroded so that the seat for the flues is too thin, thus making it practically impossible to maintain a tight metal-to-metal contact between the flue and the flue sheet. When a flue sheet is under the stresses of expansion and contraction the flue holes will become slightly elliptical in shape and very often take this shape permanently.

Firebox flue sheets have become from ⅜-inch to ½-inch longer after continued use thus elongating the flue holes. Copper ferrules should be used in resetting new flues in oblong holes.

The flues may be split or cracked at an imperfect weld if lap-welded flues are used, or from working the flues too much in expanding them in their seats. When a leak occurs around the flue end, if the flue is sound and the flue opening is in good shape, the leak can usually be stopped by expanding the flue slightly.

It is also customary to weld around the beading at the firebox flue-sheet end to prevent steam leaks.

Associations

Bureau of Locomotive Inspection of the Interstate Commerce Commission

Chief Inspector—A. G. Pack, Washington, D. C.

Assistant Chief Inspectors—J. M. Hall, Washington, D. C.; J. A. Shirley, Washington, D. C.

Steamboat Inspection Service of the Department of Commerce

Supervising Inspector General—D. N. Hoover, Jr., Washington, D. C.

American Uniform Boiler Law Society

Chairman of the Administrative Council—Charles E. Gorton, 253 Broadway, New York.

Boiler Code Committee of the American Society of Mechanical Engineers

Chairman—Fred R. Low.

Vice-Chairman—D. S. Jacobus, New York.

Secretary—C. W. Obert, 29 W. 39th Street, New York.

National Board of Boiler and Pressure Vessel Inspectors

Chairman—C. D. Thomas, Salem, Oregon.

Secretary-Treasurer—C. O. Myers, Commercial National Bank Building, Columbus, Ohio.

Vice-Chairman—William H. Furman, Albany, N. Y.

Statistician—L. C. Peal, Nashville, Tenn.

International Brotherhood of Boiler Makers, Iron Ship Builders and Helpers of America

International President—J. A. Franklin, suite 522, Brotherhood Block, Kansas City, Kansas.

Assistant International President—William Atkinson, suite 522, Brotherhood Block, Kansas City, Kansas.

International Secretary-Treasurer—Chas. F. Scott, suite 506, Brotherhood Block, Kansas City, Kansas.

Editor-Manager of Journal—John J. Barry, suite 524, Brotherhood Block, Kansas City, Kansas.

International Vice-Presidents—John J. Dowd, 142 Pearsall Ave., Jersey City, N. J.; M. A. Maher, 2001 20th St., Portsmouth, O.; R. C. McCutchan, 226 Lipton St., Winnipeg, Man., Canada; H. J. Norton, Alcazar Hotel, San Francisco, Cal.; C. A. McDonald, Box B93 Route 2, Independence, Mo.; J. N. Davis, 1211 Gallatin St., N. W. Washington, D. C.; M. F. Glenn, 1434 E. 93rd St., Cleveland, O.; W. J. Coyle, 424 Third Ave., Verdun, Montreal, Canada; Joseph P. Ryan, 7533 Vernon Ave., Chicago, Ill.; J. F. Schmitt, 25 Crestview Rd., Columbus, O.

Master Boiler Makers' Association

President—Kearn E. Fogerty, general boiler inspector, C. B. & Q. R. R., Aurora, Ill.

First Vice-President—Franklin T. Litz, general boiler foreman, Chicago, Milwaukee, St. Paul & Pacific Railroad, Milwaukee, Wis.

Second Vice-President—O. H. Kurlfinke, boiler engineer, Southern Pacific Railroad, San Francisco, Cal.

Third Vice-President—Ira J. Pool, division boiler inspector, Baltimore & Ohio Railroad, Baltimore, Md.

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Fifth Vice-President—William N. Moore, general boiler foreman, Pere Marquette Railroad, Grand Rapids, Mich.

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Executive Board—Charles J. Longacre, chairman, foreman boiler maker, Meadow Shops, Pennsylvania Railroad, Elizabeth, N. J.

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Vice-President—Reuben T. Peabody, Air Reduction Sales Company, New York.

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Secretary—Frank C. Hasse, Oxweld Railroad Service Company, 230 N. Michigan Ave., Chicago, Ill.

American Boiler Manufacturers' Association

President—H. H. Clemens, Erie City Iron Works, Erie, Pa.

Vice-President—Owsley Brown, Springfield Boiler Company, Springfield, Ill.

Secretary-Treasurer—A. C. Baker, 801 Rockefeller Building, Cleveland, Ohio.

Executive Committee—Homer Addams, Fitzgibbons Boiler Company, Inc., New York; H. E. Aldrich, The Wickes Boiler Company, Saginaw, Mich.; George W. Bach, Union Iron Works, Erie, Pa.; Sidney Bradford, Edge Moor Iron Company, Edge Moor, Del.; F. W. Chipman, International Engineering Works, Framingham, Mass.; Robert E. Dillon, Titusville Iron Works Company, Buffalo, N. Y.; C. E. Tudor, Tudor Boiler Company, Cincinnati, Ohio; A. C. Weigel, The Hedges-Walsh-Weidner Company, Chattanooga, Tenn., and E. G. Wein, E. Keeler Company, Williamsport, Pa.

States and Cities That Have Adopted the A.S.M.E. Boiler Code

States

Arkansas	Missouri	Rhode Island
California	New Jersey	Utah
Delaware	New York	Washington
Indiana	Ohio	Wisconsin
Maryland	Oklahoma	District of Columbia
Michigan	Oregon	Panama Canal Zone
Minnesota	Pennsylvania	Territory of Hawaii

Cities

Chicago, Ill.	St. Joseph, Mo.	Memphis, Tenn.
Detroit, Mich.	St. Louis, Mo.	Nashville, Tenn.
Erie, Pa.	Scranton, Pa.	Omaha, Neb.
Kansas City, Mo.	Seattle, Wash.	Parkersburg, W. Va.
Los Angeles, Cal.	Tampa, Fla.	Philadelphia, Pa.
	Evanston, Ill.	

States and Cities Accepting Stamp of the National Board of Boiler and Pressure Vessel Inspectors

States

Arkansas	Missouri	Pennsylvania
California	New Jersey	Rhode Island
Delaware	New York	Utah
Indiana	Ohio	Washington
Maryland	Oklahoma	Wisconsin
Minnesota	Oregon	Michigan

Cities

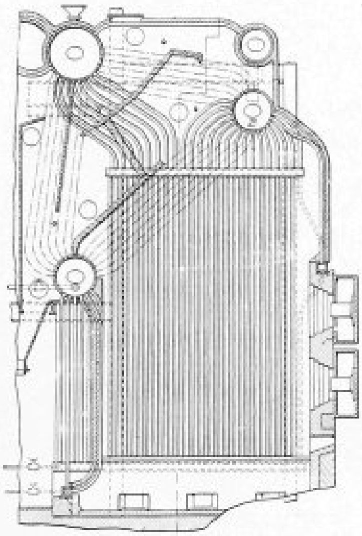
Chicago, Ill.	St. Louis, Mo.	Nashville, Tenn.
Kansas City, Mo.	Scranton, Pa.	Omaha, Neb.
Memphis, Tenn.	Seattle, Wash.	Parkersburg, W. Va
Erie, Pa.	Tampa, Fla.	Philadelphia, Pa.
Detroit, Mich.		

Selected Boiler Patents

Compiled by Dwight B. Galt, Patent Attorney, Washington Loan and Trust Building, Washington, D. C. Readers wishing copies of patents or any further information regarding any patent described, should correspond directly with Mr. Galt.

1,747,612. STEAM BOILER. PHILLIPS BADENHAUSEN, OF PHILADELPHIA, PA.

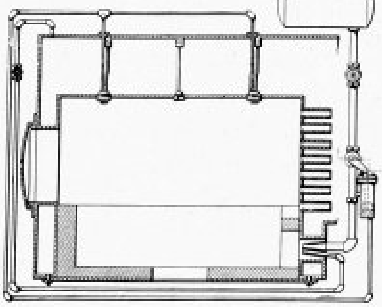
Claim.—In a boiler, the combination of a steam-generating section, comprising a lower water drum, an upper water drum, a steam drum, and watertubes connecting said upper water drum with said steam drum, connecting said steam drum with said lower water drum and connecting said lower water drum with said upper water drum, a rigid structural steel framework upon which said steam-generating section is mounted and



supported, walls enclosing said boiler on four sides and each comprising substantially vertical rows of tubes backed on the outer sides with heat-insulating material and hanging substantially suspended from said steam-generating section, conduits heat-insulated from the interior of the firebox for conducting water from the coolest portion of the steam-generating section to the bottoms of said tubes in said walls, and means to convey the water from the tops of said tubes back into the steam-generating section of the boiler. Six claims.

1,746,123. AUTOMATIC SAFETY DEVICE FOR STEAM BOILERS OR GENERATORS. SALVADOR HERREJÓN LÓPEZ, of MEXICO, MEX.

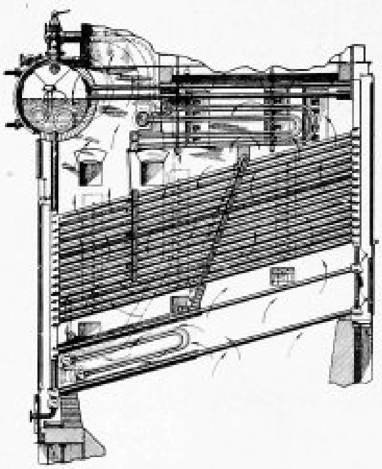
Claim.—In an automatic safety device for a steam generator of that type having a combined water and steam space over the crown sheet of the combustion chamber, the combination of a chambered base member adapted to be seated in and connected directly to the crown sheet, a steam conducting tube permanently opening into the chamber of the base member and



leading therefrom through said space for supplying steam to a steam pressure-actuated shut-off mechanism, a steam intake tube wholly within said space and having its respective ends opening into said space and the chamber of said base member, and a fusible plug within the base member, normally closing said intake tube to the chamber in said base member and fusing when the crown sheet reaches a temperature to melt the plug whereby communication is established between the intake tube and the chamber of said base member, said plug having its upper surface in horizontal alinement with the upper surface of said crown sheet. Four claims.

1,743,353. SUPERHEATER BOILER. DAVID S. JACOBUS, OF JERSEY CITY, N. J., ASSIGNOR TO THE BABCOCK & WILCOX COMPANY, OF BAYONNE, N. J., A CORPORATION OF NEW JERSEY.

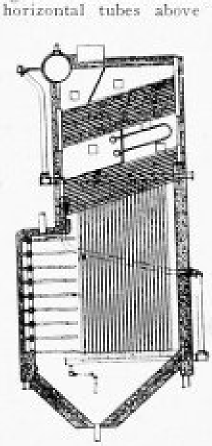
Claim.—A watertube boiler having a primary superheater connected to the boiler and a secondary superheater connected in series with the primary superheater, and means to direct a portion of the furnace gases over the



primary superheater to the exclusion of the secondary superheater and another portion of the furnace gases over the secondary superheater to the exclusion of the primary superheater, and the combined portions of the gases from the respective superheaters over a portion of the heating surface of the boiler. Four claims.

1,720,090. BOILER. THOMAS E. MURRAY, OF BROOKLYN, NEW YORK, AND JAY A. FREIDAY, OF EAST ORANGE, NEW JERSEY; SAID FREIDAY ASSIGNOR TO SAID MURRAY.

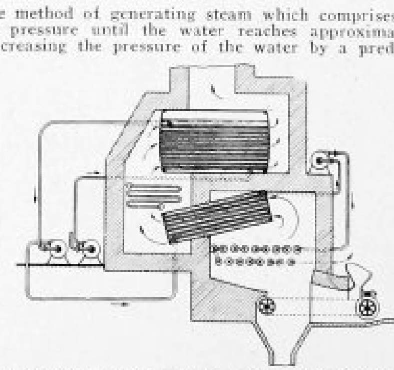
Claim.—A boiler having a furnace with water walls of vertical tubes and having a bank of horizontal tubes above the furnace, headers for



said water wall at the upper end thereof and located below the tubes, and supplementary horizontal tubes in lines extending downward below the tubes so as to form vertical screens at the sides only for screening the headers, with a clear space for the combustion gases between the opposite screens.

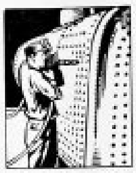
1,745,383. BOILER FOR HIGH PRESSURE. JOHANNES RUTHS, OF DJURSHOLM, AND NILS HEZEKIEL FRENNE AND MATTIAS BACKSTRÖM, OF STOCKHOLM, SWEDEN, ASSIGNORS, BY MESNE ASSIGNMENTS, TO RUTHS ACCUMULATOR AKTIEBOLAG, OF STOCKHOLM, SWEDEN.

Claim.—The method of generating steam which comprises adding heat to water at low pressure until the water reaches approximately the boiling point, then increasing the pressure of the water by a predetermined increment, again adding heat until the water reaches approximately the boiling point, again increasing the pressure by a predetermined increment and so continuing until the water has a pressure equal to that at which it is desired to generate steam, and then adding heat to the water to raise it above the boiling point and generating steam therefrom. Eight claims.



The Boiler Maker

Reg. U. S. Pat. Off.



Boiler Manufacturers

The forty-third annual meeting of the American Boiler Manufacturers' Association will be held at Skytop Lodge, Skytop, Pa., May 25 to 27. As is customary at these meetings the program will be divided into general sessions and special group meetings. At the general sessions all committee reports dealing with matters concerning the association as a whole will be presented, and addresses on subjects of particular interest to the industry will be delivered. The group meetings will be devoted to discussions of problems pertaining to the various subdivisions into which the association is divided. Golf tournaments and the annual banquet of the association will constitute a special part of the social program.

At this time the detailed program of the meeting is not available for publication. A report of the meeting, however, will appear in the June issue.

Steel Heating Boilers

A branch of the boiler manufacturing industry, which during the past several years has shown excellent possibilities of development, is that concerned with the manufacture of steel heating boilers. With production of power boilers on a decreasing scale, this low-pressure type of construction, having a volume demand, offered an excellent field for utilizing shop facilities on a production basis. The efforts of individual companies being directed towards the design and manufacture of such boilers independently, however, resulted in a multiplicity of types and sizes, with consequent marketing difficulties.

In the Fall of 1930, the manufacturers of such boilers, through the Steel Heating Boiler Institute, requested the Division of Simplified Practice, Bureau of Standards, United States Department of Commerce to assist in promoting a simplified practice program for the industry.

Some idea of the benefits of simplification to this industry can be had from the fact that at present there are being made over 300 different sizes of compact type firetube boilers. It is obvious that a substantial reduction in the variety of sizes would facilitate better planning for stocks of raw materials and finished products, hence reducing inventories. Manufacturing problems would be fewer. Architects would find it simpler to specify boilers and contractors would find it easier to secure boilers to meet the specifications.

A first questionnaire drafted by the industry proved to be inadequate and it was necessary to draft a second. The delay involved in recircularizing the industry, however, was justified by the increased scope of the data secured.

Twenty-two companies returned filled-in questionnaires. Two companies made a joint return. The returns of one company were not comparable with the others and could not therefore be included in the report. The 21 plants included in this survey produced 7805 boilers during 1930, over 90 percent of the entire output of the low-pressure steel heating boiler industry.

Briefly the results of the survey indicated that the compact type welded boilers lead in production with 5997, or 76.8 percent of the total shipments. The remaining 23.2 percent is divided almost equally between riveted and welded boilers of the barrel, firebox type. Shipments of the riveted boilers of this type amounted to 901, or 11.4 percent, and of the welded, 882, or 11.3 percent of total shipment.

Riveted boilers of the barrel, firebox type slightly exceed in production welded boilers of the same type. On the other hand, riveted boilers of the compact type were reported by only one company. Over one half of the total shipments reported were welded, direct draft, firetube boilers of the compact type. Shipments of smokeless boilers of the same type represented 12.1 percent of total shipments.

Of the 18 different varieties of boilers reported, 4 account for 83.1 percent of all shipments. They are as follows: Combination type, welded, firetube, direct draft 52.3 percent; combination type, welded, firetube, smokeless 12.1 percent; barrel type, firebox, welded, portable, up draft 10.5 percent; combination type, welded, watertube, direct draft 8.2 percent.

Each of the 18 different kinds of boilers reported are made in a variety of sizes or ratings. While a few are made in only a small number of ratings, the boilers which are shipped in greater volume are made in an average of 25 different ratings by each concern that handles them. That there is comparatively little duplication of sizes by different manufacturers is evidenced by the fact that the maximum possible variety, exceeds by only 68 the actual total variety of 1072. It also developed that 36 percent of this variety produced no business during 1930.

Of the total 7805 boilers produced it was found that 5033 had been shipped from the plants. Of this number 4223, or almost 84 percent were of only 63 ratings. In other words, 84 percent of the sales of these two kinds of boilers were in only 20 percent of the total variety of sizes produced by the industry. There were no shipments of either smokeless or direct draft boilers of 90 ratings listed, and over 28 percent of the sizes, in which the two most popular kinds of boilers are made, produced no business during 1930.

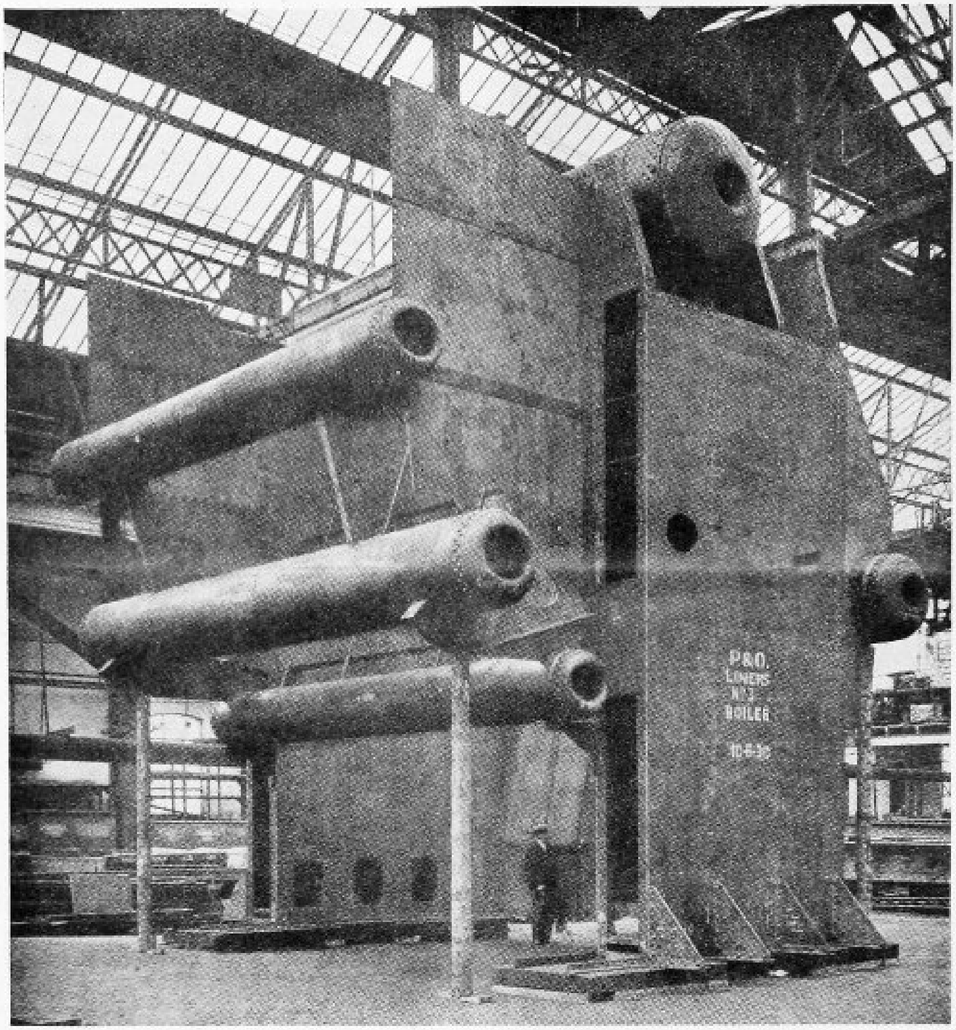


Fig. 1.—Modern Yarrow watertube marine boiler

Watertube or Scotch Boilers*

By Harold E. Yarrow and Summers Hunter, Jr.

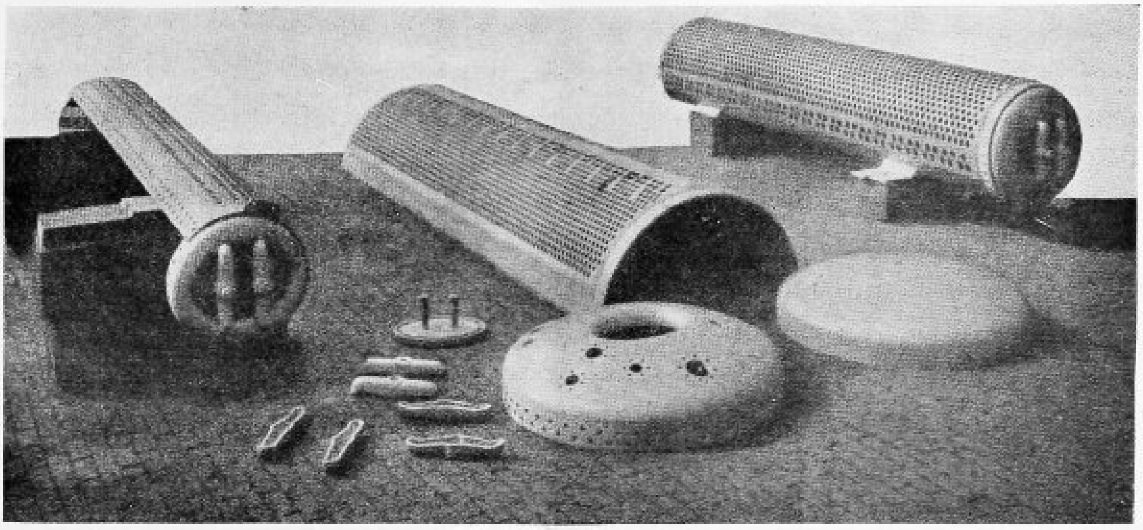
There is undoubtedly a field for both the watertube boiler and the Scotch boiler in the merchant service, although the former is tending more and more to encroach on that of the latter.

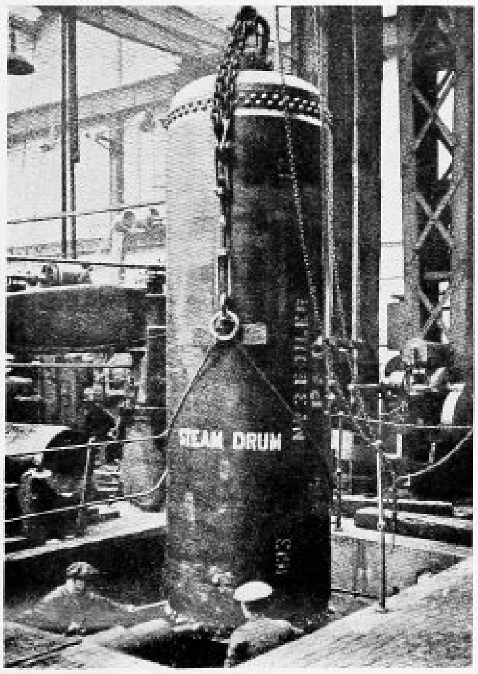
In considering the watertube boiler, some historical reference is essential to gain a true perspective of its progress. Inception took practical form between about 1880 and 1890 and nearly half a century of steady development has therefore passed. The earliest applications were in small fast naval ships where high evaporations per unit weight were essential for greater speeds, and also in river craft where savings in weight were equally important for shallow drafts. In 1900 the British Admiralty foresaw the potentialities of the watertube boiler for all naval vessels and appointed an eminent committee to investigate the whole question. This committee published its final report in 1904, and unanimously recommended the watertube boiler, following which this type was rapidly adopted for all naval purposes and now is exclusively used throughout the navies of the world.

In the mercantile marine the watertube boiler has already been accepted for large passenger liners, cross channel steamers, yachts, shallow draft vessels, etc., and some most successful applications have been under exacting conditions.

Land engineers early recognized the watertube boiler, which grew in favor until now it is universally used ashore wherever any appreciable quantity of power is generated from fuel. Power station engineers are already, in actual practice, exploring such fields as 3200 pounds per square inch pressure, 1,000,000 pounds per hour evaporation from a single unit and 1000 degrees F. steam temperature. Many factories have adopted the watertube boiler and in some cases are running on 100 percent make-up feed water.

* Abstract of paper presented at the February 10, meeting of the Institute of Marine Engineers, held in London.





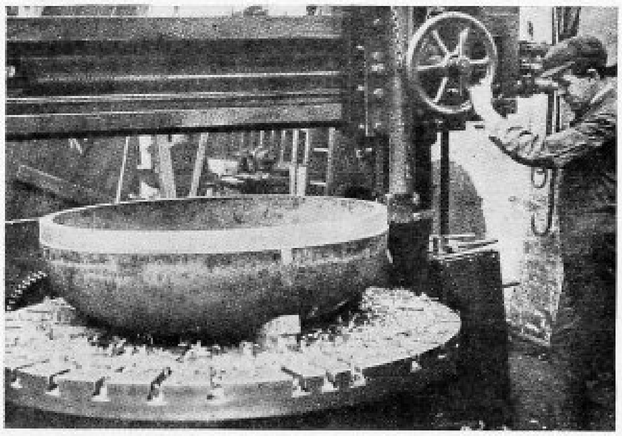


Fig. 2.—(Top) Machined drum parts for Yarrow watertube boiler. Fig. 3.—(Above) Machining the end of a watertube boiler drum. Fig. 4.—(Left) Hydraulic riveting operation on ends of a forged drum for installation in a watertube boiler

The advantages of steam at high pressure are universally realized and it must be remembered that the watertube boiler alone has made these possible. The pressures of 400 and 450 pounds per square inch adopted in a number of recent ships are by no means high for land practice and the low consumptions recorded for these ships will be still further improved upon as pressures are increased. Until recently, the watertube boiler was handicapped by uncertainty of supplies of pure feed water, but this position no longer arises, as, irrespective of pressure, the water problem has been solved. Suitable alloy tubes have dissipated condenser troubles and means are available to ensure continued purity of the feed supply. In this latter connection the Scotch boiler has proved a useful auxiliary to the watertube type, as a small Scotch unit can be used both for low-pressure services and to make up losses in the main system by supplying steam at some intermediate stage before the condenser.

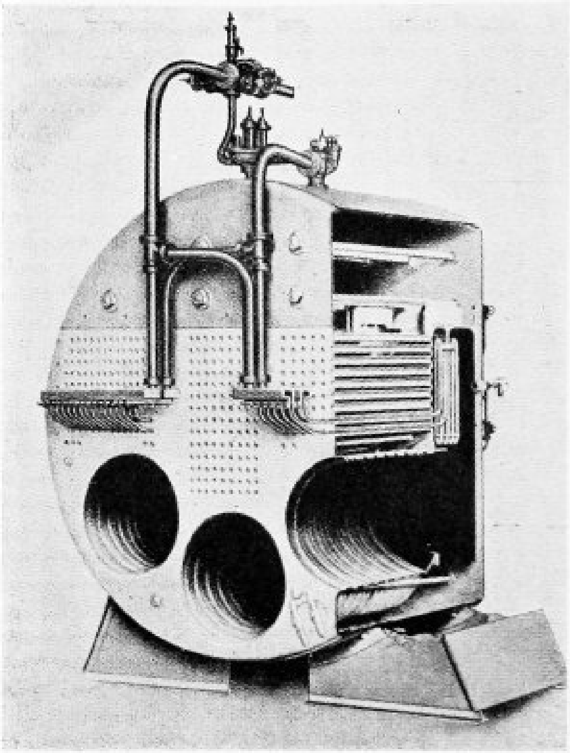
It is sometimes argued that a highly skilled personnel is required with watertube boilers. Granted that somewhat more care is required for this type, it should be borne in mind that a still higher degree of skill is required with internal-combustion engines.

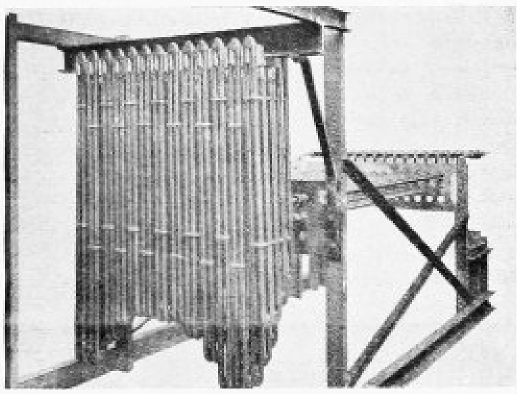
The pressure parts of the modern watertube boiler are a highly finished engineering production. For low pressures, built-up drums with riveted seams are still put forward, all joints being carefully planed or turned before riveting (Fig 2). Forged drums, machined all over, are extensively used, for moderate pressures with ends riveted. These ends are made a perfect fit (Fig. 3) and the riveting is hydraulic (Fig. 4). For high pressures the drum ends are closed in the forging process, so that the whole drum is a complete shell and the only joints are at manhole doors. Drums and tubes of a boiler (for saturated steam only) are assembled and it will be noted that all parts subject to internal pressure are cylindrical in section, which is the ideal form. For inspection and cleaning all that is necessary is to remove manhole doors at the end of each drum to gain access to the tubes and drums from which inspection and cleaning can be carried out. Only a few inspection doors are necessary and it is important that the number of bolted joints should be reduced to a minimum, especially with high pressures. In every case the nests of tubes are arranged free to expand longitudinally, each water drum being able to move with the tubes along their axes.

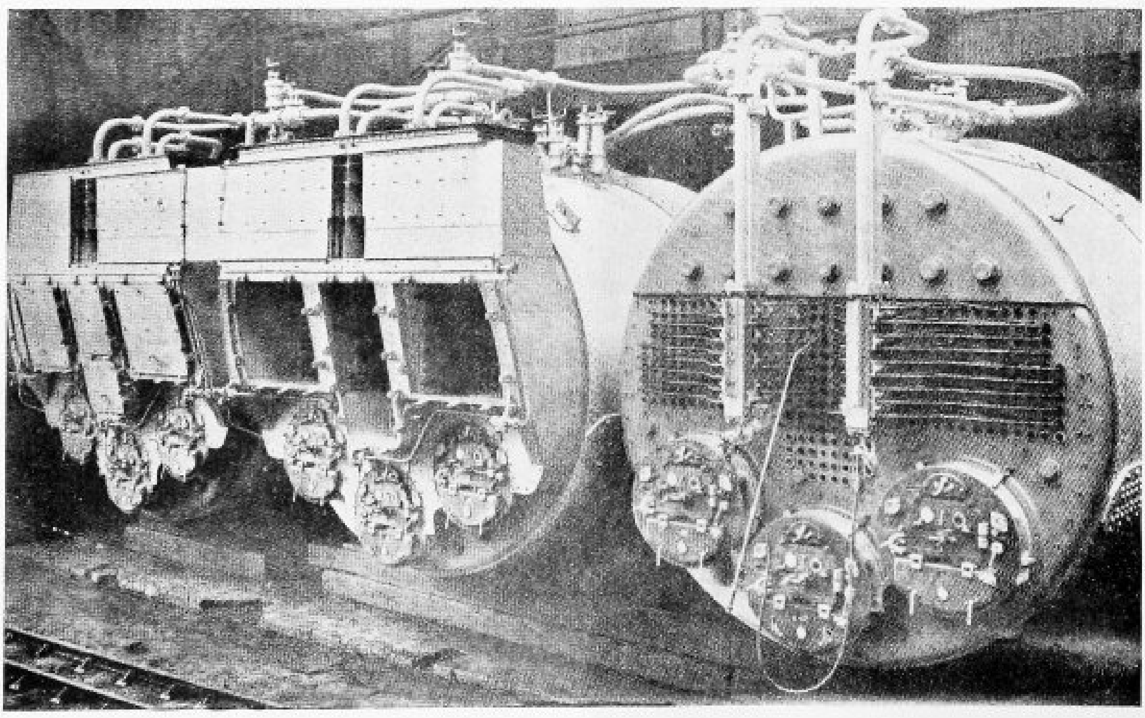
The furnace is large and of ample height to ensure completion of combustion before the gases reach the tubes. A large proportion of the boiler surface is subjected to direct radiation and absorbs the heat rapidly so that high furnace temperatures and consequent efficiency are maintained without detriment to the brickwork linings. The fire row tubes, doing the hardest work, are nearly vertical, also they are readily accessible from inside the furnace.

The superheater consists of U tubes expanded into a forged drum, and is placed between nests of boiler tubes to ensure minimum fluctuation of steam temperature. All the superheater tubes are steeply inclined and the large integral drum acts as a steam receiver providing a reserve. Two types of Yarrow marine boilers are in use, the double-flow, where gases pass both sides of the saturated steam drum, and the single-flow in which they pass only one side of that drum. With the former type a damper can be fitted at the junction of the uptakes above the boiler and regulation of this damper varies the proportion of gases passing the superheater

Fig. 5.—(Right) Sectional view of a modern Scotch marine boiler showing combustion chamber superheater. Fig. 6.—(Below) Elements of combustion chamber superheater in shop. Fig. 7.—(Bottom) Complete installation of Scotch boilers with air heaters, superheaters, etc.







and gives close control over final steam temperature.

Boiler casings are double and arranged to form air ducts for the combustion air on its way to the burners or grate, the outside air casings being, in addition, well lagged and thereby every unit is efficiently insulated.

Air heaters are usually of the tubular type, which form is the most robust and easily cleaned. The flue gases pass through the tubes and the air across them, arranged on the contraflow principle.

Fig. 1 shows a boiler for the P. & O. liner *Strathnaver*, normal evaporation about 70,000 pounds per hour, blow-off pressure 425 pounds per square inch and steam temperature 725 degrees F. The photograph was taken during construction and before tubing, and, from the scale of the man in the background, gives a good idea of furnace capacity, etc. Air heaters for this boiler are situated in the funnel uptakes.

There is no difficulty in operating the watertube boiler and the latest accessories such as low-water alarms, feed regulators, etc., further simplify stokehold duties. Several installations of watertube boilers have attained 87 percent to 88 percent gross overall efficiency, notably in the *Viceroy of India* and *Empress of Japan*.

Following are statements made by Summers Hunter, Jr., describing the use of Scotch marine boilers.

The increase in efficiency of land boiler installations during recent years has been very great, but it is not intended to make any direct comparison between the progress of merchant service boiler plants and land or naval watertube boiler plants, conditions and requirements being fundamentally different.

It is, however, considered by some that the general advances made on the marine side, especially with coal-burning ships, have not been so great as they might have been, although there are many individual cases which prove without any doubt whatsoever that in service a great deal more can be obtained from Scotch boilers without affecting the principal factors of reliability or durability of the machinery installation. Neither are the capital or maintenance costs so increased as to make the improvements now available anything but an economical proposition.

Before dealing with the component parts of the boiler installation, some actual results, on a commercial basis, which have been obtained by modernizing existing plants, may not be without interest. These relate to British-owned vessels whose records have been reduced to a common basis, being the means of several similar voyages before and after alteration.

In 1927 the C. P. S. *Empress of Australia* had a new Scotch boiler installation and propelling machinery fitted with the result that she now does 19½ knots on 150 tons of fuel oil per day, or 0.70 pound per shaft horsepower for all purposes, and 0.65 pound per shaft horsepower for propulsion, as compared with 16½ knots on 205 tons per day. This result was only obtained by combining the highest possible efficiency in each component part of the boiler installation, namely, in the boilers themselves, the furnace arrangements, the superheaters, air heaters, and the feed heaters. The new boilers supply steam at 220 pounds and 630 degrees F., so that with higher pressure and temperature steam, further economy could be attained.

By modernizing the Scotch boiler plant and renewing the turbines and auxiliary machinery where necessary, several medium-sized passenger ships were able to maintain their service with 8 Scotch boilers in operation, instead of 10, and the consumption of oil was reduced from 140 to 100 tons per day for all purposes.

In considering any variations in the design and construction of a Scotch boiler, it is well to consider where the various losses do occur. It will be admitted that the principal loss which is met with in practice is that due to the heat wasted in the funnel gases.

Following this, the greatest loss usually met with in practice is that due to external radiation. Any attempt to increase efficiency must therefore be considered from the point of view of the modification which can be made in these two principal losses.

Air heating and forced, or induced draft are usually incorporated unless special reasons dictate the adoption of natural draft. Air heating is generally obtained by tapping the heat in the flue gases by single or multi-flow heaters. Air up to 400 degrees F. can be obtained, but usually it is from 200 to 300 degrees F.

Steam superheating is perhaps the most important item to be used in connection with increasing the efficiency of steam propelling plants. It has become even more important at higher pressures with saturated steam owing to the increase in wetness of steam during the later stages of expansion. High pressures along with superheat give very excellent results when systematically utilized with appropriate modifications to the propelling machinery, but without such modifications superheat has sometimes been a failure.

The degree of superheat depends on the location and distribution of the superheater elements. Figs. 5 and 6 illustrate the combustion chamber type of superheater, which by the incorporation of suitable materials and other features of design, is proving both reliable and durable in oil burning ships. With this type, steam is being superheated up to 700 degrees F., a temperature hitherto impossible from Scotch boilers.

Feed-water heating in Scotch boilers has received greater attention and higher temperatures reached during the last few years. In a modern boiler plant, it is usual to have the feed water heated up to 300 degrees F. by various types of heaters, usually receiving heat from the auxiliary exhaust line and/or the live steam type, being fed from main steam line, or being bled from some intermediate part in the main propelling machinery. There are also several methods of heating the feed by utilizing the funnel gases, and the writer considers this is one line in which further development may take place.

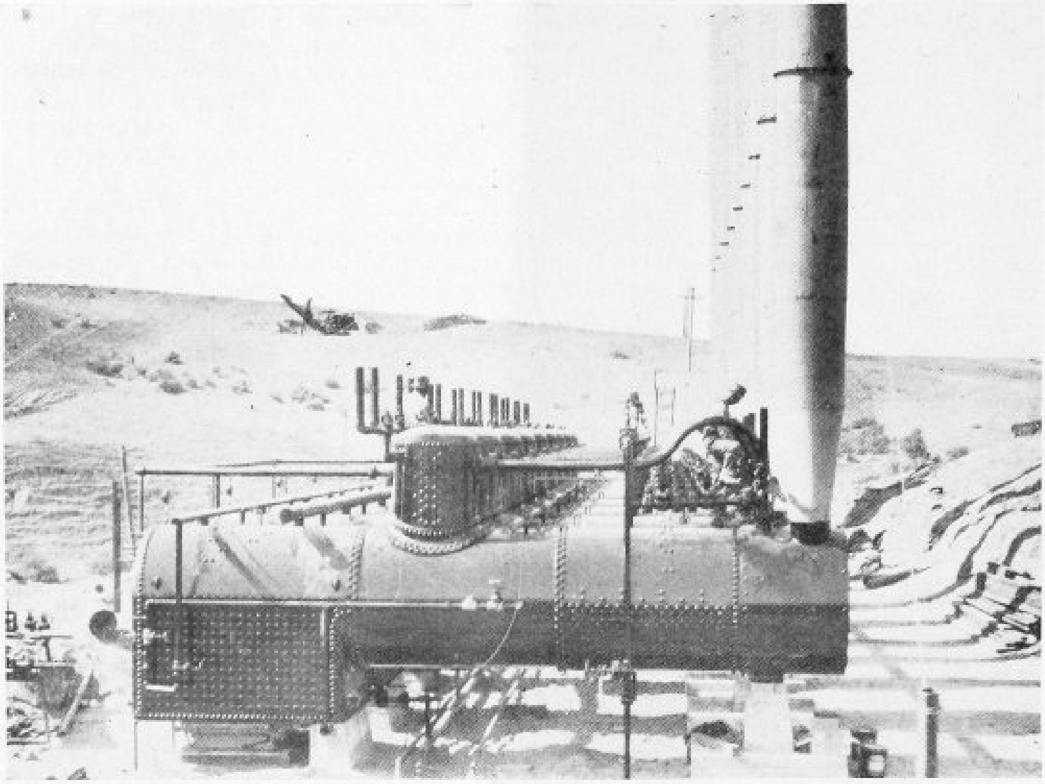
Insulation against radiation losses from the boilers themselves requires its share of attention, along with the other parts of any high temperature installation. There are several efficient insulating materials available, which, if suitably protected when initially applied, should incur very little cost of upkeep, but the possible saving in this direction is small when compared with others.

Increased pressure itself does not lead to improved boiler efficiency. It has been repeatedly pointed out by Sir Charles Parsons as an important factor in steam efficiency, and must receive full consideration.

The general form of the Scotch boiler has so far changed very little in recent years; there have been, however, improvements in details. Working pressure is limited by designing and manufacturing difficulties, but these have been, and may be further relieved by improvement in boiler material.

So far as the writer knows, the highest pressure Scotch boilers in service in an ocean-going merchant ship are of 300 pounds per square inch—this is the *City of Roubaix*, with geared turbines using steam at 600 degrees F. By incorporating modern feed-water heating, heated air at 380 degrees F., these boilers have reached an efficiency of the order of 85 percent burning coal and consumption per shaft horsepower per hour has reached the low level of 1091 pounds.

(Continued on page 138)



Battery of 250-horsepower boilers in the California fields

Modern Oil-Country Boilers

By C. E. Lester

Conservatism in the oil-field boiler industry, maker and user alike, has kept in use almost since the beginning of the industry, the same semiwater-bottom boiler with the dome over the firebox, practically without change in design except the modifications necessary to meet the requirements for increased size and pressures to reach the deeper sands.

Any proposed departure from recognized standards as regards water bottoms has met with protests from the user and still greater protest over any proposal to move the dome from the wagon top to the shell of the boiler. This type of boiler had done yeoman service in the fields for many years—why change it? If everyone were to follow this line of reasoning, progress would, indeed, be slow.

The deeper sands and the keen competition in the oil fields has created a demand for more power and still more power. This demand has been met by increasing the size of the boilers and increased pressures.

In a few short years the boiler weights have increased from 8000 pounds to something about 33,000 pounds and the pressures have been increased from 125 pounds to 325 pounds per square inch. The size and weights used at the present are represented as being near the limit that can be used with any degree of facility due to the difficulties encountered in moving them, especially in rough or marshy country. Portability is of prime consideration in an oil-country boiler.

The necessity for some changes in design has been apparent to the builders of the Broderick boiler for some time past, and the vision of superheated steam came as the solution of greater powered boilers without increased size and for some purposes, with a reduction in working pressures. The plan has been to modernize the boilers by placing the dome on the shell and the boiler to have a solid mud ring. The placing of the dome on the shell simplifies construction as well as gives a stronger, unstayed dome. The use of a solid mud ring simplifies construction, improves circulation, reduces liability of mudburning, increases direct heating surface and lessens leakage.

A general study of oil-well drilling operations was made to determine what advantages the use of superheated steam presented over the use of saturated steam. As a result of this study, which indicated many apparent advantages, two Broderick boilers were built, equipped with Elesco firetube superheaters. These boilers were set up at a rig along with the regular saturated-steam drilling boilers so that a test could be run under actual drilling conditions.

Since the purpose of the test was to obtain a comparison between superheated steam and saturated

Comparative Data on Superheater-Equipped and Saturated Steam Boilers Used in Test

	Superheater Equipped	Saturated Steam
Type of boiler	Locomotive Portable	Locomotive Portable
Code	A.S.M.E.	A.S.M.E.
Rating—horsepower	65	90
Working pressure—pounds per square inch	180	200
Test pressure—lbs. per square inch	270	300
Heating surface, evaporate—square feet	649	919
Furnace volume, cubic feet	74	86
Furnace volume per square foot heating surface, cubic feet	0.114	0.094
Number tubes—3-inch outside diameter	46	80
Number tubes—5-inch outside diameter	16	None
Length tubes, feet	12	14
Steam outlet—diameter, inches	3	4
Stack diameter—inches	25	25
Stack height—feet	32	28
Weight of complete boiler, pounds each	18,885	21,460
Burners used on boilers, low-pressure gas	Doreco	Perfecto

steam on the drilling operation, each set of boilers (two each) was operated for alternate periods of 24 hours throughout the duration of the test. The test was started when the well was at a depth of approximately 1800 feet, and discontinued at a depth of approximately 4000 feet. The test was carried on for 18 days to be sure of obtaining average drilling conditions at the well while both kinds of steam were supplied. Readings of steam pressure, temperature, speed, fluid pressure, moisture in steam, steam and fuel consumption, etc., were taken every half hour throughout the test.

In order to eliminate the advantage of steam pressure of one kind of steam over the other, the automatic fuel regulators were set to obtain the same pressure at the point of measuring the flow of steam on both sets of boilers.

Without going into too great detail of the tests, it was shown that the fuel required to operate the rig with saturated steam was 14,017 cubic feet per hour, while with superheated steam only 12,011 cubic feet were required to operate the rig at 16.3 percent increased capacity; hence an equivalent of 26.3 percent in fuel was saved for same work done by using the superheater boiler.

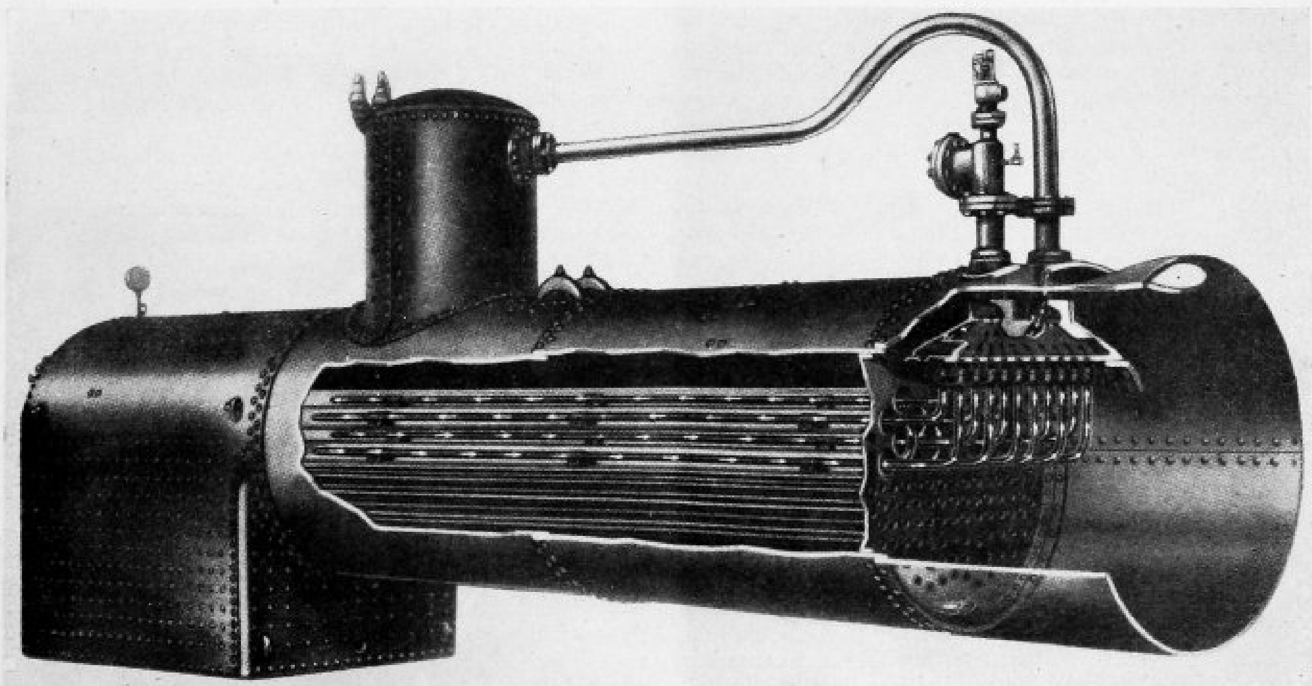
The average steam required to operate the rig with saturated steam was 9053 pounds per hour. With superheated steam it was 8010 pounds per hour. Since the steam used is equivalent to the water evaporated, the saving in water consumption was calculated to be 23.9 percent. Since scale formation is directly in proportion to the water evaporated, it can be said that there was a reduction of 23.9 percent in the scale deposit.

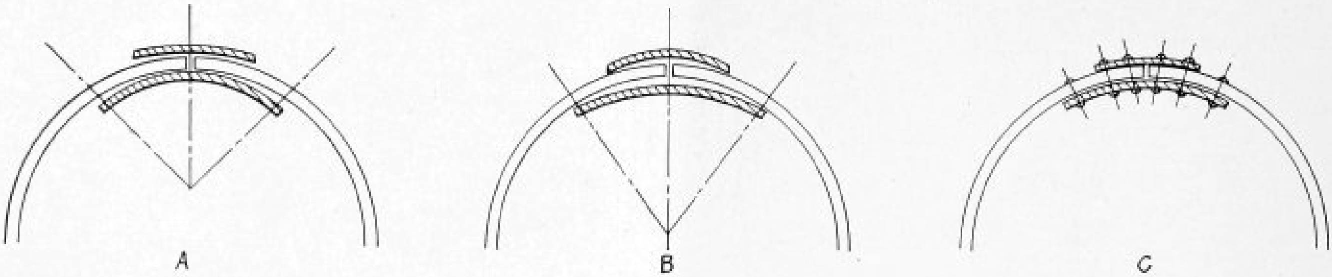
The results of the test can be stated briefly as follows:

1. Reduction of approximately 24 percent in steam consumption of rig for same work done.
2. Increase in boiler efficiency from 52.8 to 59.4 percent under actual drilling conditions.
3. Reduction in pipe line radiation losses from 39.3 boiler horsepower with saturated steam to 18.2 boiler horsepower with superheated steam.
4. Reduction of steam pressure drop in pipe lines from 26 pounds with saturated steam to 17 pounds with superheated steam.
5. Reduction of fuel consumption for same work done of approximately 26 percent.
6. Reduction of water required for boilers of approximately 24 percent.
7. Reduction of scale formation in boilers approximately 24 percent.
8. Increase in speed and flexibility of the entire drilling rig.
9. Increase in capacity of the drilling rig approximately 16 percent.
10. Reduction in the size and steam pressure of the boilers to run the same size rig.
11. Increase in the life of the pumps, engines and boilers due to better operating conditions.
12. Absence of mechanical or operating difficulties with superheater-equipped boilers.
13. Reduction in the entire investment in drilling equipment due to increased capacity and increase in speed of operation.

The results of the test having been fully up to expectations, the company decided on putting a larger modern superheater boiler in the field, and twelve 300

Broderick boiler fitted with Elerso superheater





Incorrectly and correctly formed straps. Special rolls are used to form straps correctly

pound pressure superheater boilers were built for trial in the Oklahoma City field.

The great demand for high powered boilers at the time these were built well warranted the trial of introducing them to the industry. The suspicion with which they were received was quickly dissipated, shortly after the boilers were put into operation.

It was the writer's privilege to see the first six set up and tested out in the Oklahoma City field during 1930.

Other than the two small trial boilers in Texas, this was the introduction of superheat to the oil drilling industry for drilling and until the world-wide depression failed to overlook the oil fields, the fine performance of these boilers created a demand for them that the shop was hard put to satisfy.

The first illustration shows a battery of 250-pound 125-horsepower boilers in service in California, designed to fill the demands of the Texas, New Mexico and California fields. The 300 pounds per square inch boiler for the Oklahoma fields is of the same size, the increased pressures being met with heavier plate, additional bracing, larger staybolts, rivets, etc.

The boiler in itself, aside from the superheat, is a straight-legged and straight-backed type with some unique, modernized methods of fabrication, worth mentioning. The 250 and the 300 pounds pressure boilers being of the same size, the flanged plates are identical in outline so that all shearing for flanging is done from the same pattern, the staybolt and rivet layout being the same except for the brace holes; all holes except for the flanges and the braces are drilled before flanging. This, of course, means that the lead holes only for the tubes being drilled first, the drilling of the full tube hole is done after flanging. The practice of punching flat plate having been almost entirely discontinued, and the shop being well-equipped with modern drill presses, all flanges are drilled in the flat. Staybolt holes are full size and rivet holes are ⅛ inch under size for reaming.

Manhole saddles and dome saddles have been standardized to the extent that they are burned to contours in groups with an automatic oxy-acetylene torch and the shell fit holes are drilled within ⅛ inch of rivet size before they are flanged.

The throat sheets are all drilled (staybolt and rivet holes) in groups of four (doubles) in the flat and before disassembling, the shell fit hole is burned to size automatically. After planing the mud ring, calking edge and scarfing the corners, the sheets are flanged two together; these are then cut apart with a torch and wings scarfed at a specially designed oil forge. The sheets have then, all wagon top and shell fit holes punched before starting assembly. All door hole connections of the back head and door sheet being electrically welded, a specially designed motor-driven portable boring mill has been built to make the beveled cuts on the hole flange of these two sheets. When performing this operation the portable machine is moved to the vicinity of the flange fire where the sheets are stacked under a wall crane which handles them to the machine. The sheets automatically center themselves on the machine bed and centering block; they are then bolted down and the beveled cut made in a very short time.

It is a well recognized fact in boiler making that the forming of butt straps and the shell plates to correct radii under the rolls, is a difficult and almost impossible performance due primarily to the fact that rolls of large diameters are necessarily too far apart to roll narrow butt straps or the ends of plates, the weaker net sections through the lines of holes also tend to make the bends angular rather than circular and there is also the factor of the errors of the rolls operator. The illustration on this page gives a graphic picture of straps incorrectly formed on the rolls and correctly formed as is done in this plant with a specially designed hydraulic forming machine that forms all plates to the exact radius of the former and matrix.

Formers of correct radius being provided for the several sizes of boilers, good-fitting longitudinal joints are assured which deter leakage. The thought uppermost in the design of these boilers has been to provide for the user a steam generator ample for his requirements to operate economically and to insure him a minimum of inconvenience due to the bad water conditions usually encountered in the oil fields. To this end the tube layout is in vertical rows having wide bridges allowing free circulation and assisting precipitation. A well rounded crown sheet also retards scale accumulation and an ample supply of 3½ by 4½-inch hand holes serves as openings to wash out the precipitates.

A 4⅝ by 5⅝-inch hand hole in the front tube sheet permits the removal of superheater tubes without enlarging any of the holes. The design of the large radius crown also permits a good layout of radial stays with full threads in the crown sheet.

The usual cut out and liner under the dome has been eliminated by simply providing 16, 2½-inch holes in the shell plate under the dome for the egress of steam.

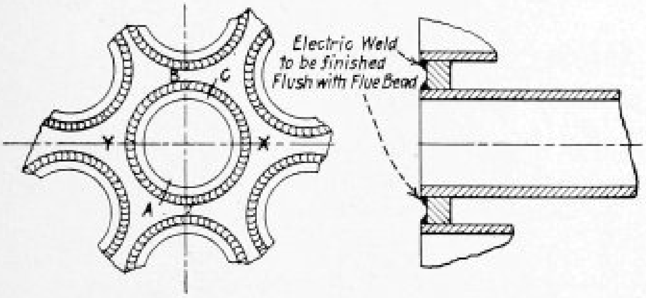
The general method of boiler assembly is to completely assemble the back end, that is, the back end (everything behind the shell) is completely finished. First the firebox and the back end are assembled separately, reamed and riveted, braces applied and riveted, firebox and back end assembled together, door hole welded, mud ring reamed and riveted on one of the hydraulic stake riveters, the rivets being heated on a wide gap electric rivet heater, the corner plugs applied and the back end goes to the staybolt gang.

Staybolts are threaded in 36-inch lengths and are inserted in the holes from the outside. This length has been found most suitable for cutting to finished length with a minimum of waste. Bolts are cut off with a torch and after driving, the back end goes to a drilling gang of three men equipped with an adjustable back stop and three rapid rotary air drills, who drill the telltale holes.

The convex type of staybolt driving set as generally used throughout the country for driving bolts is not used here. A series of experiments here developed the fact that a concave set is more satisfactory. No attempt is made to cut the head of the bolt down to the sheet when driving, the bolt is upset squarely in the hole and the head curled down to about half its height around the edges, providing a head not so finished to look at, but one that does not leak readily and one very easily touched up in case of leakage in the field.

The shell is completely assembled, dome on and all rivets driven. It is then coupled to the back end and all rivets except those behind the dome hydraulically driven on the bull. Those behind the dome and the brace rivets are the only rivets required to be driven pneumatically.

All flues are arc welded in the firebox after testing. The sheet is prepared for this by cracking the scale loose with a torch before putting in the flues. After setting, the flues are washed off with gasoline just prior to welding. Each tube and flue is welded by starting near the bottom, welding first up one side, then the other, completing the weld near the top center.



Electric welding of flues

NOTE:—Start with weld at A and work in the direction of X to B. Return to A and weld in the direction of Y to C, lapping over end of first weld, thus breaking arc at top edge of weld away from flue bead.

The boiler, after testing, is equipped with an Elesco superheater. After this is tested, the boiler is painted and is ready then for shipment.

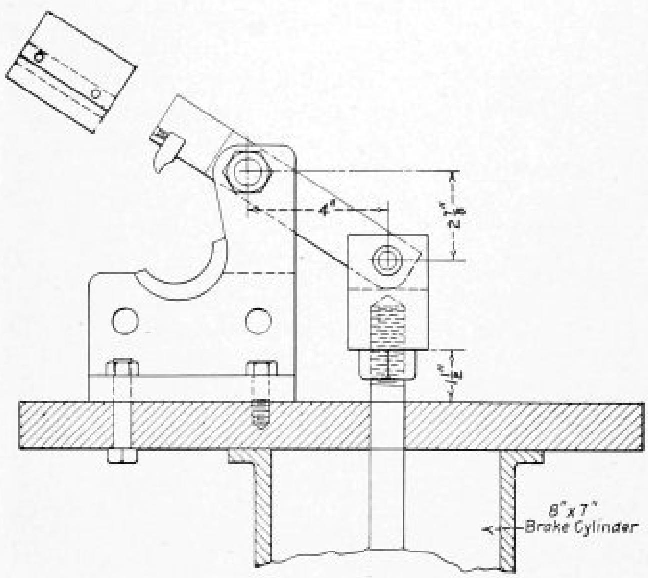
Device for Removing Fittings from Hose

When it becomes necessary to remove fittings from scrap steam and air hose, the pneumatically-operated cutting knife shown in the drawing can be used effectively. It is comprised of an 8-inch by 7-inch brake cylinder, the piston rod of which actuates the cutting knife. The cylinder is mounted beneath the work bench to which is bolted the stand for holding the hose while it is being cut along the fitting stem. The stand is designed to hold steam hose but by inserting the bushing shown in the detailed drawing it can be used for cutting the smaller air hose.

The stand is built up by riveting a right-hand and left-hand section to a central block which is machined with a concave recess for inserting the hose and which is 1½ inches thick, 3⅜ inches high and 5⅞ inches long. The right-hand and left-hand sections are also machined with the concave recess for holding the hose during the cutting operations. When riveted to the central block the assembly has a solid base with a total width of 3 inches. The central block does not extend into the upright part of the end sections, leaving the 1½-inch space between the uprights to be used as a fulcruming point for the cutting lever.

The cutting lever is attached to the piston rod of the brake cylinder at one end and fitted with the cutting blade at the other. Two cutting blades are used, one for steam hose and the other for air hose. Both blades have a thickness of ½ inch and a length of 3 inches but the width of the former is 1⅛ inches while the width of the latter is 1 5/16 inches.

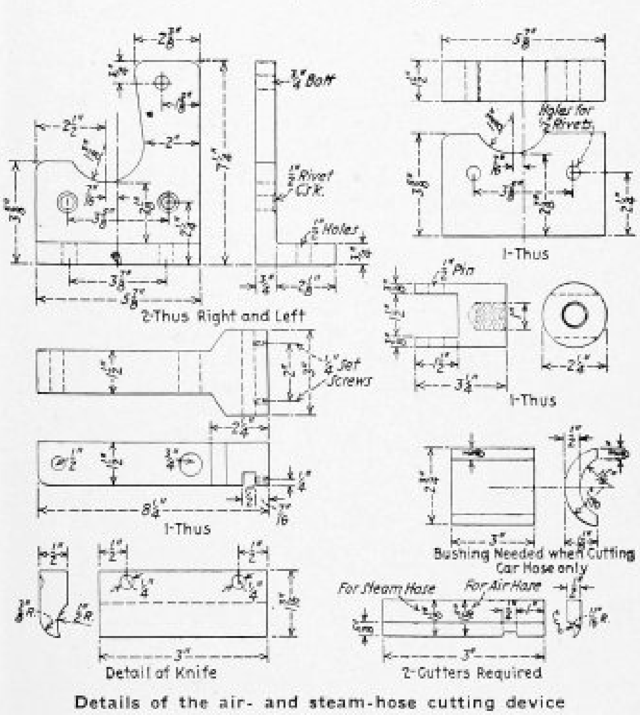
When cutting steam hose, the smaller blade is inserted in the cutting lever and the hose is placed in the



Assembly of pneumatically-operated cutting knife

concave recess machined in the right-hand and left-hand sections and in the block riveted between them. As the air is applied, the cutting knife comes in contact with the hose, parallel with the center line of the hose fitting. The blade severs the hose along the fitting stem, after which the fitting can be removed readily by hand without any effort.

When cutting air hose, a bushing is placed in the



Details of the air- and steam-hose cutting device recess of the stand. This bushing is machined with a $1\frac{1}{16}$-inch face radius suitable for holding the air hose firmly while the pressure against the hose and fitting is being applied. The cutter slits the hose through to the fitting, after which it can be removed easily.

Modern British Boiler Repairs Methods

By G. P. Blackall

James A. Mulhern, president of the Liverpool Marine Engineers' Association, recently delivered to the members of that organization a very illuminating lecture on boiler repairs. Mr. Mulhern, who is well-known as one of the leading practical engineers on Merseyside, made it clear at the outset that he did not intend to go into any calculations nor discuss the construction of boilers. His object was to give some idea of how boiler repairs were carried out in present-day practice in the United Kingdom, and he stated that the most common defect in a boiler is leaky tubes. In the case of a multi-tubular boiler, if the leak is around the neck of the tube, it may be made good by expanding. If due to a burst tube then a stopper is usually fitted until the tube can be replaced.

The method of fitting a tube stopper and the various designs of stoppers were carefully explained by the lecturer. In fitting in the new tube, special attention was drawn to the method of using the expander and the danger of necking the tube. The lecturer related an incident which occurred on board a new steamer that started on a voyage without any tube stoppers. One of the tubes gave out and a stopper was made out of a piece of a handrail, part of an oil tank sounding pipe, and four pieces of plate iron cut to fit the inside of the tube, also some asbestos tape. This was entirely successful in stopping the leak.

Dealing with the method of renewing stay tubes, Mr. Mulhern said that in the case of a defective thread in the tube plates it is now usual to build up by electric welding, ream the holes and retap them.

In dealing with defective stays, the importance of having the hole in the end plate, or boiler shell, was described. Stays lying at an angle to the plate and fitted with beveled washers should only be tolerated in exceptional circumstances. Methods of detecting fractured stays were shown. It was remarked that the efficiency of the stays depends on the soundness of the screwed thread on stay and in the plate.

With regard to combustion chamber tops and their removal when badly corroded or bulged through overheating, it was shown that this repair is now very quickly and soundly done by electric welding.

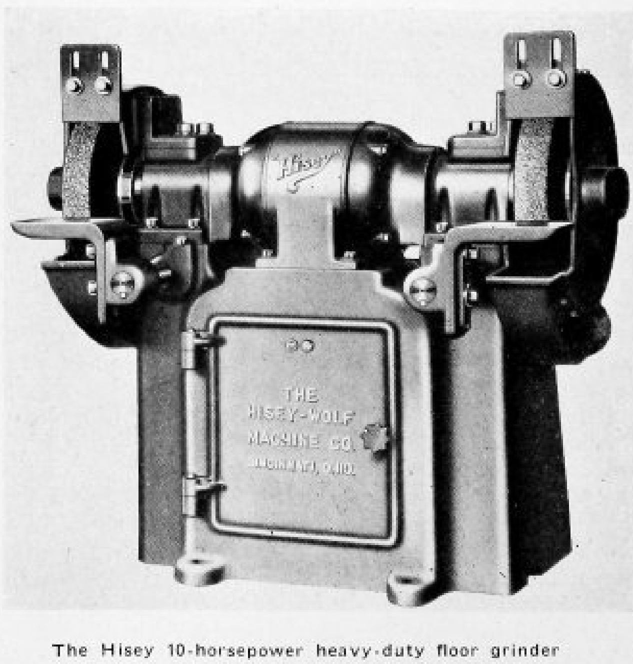
It was shown how to renew defective longitudinal stays when there is insufficient room to put in the stay in one piece; that is, by making it in two pieces and connected by knuckle joint or a long nut. The use of electric welding has now made the repairs to boilers comparatively easy, compared with former times, and President Mulhern explained several instances in which the process was used for overcoming difficulties due to leaky joints and rivets, such as making up corroded plate in way of check valve chests, leaky circumferential seams on front end plates, etc.

One of the most interesting repairs dealt with was that which was effected by the lecturer on a boiler in which the furnace tops came down on the bars, and back tube plate buckled. This repair was only made possible by the aid of electric welders. The furnaces were cut out, the tube plate and combustion wrapper plate cropped. New saddle plates were fitted to accommodate new furnaces made on the bottle-neck principle. The boiler afterwards successfully stood the usual hydraulic test without the least sign of leakage.

Referring to bulged surfaces, a very lucid explanation was given of the method of setting them up by hydraulic pressure when the bulge is not too great. But if the furnace is not down more than, say, one and one-half inches, it should not be disturbed. Several interesting experiences were related in connection with bulged furnaces. In one particular case, after much speculation, test holes were drilled and it was found that the top of the furnace was $\frac{5}{16}$ inch thick and the bottom $\frac{7}{8}$ inch, a fault in the rolling, which, of course, is exceptional.

Hisey Heavy-Duty Floor Grinders

The Hisey-Wolf Machine Company, Cincinnati, Ohio, recently placed on the market a line of heavy-duty floor grinders with capacities of 5 horsepower, $7\frac{1}{2}$ horsepower and 10 horsepower. The grinders are similar to other Hisey grinders, but have the following improvements: Adjustable steel-plate guards, heavy steel grinding rests which are adjustable and removable, a large door for access to the motor starter, a larger spindle, and larger bearings. All the feed wires are encased in flexible metal conduit. The 5-horsepower capacity machine has 3-inch by 18-inch wheels, a no-load speed of 1,400 revolutions per minute measures 43 inches between centers and $34\frac{1}{2}$ inches from the floor to the spindle and has a net weight of 1,650 pounds. The $7\frac{1}{2}$-horsepower machine has 4-inch by 20-inch wheels, and a no-load speed of 1,140 revolutions per minute. It measures 44 inches between wheel centers, $34\frac{1}{2}$ inches from the floor to the spindle and weighs 1,800 pounds.



The Hisey 10-horsepower heavy-duty floor grinder

Fusion Welding and Its Use in Pressure Vessel Construction

*By W. D. Halsey**

Because of the recent rapid development in fusion welding, the American Society of Mechanical Engineers', Boiler Code Committee has in the course of preparation a code covering its use in pressure vessel construction. The present article, published through the courtesy of the Hartford Steam Boiler Inspection and Insurance Company, states the attitude of the insurer of such vessels towards the process, and the procedure to be followed in applying coverage for installations of such character. ***The Editors.***

No sooner had man discovered the art of working metal than there came the desire—and the necessity, if his discovery was to be of benefit—to join together such parts as his facilities and ability permitted him to make. No doubt, he early found that his crudely made wrought iron could be joined, part on part, by raising the temperature to such a point that the metal became soft, plastic, almost molten, and in such state could readily be fused together under the blows of a hammer. Such a process we have long known as forge welding. In some brilliant mind in the age of early man, riveting as a means of securing two parts was given its start and later—in relatively more modern times—there came the use of machine screws and bolts. Man's limitations widened, there came the ability to fabricate metal in parts of larger size, but always the demand increased for structures of still greater magnitude, fewer component parts, and methods of securing together such parts in a simpler and more efficient manner. It appeared that this demand might be met when a concentrated heat of high temperature became possible through the application of electric current and the various types of gas torches.

Boilers and pressure vessels have long been built with riveted seams. Experience has taught us how to construct a properly riveted seam and how to compute its strength with a considerable degree of accuracy. But under certain conditions, a riveted seam will leak and in a vessel requiring very thick plates it becomes extremely difficult, even impossible, to use such a form of construction. Forge welding has also been applied to the construction of boiler drums and pressure vessels, but this process also, while making possible to a high degree the fabrication of a vessel free from leakage, has its limitations.

Fusion welding, the term now more generally accepted instead of autogenous welding, is the process of securing two pieces of metal by the application of concentrated heat of high temperature to the edges of the pieces to be joined, usually with the addition of some filler metal at the joint. The edges of the metal at the joint are brought to a molten state by the high temperature of an electric arc or the flame of a gas torch and the additional metal required is provided in the form of a rod or wire which is likewise melted into the joint. The process appears simple. Its application seems easy. Unfortunately, it is neither as simple nor as easy as it would appear.

It will be readily appreciated that the ultimate desire for a welded joint is that it have as nearly as possible the same characteristics of soundness, strength and ductility as the metal that is joined, commonly referred to as the base metal. The Hartford Steam Boiler Inspection and Insurance Company has followed the development of fusion welding from its early days, but unfortunately the company has not, until recently, been satisfied that fusion welded joints with the desired properties were being *consistently* obtained. Indeed, this company has in its files a large and impressive list of failures of fusion-welded vessels, totaling many thousands of dollars damage and, more serious, the loss of many lives. Examination has been made of many such vessels that have ruptured. In a very large number of cases the cause of the failure had been a poorly made weld, either unsound in itself or lacking in the proper bond between the weld metal and the base metal.

As a result of these investigations this company has heretofore been very reluctant to accept fusion-welded vessels for insurance. One great difficulty has been the lack of any ready means of determining, after a vessel had been placed in service, whether the welding was sound and properly made. The exterior appearance of the weld is not a safe guide because mere good appearance is not particularly difficult to obtain.

To construct properly a riveted vessel of any appreciable size, considerable equipment is required. To the early builder of fusion-welded vessels it appeared that much of this expense could be avoided by the use of only a pair of rolls to form the cylindrical part of the vessel, and the purchase of welding equipment which in itself did not entail a very large expenditure of money. Dished heads may be purchased from a number of sources and it seemed therefore, that one could set himself up in the business of fabricating fusion-welded vessels at relatively small expense. Furthermore, fusion welding has always been desirable from the standpoint of freedom from leakage. Thus it developed that many rushed into the business of fabricating fusion-welded vessels without a full appreciation of the many and intricate problems that are involved in the making of a properly welded joint.

In recent years the picture has changed very materially. With the ever-increasing demand for larger and larger vessels suitable for higher and still higher pressure and also for entire freedom from leakage, there

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has been in the recent past a very intensive study of the problems connected with fusion welding.

In the making of a fusion-welded joint many things are involved. There is needed the advice of the chemist, the metallurgist, the testing engineer, the electrical engineer and many others. It is indeed a very scientific problem. Consider only the problem of surrounding a pool of molten metal at very high temperature with the relatively cold mass in the walls of the vessel. With the consequent expansion and contraction there results the possibility of setting up more or less severe stresses in the weld or in the metal adjacent to it. Such stresses are referred to as "locked-up stresses." There is no question whatsoever but that such stresses do exist. How severe they may be and what their distribution is, have not been positively determined; but in many cases, and particularly in vessels of heavy plate thickness, steps must be taken to relieve such stresses if the vessel is to be safe for use.

Steel, while it is being melted or while in the molten state, will readily absorb oxygen and nitrogen from the atmosphere if it is not properly protected. Such absorption will result in a brittle, porous weld of inadequate strength.

One might think that the fusing of the added metal to the base metal at the joint would be a simple operation. However, considerable skill is required to obtain a proper bond and much thought has been given to the overcoming of this difficulty. It is primarily a problem that can be overcome only by the skill of the welding operator. Such skill cannot be obtained in a few hours.

As has been indicated above, much thought has been given to, and considerable research work has been done on the proper method of making a fusion welded joint that will have the desired properties of strength, ductility and soundness. Today there are a number of concerns that have solved the problem and that are fabricating unfired pressure vessels as safe to operate as those of riveted construction.

The Hartford Steam Boiler Inspection and Insurance Company has every confidence in the safety of a fusion-welded unfired pressure vessel that has been properly constructed. However, the difficulty has been to separate the "wheat from the chaff." Some manufacturers have solved the problem. Others, through a lack of appreciation of the difficulties involved, have not, as this company views the situation, made a satisfactory solution.

This company has fully appreciated the desirability of fusion-welded construction for many classes of service. To meet the situation it detailed one of its engineers, some time ago, to give the problem careful consideration in order that it might be able to advise its assured where properly constructed fusion-welded vessels might be obtained. Special methods of testing and inspection have been developed and these methods have been widely recognized as proper and adequate. A careful investigation has been made of the work of certain manufacturers who have sought our approval of their fusion-welded vessels and to some of them this approval has been given. In several cases this company has demonstrated to shops that have been doing welding for years that their methods did not produce results approximating the quality necessary for our approval and the most progressive of these concerns have lost no time in seeking a means for improving their product. Naturally, the company is careful, in carrying on its advisory work, not to divulge confidential information or methods in use at other plants, but rather to point out just wherein a welder's finished work falls below par and to stimulate him to make the research necessary to achieve the required results.

A manufacturer who desires to obtain the approval of its work first of all submits a procedure control or specification for his method of making a weld. He then proceeds to make several welds by such procedure control under the observance of a company representative. These welds are cut into coupons or specimens for various kinds of tests involving the determination of tensile strength, ductility, and soundness. If the tests indicate that the procedure control will produce a weld of the desired properties, approval of the process is given. Arrangements are then made for inspection during the course of construction of a vessel in order to certify to the purchaser that, in the opinion of the company, the vessel is safe for use.

Manufacturers of fusion-welded vessels who have obtained such approval are placed on an approved list. This list is constantly being added to and is on file at the various departmental offices, so that the assured may, upon inquiry, obtain the names of manufacturers who are in a position to construct fusion-welded vessels which will be acceptable for insurance.

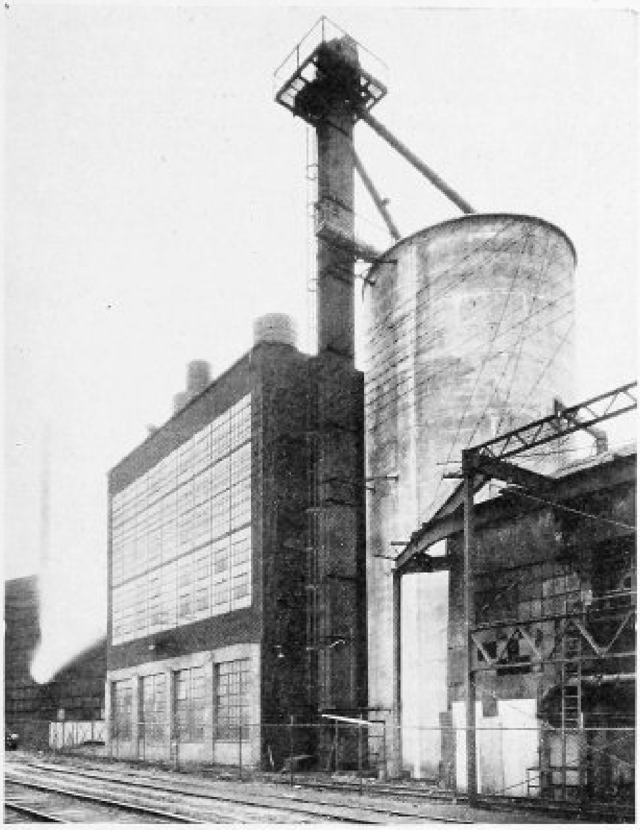
The Boiler Code Committee of The American Society of Mechanical Engineers has been giving very careful thought over an extended period of time to the drafting of an adequate code for the construction of fusion-welded unfired pressure vessels. In this work the code committee has had our close co-operation. It is clearly recognized by both that there are various grades of welding, differing as to physical properties and each suitable for certain classes of vessels. The Hartford Steam Boiler Inspection and Insurance Company early recognized this fact and information regarding the classification that it has made of the various types of vessels and the grade of welding it will accept for insurance on each is also available at its branch offices. Without doubt some such classification will be adopted by the Boiler Code Committee as is evidenced by the "Proposed Specifications for Fusion Welding" which has been published.

The future also holds much promise for the fusion-welded power boiler and our company has given this subject very careful consideration. Such a boiler, when constructed by a manufacturer on the approved list in accordance with the requirements for fusion-welded power boilers, will be as acceptable for insurance as a properly constructed riveted boiler is at present.

Novel Boiler Equipment For Forge Shop

Marking an innovation in a forge shop, a new giant coal silo, boiler and auxiliary equipment, including a fuel economizer for the utilization of waste heat to reduce production expenses, have been installed by the Champion Machine & Forging Company, Cleveland, O. The boiler is the largest single unit of its kind in any forge shop, and is fed by the silo, which is another novelty in a manufacturing plant.

The entire setting and boiler house, as laid out by W. C. Kammerer of Hadlow, Hughes, Hick & Conrad, Cleveland engineers and architects, is designed to produce steam at the lowest possible cost. The saving has been effected by having efficient, high-grade boiler equipment and a stoker of a size and a boiler with a height of setting that permits the use of cheap, high-volatile, low-fusion coal. With the new unit in operation, the cost of



Coal silo elevator and boiler room of the Champion Machine & Forging Company

manufacturing steam for Champion Company's giant hammers, has been lowered considerably. The boiler is of the standard watertube type, developing 1000 horsepower which can be continuously operated at 300 percent rating and was built by the D. Connelly Boiler Company, Cleveland, O. It is fired by a 10-retort, 25-tuyere, rotary ash discharge, Taylor stoker.

Above the hopper is a coal spreader which spreads the fuel over the stoker hopper as it is delivered from the silo spout. The boiler bridge wall is water-cooled to effect economies in maintenance and the boiler's front and side walls are air cooled. This keeps the fire brick cool and results in low maintenance cost for the boiler setting.

The economizer, manufactured by The Foster-Wheeler Corporation, New York, is situated on the operating room floor between the boiler outlet and the induced-draft fan. The flue gases in passing through the economizer are dropped from 550-600 degrees F. to approximately 350 degrees F. and the heat is absorbed by the feed water, the temperature of which is raised 50 to 100 degrees in passing through the economizer.

The boiler house was erected on an odd-shaped lot and its dimensions are: Length, 61 feet 10 inches and height, 60 feet 11 inches. On one side it is 54 feet 4½ inches and on the other, 32 feet 7¼ inches. The basement has the same dimensions except that its height is 18 feet, 6 inches.

"Under normal operating conditions," J. Fred Connelly, vice-president of the company, says, "there is a fuel saving of 100 tons of coal per week through operation of the new unit. The old and new units give us a combined maximum capacity of 4650 boiler horsepower."

The silo, a cylindrical-shaped coal bin, 67 feet high and 27 feet inside diameter, has a capacity of 950 tons. It is built of reinforced concrete with 6-inch walls. A rather common coal handling method is followed in delivering the coal to the silo. The fuel is dumped from hopper bottom cars into a hopper beneath the track and a reciprocating feeder carries it a few feet in a pit. It passes through a crusher, or can be by-passed, into a bucket elevator which carries it to the top of the silo at the rate of 35 tons per hour.

Tests on Enduro Firebox Plate

*By Howard L. Miller**

An interesting experiment carried out during 1928 and 1929 on the Nickel Plate Railroad serves to give some idea of the relative characteristics of Enduro Type-A high-chromium iron and ordinary steel plate. On two of the locomotives operated on that road tests were carried out, each engine running approximately the same distance. One of the locomotives, designated as No. 631, was equipped with a pair of ¾-inch side sheets of Enduro Type-A and was placed in service on June 6, 1928. The other engine, No. 633, operating in the same division and the same service, was equipped with a pair of ordinary steel sheets that were later removed because of bad corrugation and cracking on the fire side of the plate at the staybolt holes. Both engines ran approximately 69,400 miles and at the end of this service, the Enduro plates were in good condition but some cracks developed during the redriving of staybolts on Class 3 repairs. These cracks were similar to those that often occur when re-driving staybolts in ordinary steel plates that have been in service.

Investigation shows that both ordinary steel and Enduro A are more brittle at room temperatures after they have been in service than when installed. This brittleness, however, is not in evidence if the plates are warmed up to, say, 212 degrees F. when re-driving bolts. The following table shows the data obtained in the service tests and the condition of the plates after removal:

Engine Numbers	631	633
Side sheets	Enduro A	Regular steel
Type	2-8-2	2-8-2
In service	16 months	18 months
Feedwater heater	Worthington	Elesco
Stoker	Duplex	Duplex
Staybolts	1" hollow flexible	⅞" solid flexible
Washout period	1200 miles	1200 miles
Mileage on plates	69,492	69,398
Cause of removal	Cracked on redriving of staybolts	Corrugation 56 staybolt holes showed cracks in plate
Condition of water side	Scale falls off plate in hot zone when washing out No corrosion or strain lines on surface	About 1/16" scale adhering Grooving about 1/16" deep along mud ring Strain lines in plate around holes

The carbon steel plate had deteriorated sufficiently to cause removal, while the Enduro plate was in good condition so far as resistance to corrosion and cracking was concerned, but six small cracks, ¼-inch to ½-inch long, and one longer crack, 2½ inches long, were caused by re-driving staybolts at shop temperatures. This driving of the staybolts at room temperature was done in the

*Metallurgist, Republic Steel Corporation, Youngstown, Ohio.

nature of a test to determine if such procedure could be followed. It was evident, however, that room temperature is not suitable for this operation. The manufacturers recommend a temperature near the boiling point of water when re-driving the bolts.

The resistance of this material to heat and corrosion seems to have been demonstrated up to the point at which this test was stopped. Additional service tests, however, are needed to fully prove the superiority of this material.

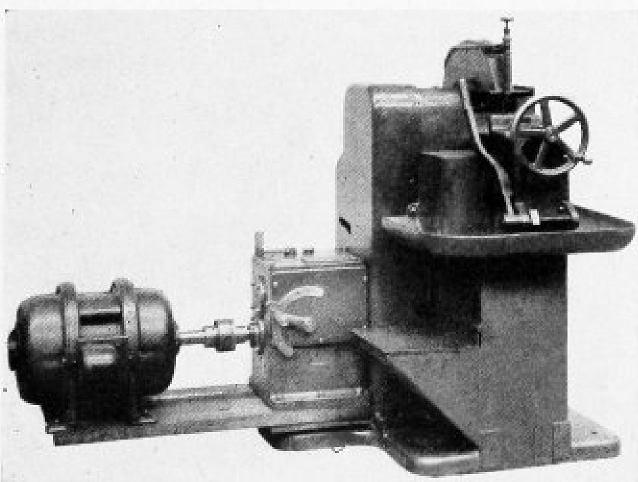
One peculiar feature was noticed during inspection after washing out, this feature being that the boiler scale fell off the plate in the hot spot at the sides. This peculiarity undoubtedly kept the plate below the temperature at which bulging would occur and is probably caused by the fact that Enduro A has a lower expansion than ordinary steel with the same temperature rise.

Cochrane-Bly Abrasive Cut-Off Machine

The abrasive cut-off machine illustrated has recently been developed by the Cochrane-Bly Company, Rochester, N. Y., to increase the rate of cutting and the number of cuts for a given amount of wheel wear. The machine has a hardened and ground spindle mounted in dust-proof Timken roller bearings, and a heavy carriage mounted on ball-bearing ways which is moved to the work by means of a lever. The carriage is extended at the front underneath the knee and covers the ball-bearing ways, protecting them from grit.

The machine is driven through a four-speed gear box, having hardened nickel-steel gears running in oil and shafts mounted in Timken roller bearings. This gear box provides four spindle speeds varying from 2400 revolutions per minute to 3600 revolutions per minute, which give a periphery speed to the 16-inch abrasive wheel of 10,000 to 15,000 feet per minute. The machine can be speeded so that the speed changes compensate to a degree for the wear in the wheel diameter and maintain an approximately uniform periphery speed as the wheel wears down.

The machine is driven from the speed box to spindle by multiple V-belts. An idler pulley maintains uniform belt tension and compensates for any variation in centers of pulleys caused by carriage movement. It is designed for either wet or dry cutting and is provided with a pump which delivers a stream of coolant or lubricant to the wheel or saw blade. The wear of the wheel when cutting wet is just half the wear when cutting dry for a given number of cuts at the same rate. The machine is designed to cut cold-rolled bar, $1\frac{7}{16}$ inches round, in $2\frac{1}{2}$ seconds and 1-inch rounds or squares in about 1 second. The machine can also be used with a saw blade for cutting non-ferrous metals, wood, fiber, bakelite, etc.



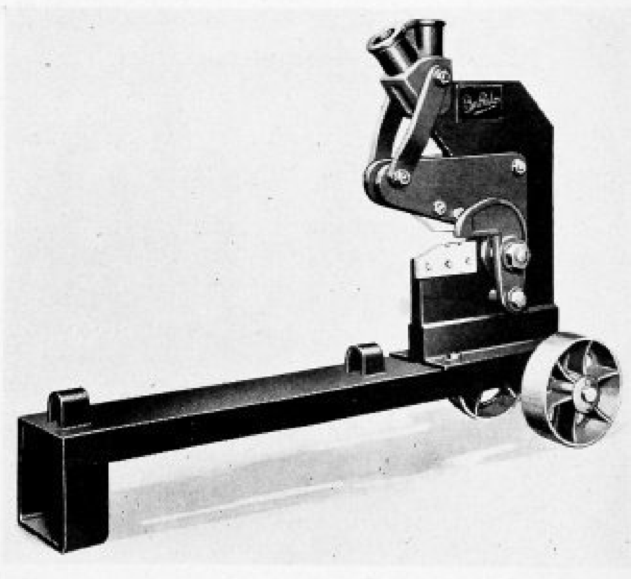
The Cochrane-Bly cut-off machine for wet and dry cutting

Specifications of the No. 21 Cochrane-Bly Abrasive Cut-Off Machine

Capacity, round stock	4 inches
Diameter abrasive wheel or saw	16 inches
Speed range of spindle	800-6000 r.p.m.
Spindle speed for abrasive wheel	2500-3600 r.p.m.
Spindle speed for saw blade	800-3600 r.p.m.
Spindle speed for friction disc	4200-6000 r.p.m.
Floor space, belt drive	38 inches by 40 inches
Floor space, motor drive (without speed box)	38 inches by 50 inches
Floor space, motor drive (with speed box)	38 inches by 68 inches
Net weight, belt drive, approx.	1,500 pounds
Motor required	15 horsepower

Buffalo No. 104 Armor-Plate Shears

The Buffalo Forge Company, Buffalo, N. Y., recently added to its line of products the portable hand-operated armor-plate shears shown in the illustration. The armor-plate frame of the shears, from which the tool derives its name, is guaranteed to be unbreakable, while the all-steel truck and pipe handle are both designed for heavy-duty work. The pipe is used both as an operating handle for the shears and as a truck handle. The leverage system which employs a double socket to permit convenient operation, is powerfully compounded and is designed with no working parts which can get out of order. A stripper on the side of the shears prevents binding.



Buffalo truck mounted, hand-operated shears

The shears are capable of cutting flat bars 3 inches wide by $\frac{5}{8}$-inch thick and can be fitted with special knives for cutting round stock 1 inch in diameter. The No. 104 shear illustrated is truck mounted and weighs 340 pounds. The hand-operated shears can also be furnished in a bench type, which has the same capacities as the No. 104 shears and which weighs 250 pounds.

Locomotive Boiler Strength Formulas*

By C. J. Zusy and G. M. Davies

P-20.—The method of calculating the efficiency of a quadruple-riveted butt joint is as follows:

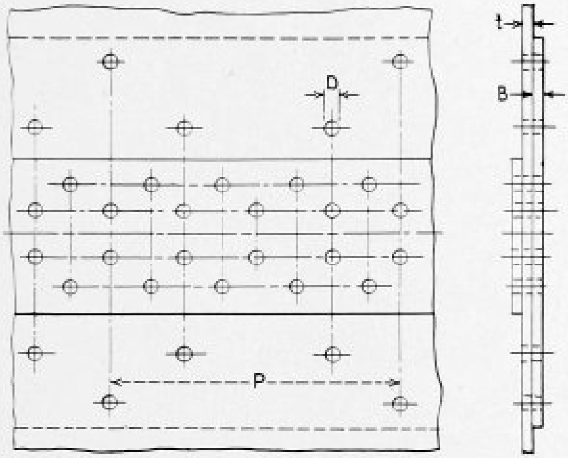


Fig. 7.—Quadruple-riveted butt joint with inside and outside welts

This joint may fail in the following ways:

1.—Tearing of plate between rivet holes in outer row.

2.—Tearing of plate between rivet holes in the second row and shearing one rivet in single shear in the first row.

3.—Tearing of plate between rivet holes in the third row and shearing three rivets in single shear in the first and second rows.

4.—Shearing eight rivets in double shear in third and fourth rows and three rivets in single shear in the first and second rows.

5.—Tearing of plate between rivet holes in the second row and crushing welt strip in front of one rivet in the first row.

6.—Tearing of plate between rivet holes in the third row and crushing welt strip in front of the three rivets in the first and second rows.

7.—Crushing the plate in front of eight rivets in the third and fourth rows and crushing the welt strip in front of three rivets in the first and second rows.

8.—Crushing plate in front of eight rivets in thira and fourth rows and shearing three rivets in single shear in first and second rows.

RESISTANCE TO FAILURE

1.— $$\frac{(P - D) \times TS \times t}{P \times TS \times t}$$

2.— $$\frac{(P - 2D) \times TS \times t + A \times s}{P \times TS \times t}$$

3.— $$\frac{(P - 4D) \times TS \times t + 3A \times s}{P \times TS \times t}$$

4.— $$\frac{8A \times 5 + 3A \times s}{P \times TS \times t}$$

5.— $$\frac{(P - 2D) \times TS \times t + D \times B \times C}{P \times TS \times t}$$

6.— $$\frac{(P - 4D) \times TS \times t + 3D \times B \times C}{P \times TS \times t}$$

7.— $$\frac{8D \times t \times C + 3D \times B \times C}{P \times TS \times t}$$

8.— $$\frac{8D \times t \times C + 3A \times s}{P \times TS \times t}$$

Efficiency = Least value obtained in 1, 2, 3, 4, 5, 6, 7 or 8.

Example.—Assuming TS = 55,000 pounds per square inch.

t = ½ inch = .5 inch.
B = $\frac{7}{16}$ inch = .4375 inch.
P = 15 inches.
D = $\frac{15}{16}$ inch = .9375 inch.
A = .6903 square inches.
s = 44,000 pounds.
S = 88,000 pounds.
C = 95,000 pounds.

1.— $$\frac{(15 - .9375) \times 55{,}000 \times .5}{15 \times 55{,}000 \times .5} = 93.7$$

2.— $$\frac{(15 - 2 \times .9375) \times 55{,}000 \times .5 + .6903 \times 44{,}000}{15 \times 55{,}000 \times .5} = 94.8$$

3.— $$\frac{(15 - 4 \times .9375) \times 55{,}000 \times .5 + 3 \times .6903 \times 44{,}000}{15 \times 55{,}000 \times .5} = 97$$

4.— $$\frac{8 \times .6903 \times 88{,}000 + 3 \times .6903 \times 44{,}000}{15 \times 55{,}000 \times .5} = 139.9$$

5.— $$\frac{15 - 2 \times .9375 \times 55{,}000 \times .5 + .9375 \times .4375 \times 95{,}000}{15 \times 55{,}000 \times .5} = 92.2$$

6.— $$\frac{15 - 4 \times .9375 \times 55{,}000 \times .5 + 3 \times .9375 \times .4375 \times 95{,}000}{15 \times 55{,}000 \times .5} = 89.1$$

7.— $$\frac{8 \times .9375 \times .5 \times 95{,}000 + 3 \times .9375 \times .4375 \times 95{,}000}{15 \times 55{,}000 \times .5} = 117.8$$

8.— $$\frac{8 \times .9375 \times .5 \times 95{,}000 + 3 \times .6903 \times 44{,}000}{15 \times 55{,}000 \times .5} = 125.7$$

Efficiency = 89.1 percent.

P-21.—The method of calculating the seam efficiency of a quintuple-riveted butt joint is as follows:

This joint may fail in the following ways:

1.—Tearing of plate between rivet holes in outside row.

2.—Tearing of plate between rivet holes in the third row and shearing one rivet in single shear in the outside row and one rivet in single shear in second row.

3.—Tearing of plate between rivet holes in the fourth row and shearing one rivet in single shear in the outside row, one rivet in single shear in the second row and two rivets in single shear in the third row.

4.—Shearing eight rivets in double shear in fourth and fifth rows and four rivets in single shear in first, second and third rows.

5.—Tearing of plate between rivet holes in the third row and crushing welt strip in front of one rivet in outside row and one rivet in second row.

* This is the third of a series of articles entitled "Locomotive Boiler Strength Formulas." The first and second appeared in the March and April issues.

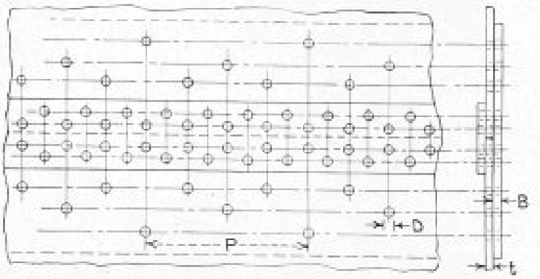


Fig. 8.—Quintuple-riveted butt joint with inside and outside welts

6.—Tearing of plate between rivet holes in fourth row and crushing welt strip in front of one rivet in out- and fifth rows and welt strip in front of four rivets in third row.

7.—Crushing plate in front of eight rivets in fourth and fifth rows and welt strip in front of four rivets in first, second and third rows.

8.—Crushing plate in front of eight rivets in fourth and fifth rows and welt strip in front of four rivets in in first, second and third rows.

RESISTANCE TO FAILURE

1.— $\dfrac{(P - D) \times TS \times t}{P \times TS \times t}$

2.— $\dfrac{(P - 2D) \times TS \times t + 2A \times s}{P \times TS \times t}$

3.— $\dfrac{(P - 4D) \times TS \times t + 4A \times s}{P \times TS \times t}$

4.— $\dfrac{8A \times S + 4A \times s}{P \times TS \times t}$

5.— $\dfrac{(P - 2D) \times TS \times t + 2D \times B \times C}{P \times TS \times t}$

6.— $\dfrac{(P - 4D) \times TS \times t + 4D \times B \times C}{P \times TS \times t}$

7.— $\dfrac{8D \times t \times C + 4D \times B \times C}{P \times TS \times t}$

8.— $\dfrac{8D \times t \times C + 4A \times s}{P \times TS \times t}$

Efficiency = Least value obtained in 1, 2, 3, 4, 5, 6, 7 or 8.

Example.—Assuming

$TS = 55{,}000$ pounds per square inch.
$t = 25/32$ inch = .78125 inch.
$B = \frac{9}{16}$ inch = .5625 inch.
$P = 16$ inches.
$D = 1\frac{3}{16}$ inches = 1.1875 inches
$A = 1.1075$ square inches.
$s = 44{,}000$ pounds
$S = 88{,}000$ pounds
$C = 95{,}000$ pounds

1.— $\dfrac{(16 - 1.1875) \times 55{,}000 \times .78125}{16 \times 55{,}000 \times .78125} = 92.5$

2.— $\dfrac{(16 - 2 \times 1.1875) \times 55{,}000 \times .78125 + 2 \times 1.1075 \times 44{,}000}{16 \times 55{,}000 \times .78125} = 99.3$

3.— $\dfrac{(16 - 4 \times 1.1875) \times 55{,}000 \times .78125 + 4 \times 1.1075 \times 44{,}000}{16 \times 55{,}000 \times .78125} = 98.6$

4.— $\dfrac{8 \times 1.1075 \times 88{,}000 + 4 \times 1.1075 \times 44{,}000}{16 \times 55{,}000 \times .78125} = 141.7$

5.— $\dfrac{(16 - 2 \times 1.1875) \times 55{,}000 \times .78125 + 2 \times 1.1875 \times .5625 \times 95{,}000}{16 \times 55{,}000 \times .78125} = 103.6$

6.— $\dfrac{(16 - 4 \times 1.1875) \times 55{,}000 \times .78125 + 4 \times 1.1875 \times .5625 \times 95{,}000}{16 \times 55{,}000 \times .78125} = 107.2$

7.— $\dfrac{8 \times 1.1875 \times .78125 \times 95{,}000 + 4 \times 1.1875 \times .5625 \times 95{,}000}{16 \times 55{,}000 \times .78125} = 139.4$

8.— $\dfrac{8 \times 1.1875 \times .78125 \times 95{,}000 + 4 \times 1.1075 \times 44{,}000}{16 \times 55{,}000 \times .78125} = 130.9$

Efficiency = 82.5 percent.

P-22.—The method of calculating the seam efficiency of a diamond butt joint is as follows:

As the diamond seam cannot be divided into several sections, having the same number and location of rivets in each section, as can the ordinary seam, the whole length of the seam is taken as the pitch.

This joint may fail in the following ways:

1.—Tearing of plate through rivet hole (one rivet) in outside row.
2.—Tearing of plate through rivet holes in second row and shearing one rivet in single shear in outside row.
3.—Tearing of plate through rivet holes in third row and shearing three rivets in single shear in first and second rows.
4.—Tearing of plate through rivet holes in fourth row and shearing six rivets in single shear in first, second and third rows.
5.—Tearing of plate through rivet holes in fifth row and shearing thirteen rivets in single shear in first, second, third, and fourth rows.
6.—Tearing of plate through rivet holes in sixth row and shearing twenty-one rivets in single shear in first, second, third, fourth and fifth rows.
7.—Tearing of plate through rivet holes in inside and outside welts, sixth row.
8.—Shearing nineteen and a half rivets in double shear and a half rivet in single shear in the sixth row, and twenty-one rivets in single shear in the first, second, third, fourth and fifth rows.
9.—Tearing of plate through rivet holes in second row and crushing welt strip in front of one rivet in outside row.
10.—Tearing of plate through rivet holes in third row and crushing welt strip in front of three rivets in first and second rows.
11.—Tearing of plate through rivet holes in fourth row and crushing welt strip in front of six rivets in first, second and third rows.
12.—Tearing of plate through rivet holes in fifth row and crushing welt strip in front of thirteen rivets in first, second, third and fourth rows.
13.—Tearing of plate through rivet holes in sixth row and crushing welt strip in front of twenty-one rivets in first, second, third, fourth and fifth rows.
14.—Crushing plate in front of twenty rivets in sixth row and welt strip in front of twenty-one rivets in first, second, third, fourth and fifth rows.

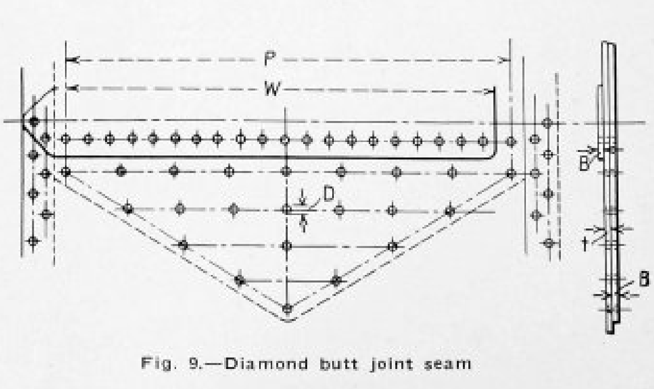


Fig. 9.—Diamond butt joint seam

15.—Crushing plate in front of twenty rivets in sixth row and shearing twenty-one rivets in single shear in first, second, third, fourth and fifth rows.

RESISTANCE TO FAILURE

1.— $$\frac{(P-D)\times t\times TS}{P\times t\times TS}$$

2.— $$\frac{(P-2D)\times t\times TS + A\times s}{P\times t\times TS}$$

3.— $$\frac{(P-3D)\times t\times TS + 3A\times s}{P\times t\times TS}$$

4.— $$\frac{(P-7D)\times t\times TS + 6A\times s}{P\times t\times TS}$$

5.— $$\frac{(P-8D)\times t\times TS + 13A\times s}{P\times t\times TS}$$

6.— $$\frac{(P-20D)\times t\times TS + 21A\times s}{P\times t\times TS}$$

7.— $$\frac{[(P+W)-(39.5\,D)]\times B\times TS}{P\times t\times TS}$$

8.— $$\frac{19.5A\times S + 21.5A\times s}{P\times TS\times t}$$

9.— $$\frac{(P-2D)\times t\times TS + D\times B\times C}{P\times t\times TS}$$

10.— $$\frac{(P-3D)\times t\times TS + 3D\times B\times C}{P\times t\times TS}$$

11.— $$\frac{(P-7D)\times t\times TS + 6D\times B\times C}{P\times t\times TS}$$

12.— $$\frac{(P-8D)\times t\times TS + 13D\times B\times C}{P\times t\times TS}$$

13.— $$\frac{(P-20D)\times t\times TS + 21D\times B\times C}{P\times t\times TS}$$

14.— $$\frac{20D\times t\times C + 21D\times B\times C}{P\times t\times TS}$$

15.— $$\frac{20D\times t\times C + 21A\times s}{P\times t\times TS}$$

Efficiency = Least value obtained in 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, or 15.

Example.—Assuming P = 70 inches.
W = 68.25 inches.
TS = 55,000 pounds per square inch.
t = 25/32 inch ÷ .78125 inch.
D = 1.25 inches.
A = 1.2272 square inches.
B = .625 inch.
s = 44,000 pounds per square inch.
S = 88,000 pounds per square inch.
C = 95,000 pounds per square inch.

1.— $$\frac{70-1.25\times .78125\times 55{,}000}{70\times .78125\times 55{,}000} = 98.2$$

2.— $$\frac{70-(2\times 1.25)\times .78125\times 55{,}000 + 1.2272\times 44{,}000}{70\times .78125\times 55{,}000} = 98.2$$

3.— $$\frac{70-(3\times 1.25)\times .78125\times 55{,}000+3\times 1.2272\times 44{,}000}{70\times .78125\times 55{,}000} = 100$$

4.— $$\frac{70-(7\times 1.25)\times .78125\times 55{,}000+6\times 1.2272\times 44{,}000}{70\times .78125\times 55{,}000} = 98.2$$

5.— $$\frac{70-(8\times 1.25)\times .78125\times 55{,}000+13\times 1.2272\times 44{,}000}{70\times .78125\times 55{,}000} = 109$$

6.— $$\frac{70-(20\times 1.25)\times .78125\times 55{,}000+21\times 1.2272\times 44{,}000}{70\times .78125\times 55{,}000} = 101.9$$

7.— $$\frac{[(70+68.25)-(39.5\times 1.25)]\times .625\times 55{,}000}{70\times .78125\times 55{,}000} = 101.5$$

8.— $$\frac{19.5\times 1.2272\times 88{,}000+21.5\times 1.2272\times 44{,}000}{70\times .78125\times 55{,}000} = 108.6$$

9.— $$\frac{(70-2\times 1.25)\times .78125\times 55{,}000+1.25\times .625\times 95{,}000}{70\times .78125\times 55{,}000} = 98.8$$

10.— $$\frac{(70-3\times 1.25)\times .78125\times 55{,}000+3\times 1.25\times .625\times 95{,}000}{70\times .78125\times 55{,}000} = 102$$

11.— $$\frac{(70-7\times 1.25)\times .78125\times 55{,}000+6\times 1.25\times .625\times 95{,}000}{70\times .78125\times 55{,}000} = 102.3$$

12.— $$\frac{(70-8\times 1.25)\times .78125\times 55{,}000+13\times 1.25\times .625\times 95{,}000}{70\times .78125\times 55{,}000} = 117.7$$

13.— $$\frac{(70-20\times 1.25)\times .78125\times 55{,}000+21\times 1.25\times .625\times 95{,}000}{70\times .78125\times 55{,}000} = 116.1$$

14.— $$\frac{20\times 1.25\times .78125\times 95{,}000+21\times 1.25\times .625\times 95{,}000}{70\times .78125\times 55{,}000} = 113.5$$

15.— $$\frac{20\times 1.25\times .78125\times 95{,}000+21\times 1.2272\times 44{,}000}{70\times .78125\times 55{,}000} = 99.3$$

Efficiency of seam = 98.2 percent.

P-23.—Tension on net section of shell plate,

$$T = \frac{ID\times BP}{2\times t\times E}$$

where
T = tension on net section of shell, pounds per square inch.
ID = largest inside diameter of shell course, inches.
BP = boiler pressure.
E = efficiency of longitudinal seam or through holes for studs, rivets or bolts where four or more are applied in a section.
t = thickness of shell plate in inches.

Example.—Assuming ID = 65 inches.
BP = 200 pounds per square inch.
E = 97.2 percent.
t = 21/32 inch = .65625 inch.

then,

$$T = \frac{65\times 200}{2\times .65625\times .972} =$$

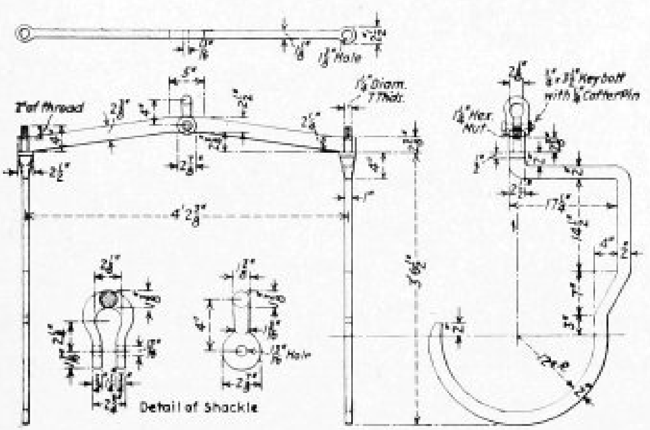
10,190 pounds per square inch, tension on net section of shell.

(To be continued)

Device for Lifting Air Reservoirs

In engine houses and back shops diverse means are employed for lifting air reservoirs into position beneath running boards. A device which is designed to expedite this particular operation is shown in the drawing.

The device is made with two J-type hangers bolted to a cross member, in the center of which is attached an inverted-U shackle for the insertion of a crane hook. The J-type hangers are constructed of 1-inch by 2-inch steel, that portion of the hanger for supporting the reservoir being bent to a 12-inch radius. The two hangers are spaced at a distance of 4 feet 2⅜ inches by a cross beam made from 2⅜-inch by 1⅛-inch steel with an eye forged at each end. The top of the J-type hangers are bent as shown in the drawing and threaded to permit bolting them to the cross member. They are designed to permit the equalization of the suspended load and with a 4-inch offset in the vertical stem of the J for running board clearance.



Details of air reservoir lifting device

Although the lifting device was primarily designed for raising air reservoirs into position on locomotives in the round houses, where the running board is seldom removed, it can be used in back shops in place of chains, thus removing a safety hazard.

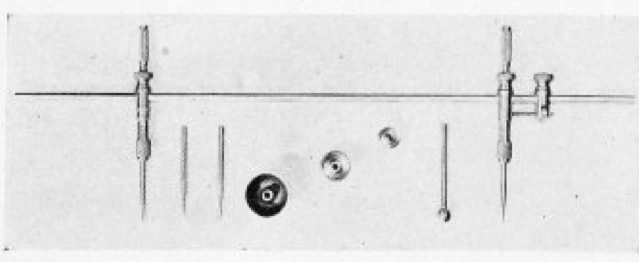
Starrett Trammels With Steel Beams

Metal workers, draftsmen, lay-out men and others whose work demands precision in long measurements will be interested in a trammel now being manufactured by the L. S. Starrett Company, Athol, Mass.

The No. 251 Starrett trammel presents a number of refinements and improvements over old types. The beam is a steel rod, stiff enough to prevent the bending which often causes inaccuracy in wood-beam trammels. The beam is flattened on top so that the trams, once clamped in position, have no tendency to turn when pressure is applied to the points. As the illustration shows, one of the trams has an adjusting screw which permits fine adjustments. The setting of the points is made easy by the arrangement of a spring friction which holds the tram in place when the nuts are loosened.

An improvement which makes the trammels more accurate and at the same time makes them easier to use is the design of the knurled grips. These are in the form of rollers which turn freely with the fingers as the arc is scribed.

The trammed points are adjustable in the spring chucks. They can be replaced by pencils, caliper legs or ball points. The ball points permit working from holes up to 1½ inches in diameter. The trammel is supplied with steel beams of various lengths to scribe circles of 18 inches, 26 inches and 36 inches in diameter. In addition, an extra 20-inch beam with a rigid coupling is obtainable, increasing the range of the tool to circles 72 inches in diameter.

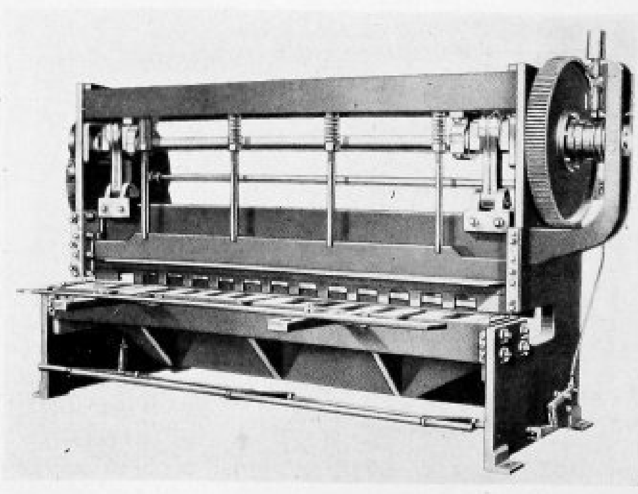


The No. 251 steel-beam Starrett trammel

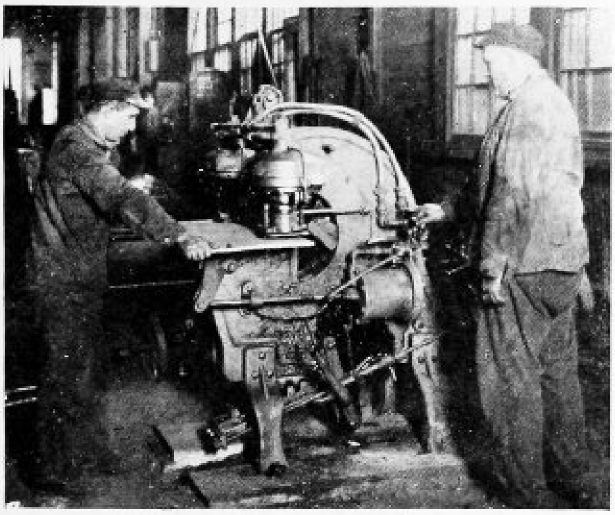
Power Squaring Shears

The Dreis & Krump Manufacturing Company, Chicago, Ill., has recently placed on the market a new machine tool known as the Chicago steel power squaring shear. Incorporating the latest developments in arc-welding steel plate construction, the entire machine is built of steel plates welded into a solid unit. The bed and top leaf have welded cross bracing and the housing has a welded reinforcement around the gap. The gears are also made of rolled steel sections and completely welded together.

These machines are furnished in sizes from 36 inches to 168 inches in length and from 14 gage to 1-inch capacity. Because of the steel construction, the weights are approximately 75 percent of cast iron shears of the same capacity. The lubrication is by a centralized system to all moving parts. Hold-down is so constructed that full pressure is applied before the knives start to cut. The clutch is of the positive jaw type and the machines are driven by forged crank shafts.



Dreis & Krump power squaring shears



Erie Railroad Standards of Locomotive Boiler Practice

Boiler Studs: Boiler studs (except as hereafter specified) must be at least ¾ inch diameter. Jacket certain stoker bracket, steam gage bracket and similar light duty studs must be at least ⅝ inch diameter. Boiler studs shall have the firebox or boiler end threaded straight with 12 U. S. form threads per inch.

Boiler studs must be threaded a sufficient length to insure screwing in so as to be at least flush with the sheet on the inner side.

When locomotives receive general or Class 3 repairs, all studs inside of fireboxes, screwing through the sheets into the water, must be renewed.

The nicking or cutting of weakening grooves in all boiler studs is prohibited.

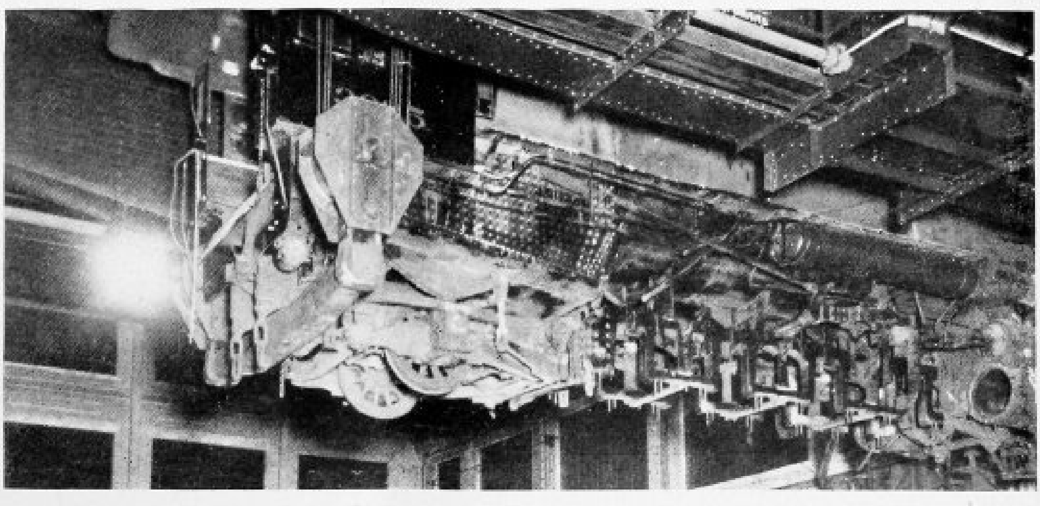
Thermic Syphon Applications The rectangular shaped opening to be cut in the crown sheet should be laid out in accordance with drawings of syphon arrangement, after checking both firebox and syphon with the drawing.

Third installment of article on boiler shop practice. The first appeared on page 60 of the March issue, the second on page 97 of the April issue.

Allowance all around the opening should be made for the ½ inch lap of the syphon under the edge of the crown sheet. The syphon flanges should be laid off and marked to match the crown sheet marking, also allowing for the lap joint. The location of the holes through which the radial staybolts will pass should also be marked on the flanges. These locations are transferred from the radials in the crown by any convenient and accurate method, such as a template or stick, care being exercised to insure their corresponding with the respective rows of radials in the crown.

The section of the crown sheet to be removed can be burned out with the gas torch, ⅛ inch chipping stock being allowed during the operation. The radials to be removed may be burned out at the roof sheet, which will permit plate and radials to fall out in a body. In burning out radials, the top ends of the center row, when this row occurs over the center of syphon, can be allowed to remain as plugs, the radials being burned off under the roof sheet and riveted over.

Fig. 11.—(Above) McCabe cold-flanging machine in operation at one of the Erie shops. Fig. 12.—(Right) method of shifting locomotives in the shop



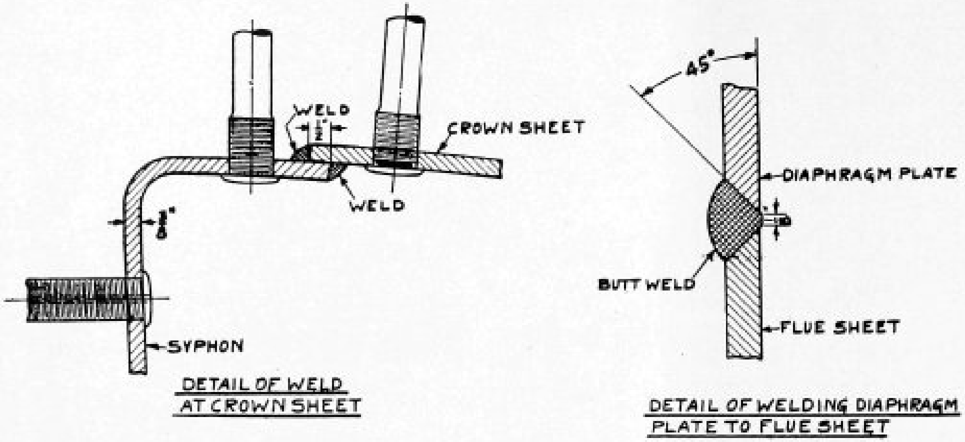


Fig. 13.—Details of the method of welding a syphon to firebox crown and flue sheets

Chipping stock on the crown sheet should be beveled off to form a clean edge for welding. The rough stock around the flange of the syphon should be burned off and chipped on a bevel to form the other welding surface and the holes for the radial staybolts should be drilled to reamer size.

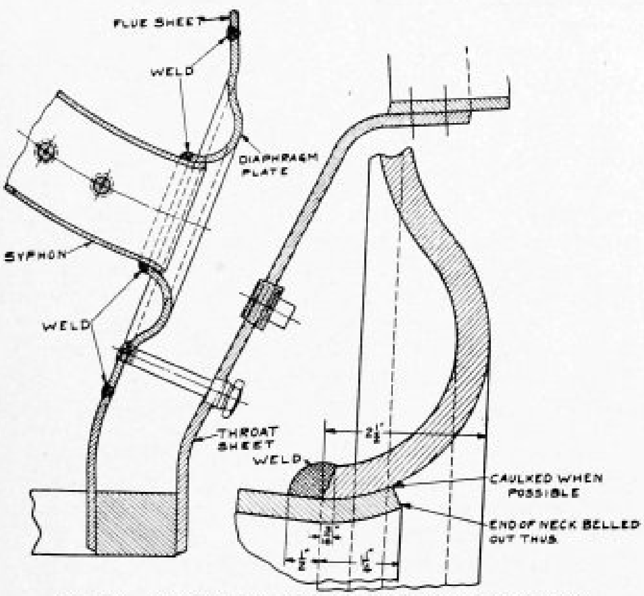


Fig. 14.—Welding the syphon to the diaphragm plate

The syphon is now ready to be fitted in the firebox. All welding surfaces should be cleaned of any scale to insure a good efficient weld.

The flue sheet should be laid off for an opening to receive the diaphragm plates, the location to be taken from the drawing furnished or from the syphon. Burn out the part to be removed, at the same time removing the staybolts in the enclosed area, and chip off the rough edge of the hole to suit a butt weld.

It is most convenient, if conditions permit, to apply the syphon when the firebox is turned upside down, as welding may be done in the downward position.

The neck of the syphon is provided with about 3 inches of extra stock on the end to allow for irregularities in the fireboxes to which it is applied. Enough of this stock should be burned off to allow the end of the neck to clear the throat sheet after the syphon is in place for fitting up.

Now place the syphon in its position in the firebox. While this is being done, the diaphragm should be brought into position on the syphon neck and after the syphon is temporarily bolted to the crown sheet, it is brought against the flue sheet, where it is laid off for trimming from the opening into which it is to fit. Staybolt holes in the diaphragm may also be laid out at this time, as it is desirable to utilize as many as possible of the old staybolt holes in the throat sheet.

The diaphragm should be trimmed with a torch and the edge chipped to a bevel, after which it should be fitted and bolted into place in the flue sheet. The holes for the staybolts must be drilled and not burned, either being drilled in place, or by removing through releasing syphon and drilling on a drill press. If for any reason the diaphragm plate must be heated or altered, it should finally be annealed before being installed.

The syphons should be spaced center to center exactly as specified on the drawing, so that the brick arch will fit into place without difficulty.

With the syphons and diaphragm plates bolted into proper position, the neck cut off to proper length and fitted according to the drawings furnished for the in-

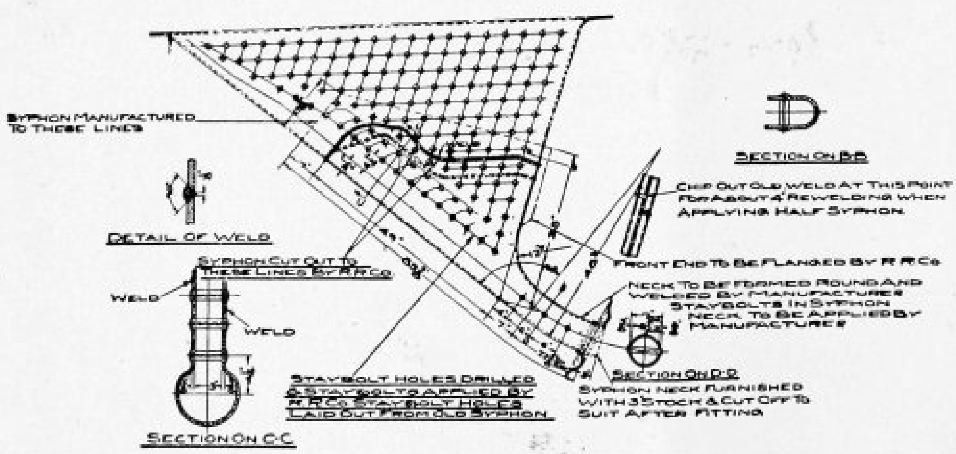


Fig. 15.—Principal details of the method of applying half syphons

stallation, the welding may be started. Thermic syphons and diaphragms should be welded by the electric process only. A good ductile weld is desired, free from pin holes and thoroughly fused with the plates. Care should be taken to provide for the stresses set up by expansion and contraction and the syphon should therefore be welded to the crown sheet before welding to the diaphragm.

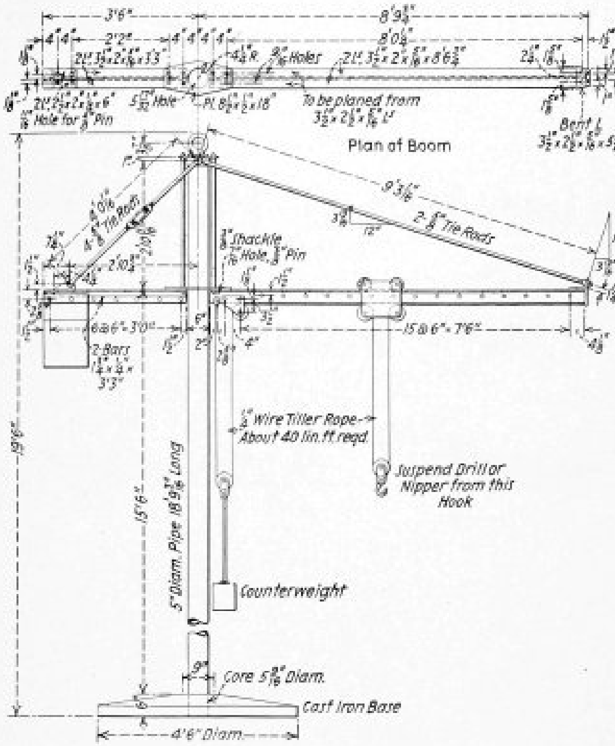
The holes for the radial staybolts through the syphon flanges should be reamed and tapped and the radial staybolts applied, after the completion of welding at the crown sheet and flue sheet connections. The firebox ends of all radial staybolts passing through the syphon flanges are to be hammered over, the use of button head radial bolts in this location being undesirable.

The staybolts around the neck of the syphon, through the diaphragm plate should be flexible staybolts.

Cleaning Syphons: Syphons should be thoroughly bumped with an air hammer at thirty day washout inspections to loosen any scale formation, and washout and inspection plugs removed and syphon thoroughly washed.

Inspection of Syphons: Syphons should be thoroughly inspected each time fire is dumped for any bulging, blistering or other evidence of imparied circulation due to obstruction, scale or other cause. Syphons found cracked in the neck, diaphragm or lower portion of the syphon must not be continued in service, but must have the cracked portion renewed.

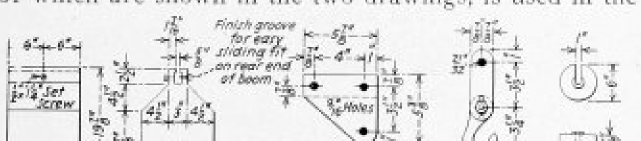
Repairs to Syphons: Cracked syphons must be repaired by applying a half syphon as shown by Fig. 15. Half syphons should be welded in place and to the body of old syphon by the electric process only.



Assembly drawing of the portable jib crane

Portable Jib Crane for Power Tools

The portable jib crane, the assembly and detail parts of which are shown in the two drawings, is used in the shops of a car manufacturer and also on several railroads in the east. This crane was designed primarily to lessen the labor of handling and operating air and electric tools along the side of a car or on the truck-repair track. Nippers, rivet busters, power drills and heavy hand tools of similar nature are suspended from the hook when in use. This method not only relieves fatigue, but frequently enables one man to perform work where ordinarily two are required thus saving both time and money.



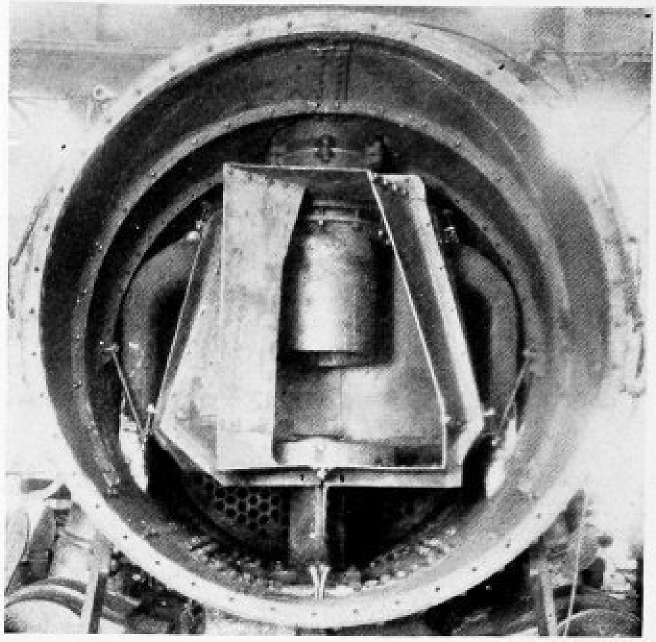
Details of the portable jib crane

The crane, as shown in the assembly drawing is supported on a cast-iron base weighing 2,625 pounds. In some shops where this crane is used, it is carried on a four-wheel hand truck. The maximum operating radius of the hook is 8 feet. The height from the bottom of the base to the bottom of the boom is 15 feet 8½ inches. The trolley and boom are counterbalanced as shown to permit easy operation of the crane and tool. All of the parts are of wrought iron, with the exception of the base and counterweights, which are of cast iron construction.

Leaky Fusible Plug Eroded Tube

While investigating a case of tube leakage in a water-tube boiler, an inspector recently came upon a rather unusual circumstance. The soft metal of the fusible plug had been melted out apparently for some time, but a deposit of flint-like scale had so nearly closed the opening through the plug that there had not been enough leakage to attract the operator's attention. However, the opening had been large enough to permit the escape of a thin jet of steam and this jet, impinging on one of the tubes, had cut its way entirely through the metal. Examples of tube and drum erosion caused by jets of steam are not uncommon, but it is seldom that the fusible plug can be cited as the cause.—*The Locomotive.*

Northern Pacific Uses Improved Spark Arrester



Cyclone spark arrester installation

For a number of years the Northern Pacific Railroad has been using Rosebud coal successfully on locomotives, this light lignite, secured from a large strip mine in eastern Montana, burning freely but being readily drawn to the smokebox and out of the stack. To find some means of burning this coal without attendant fire hazards, the Northern Pacific began experimenting, about two years ago, with a front-end device which depended upon centrifugal action rather than netting to prevent the emission of live sparks from the locomotive stack. This device was developed by M. F. Brown, general fuel supervisor of the Northern Pacific, and called the Cyclone spark arrester. It is now being manufactured by the Locomotive Firebox Company, Chicago, and is applied to about 300 locomotives on the Northern Pacific. A number of other roads are making applications.

Extensive tests on the Northern Pacific, including two conducted by the Forestry Department of the United States Department of Agriculure, indicate that the new spark arrester prevents any sparks leaving the stack of sufficient size to start a fire on the right of way. Besides functioning without front-end netting, a valuable feature of this spark arrester, as shown by the tests, is that it can be used without paying any penalty in decreased efficiency due to higher cylinder back pressure. In fact, with this type of spark arrester, as compared with the standard Master Mechanic's front-end design, a slightly larger exhaust nozzle can generally be used. In addition to promoting the safe burning of light lignite, as well as heavier coals on coal-burning locomotives, the new spark arrester is said to be equally adaptable to use on oil burners to prevent the emission of sparks produced from particles of firebrick and carbon deposits which become detached and overheated.

The Cyclone spark arrester consists of a large sheet metal drum which surrounds the smoke stack extension and the nozzle tip, and carries at the sides and tops, vertical baffle plates. The intake is also provided with deflectors so arranged that when a locomotive is working the gases and cinders enter the drum in a tangential direction and continue in a circular movement throughout the drum. Centrifugal force carries the cinders to the wall of the drum where they are broken up by friction, ground to the size of coarse sand and extinguished in the gases which fill the drum. Gradually, the cinders work down to the bottom of the drum and, when small enough, are picked up and carried out of the stack in the usual manner.

As indicated, wire netting, or perforated plate, is not used in connection with the Cyclone spark arrester, this being a fundamental divergence from general practice, as netting in one form or another is commonly depended upon to prevent the emission of sparks from locomotive stacks. Owing to the absence of netting, there is no possibility of holes developing through which large sparks can pass an cause fires, nor is there any chance of clogged openings, with reduced effective air space and attendant possibility of steam and engine failures. The size of the drum in the new spark arrester corresponds to the cross section of the flue area in such a way that there is no restriction of the draft.

The Cyclone spark arrester consists of a large sheet plate, made in sections, which can be removed to facilitate necessary repairs to tubes or superheater units. Ease of inspection is an important feature, there being no necessity to look for small holes either in a netting or around the plates, as in the standard Master Mechanic's front end. The cost of inspection, as well as maintenance, is, therefore, minimized.

Record of Burned Holes and Spots on Test Paper Back of Locomotive 1575, Equipped with Master Mechanic's Front End

Test No.	Mile	Train speed M. P. H.	No. 1 112 ft. back of stack Box	No. 2 153 ft. back of stack Box	No. 3 194 ft. back of stack Box	Track grade per cent
1	119	19	2	0	0	1.35+ to 1.40+
2	103	25.7	28	10	8	0.00 " 0.395+
3	89	25.7	0	2	2	0.286+ " 0.00
4	81	Pulling out of Bearmouth	24	11	0	0.00 " 0.353+
5	75	25.7	3	0	18	0.225+ " 0.337+
6	67	26.7	0	0	6	0.40+
7	60	27.7	0	4	13	0.37+ " 0.40+
8	50	Pulling out of Garrison	0	0	0	0.4+ " 0.6+
9	36	22.0	0	0	0	0.8+
10	28		0	0	0	1.35+ " 1.40+
		Total	57	27	47	

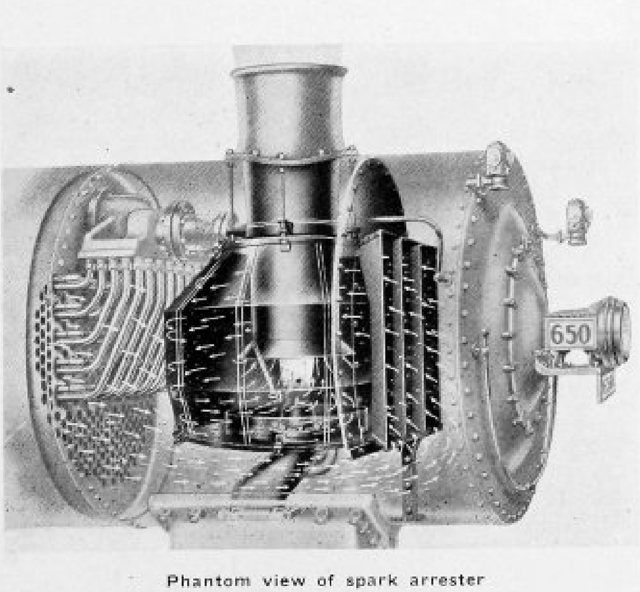
According to a report issued by John McLaren, regional inspector, Forest Service, United States Department of Agriculture, under date of March 19, 1930, representatives of the U. S. Forest Service, the state forester's office, the University of Montana, and several railway officers were present during a test run in which a 3465-ton freight train was operated from Missoula, Mont., to Helena, passing over the transcontinental divide en route. The party rode in a caboose coupled directly to the tender of Northern Pacific Locomotive No. 1809, equipped with the Cyclone spark arrester. A second locomotive, No. 1812 of the same type but fitted with a Master Mechanic's front-end arrangement, was coupled six car lengths behind the leading locomotive. These locomotives were both of the Mikado type, stoker fired, carrying a boiler pressure of 200 pounds per square inch and burning Rosebud coal. Observations were made on both locomotives at night in order that any sparks emitted from the stacks could be seen more readily. According to the report, two small "floaters" were the only sparks that came from the stack of Locomotive 1809 during this test run, regardless of how hard the locomotive was working and whether or not the grates were being shaken. Locomotive 1812, on the other hand, was reported to have thrown showers of sparks almost continuously when working hard, many of these sparks falling four and five car lengths back of the locomotive.

On September 5, 1930, another test was made, with the object of obtaining measureable results as to the comparative value of the Cyclone spark arrester and a Master Mechanic's front end equipped with wire netting, the openings of which were 1/10 inch square. A freight train, consisting of 81 cars of 3691 tons, was made up at Missoula, and hauled by Northern Pacific Locomotive No. 1815, equipped with a Cyclone spark arrester. Ten car lengths back, Locomotive No. 1575, equipped with the Master Mechanic's front end, was coupled in. The coal used on both of these locomotives was of light Rosebud lignite. Test boxes Nos. 1, 2 and 3 were placed on top of the second, third and fourth cars behind Locomotive No. 1575 at distance of 112 feet, 153 feet, and 194 feet, respectively, from the smoke stack. Boxes Nos. 4, 5 and 6 were placed on the second third and fourth cars back of Locomotive No. 1815 at distances of 96 feet, 137 feet, and 178 feet from the stack. These test boxes were made of light lumber, 5 feet long by 11 inches wide by 8 inches high, with baffles placed at uniform distances on the bottoms to keep the cinders from piling up in one end of the box. Inflammable paper toweling was secured to the inside of the bottoms of the boxes by thumb tacks and an observer was assigned to each box. At a whistle signal on starting, a canvas cover was removed from each box and kept off for four minutes, each paper then being removed, given a test and box number, rolled up and carefully preserved. New papers were then put in place and the operation repeated on ten individual tests. Records of temperature, humidity and wind velocity were kept, as well as a log of the run, including a record of train speed, etc.

The train left Missoula at 6:25 a.m., and the run to Blossburg, Mont., a distance of 98.8 miles, was completed at 12:16 p.m., several stops being made en route. Side winds, track curvature and the relatively high humidity account for fewer burned spots than might otherwise have been recorded, but a total of 57 burned holes and spots were made on test papers from Box No. 1, 27 from Box No. 2 and 47 from Box No. 3, as shown in the table. All of the tests were uniformly four-minute exposures, except No. 10, when the test covered a period of 20 minutes.

Several holes were burned in the clothing of the men on the cars immediately back of Locomotive No. 1575 and a cinder falling in the grass at Mile Post 110 started a small fire on the right of way. The fact that the test box nearest the locomotive registered the greatest number of burned holes and spots indicates that the heaviest cinders, which would naturally fall first, are also the hottest. The record of Box No. 3 during Test 5 shows, however, that under favorable conditions of track curvature on wind a large number of hot embers may be carried as far as 194 feet back of the locomotive.

Each of the tests mentioned was made simultaneously with Boxes Nos. 4, 5 and 6 behind Locomotive No. 1815 and no burned holes or charred spots were found on papers carried in these boxes during the entire trip.



Phantom view of spark arrester

Rolling Molds and Skeleton Gages

By George Gardner

It sometimes happens that an irregular transition piece or connection is required that cannot be laid out by geometrical methods, and, if possible by triangulation, would involve a great deal of constructional drawing and laying out. In such cases, a frame or skeleton of the piece might be made, and such mold rolled upon a plate (at the same time making the contour) to give the required shape. Good material for such a mold is 13/16-inch or ¼-inch welding rod. It is shaped easily and can be welded together in a short time. The construction depends upon the job and the skill of the man doing the work. Quite satisfactory results can be obtained that way; and if properly made, the mold retains its shape. Sets of gages can be made from it to bend the sheets. Gages for flanged boiler patches and corner or knuckle patches can be made this way, and the gage can even be dropped without altering its shape. It is far superior to using sheet lead as it can be applied to a patch while the patch is fairly hot. It will be of interest to hear of other methods used by readers to accomplish the same object.

Fusion Welding

Because of the importance to many of our readers of developments of fusion welding in the pressure vessel field, the proposed revisions and addenda to the American Society of Mechanical Engineers Boiler Code on this subject were published in the April issue. In connection with the action taken by the committee in the matter, the secretary has issued the following statement of progress:

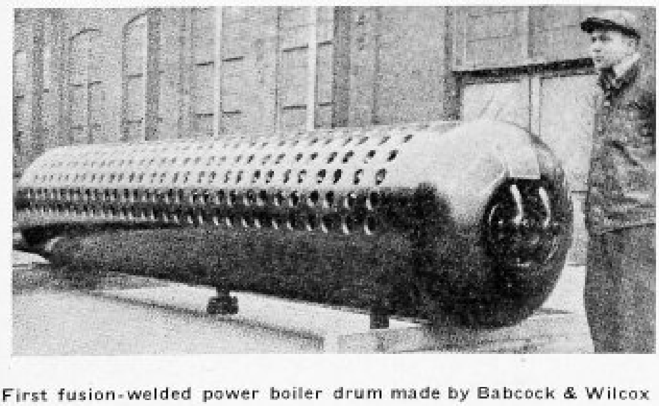
"The proposed Codes for Fusion Welding of Unfired Pressure Vessels and of Drums or Shells of Power Boilers were considered at the meeting of the A. S. M. E. Boiler Code Committee held on April 23. Important changes were made in view of the criticisms and suggestions that had been received, including those from the American Welding Society and the Compressed Gas Manufacturers Association. The Proposed Codes with the revisions which were agreed upon will be published.

"It is contemplated that final action will be taken at the June meeting of the Boiler Code Committee, and it is important that all discussions be received before June 15. Preprints will be available about May 15, and may be secured by communicating with the secretary of the Boiler Code Committee, 29 West 39th street, New York, N. Y."

First Fusion-Welded Power Boiler Drum in U. S.

An event that will doubtless be looked back upon as a milestone in the history of boiler-making occurred within recent weeks at the plant of Brown Paper Mills, Inc., Monroe, La., where the first fusion-welded power boiler drum ever to be used in the United States was installed on a watertube boiler intended for operation at 200 pounds per square inch pressure. The drum was made by the Babcock & Wilcox Company at its plant in Barberton, O., by a welding method developed by its engineers. It was inspected during construction by representatives of the Hartford Steam Boiler Inspection and Insurance Company. In addition to a careful investigation of the physical properties of the welds, the X-Ray was resorted to for an accurate determination of the soundness of the joints.

The drum is 36 inches in diameter, 17 feet in length, and made of 13/16-inch firebox steel plate. Heads are of the semi-elliptical type. The illustration shows the drum as it was being prepared for shipment on February 21.



First fusion-welded power boiler drum made by Babcock & Wilcox

It is interesting to note that the drum replaces one of riveted construction in which caustic embrittlement had made its appearance. The welded vessel has no seams, of course, in which caustic concentration can take place.—*The Locomotive.*

Watertube or Scotch Boilers

(Continued from page 119)

Feed water filtering can now be efficiently dealt with by various types of filters. Perhaps the gravitation type is preferable when utilized in conjunction with superheated reciprocating machinery, where a small amount of internal lubrication is necessary—this design of filter easily enables the condition of the feed water to be examined at any time.

The purity of feed water for Scotch boilers is not of such vital importance as in some others; just as the supply and control of feed water is more easily dealt with when using Scotch boilers, similarly this type of boiler has the advantage of a larger reserve of water and steam.

Space does not permit of more than reference to devices for maintaining efficiency in service, such as tube blowers, circulators and steam driers. Suitable material for firebars and furnace fittings is now available to be durable and efficient under the harder working conditions of the present day.

The above brief summary covers the items which if incorporated in a modern Scotch boiler plant, would result in an increase rating and efficiency, thereby reducing cost, weight and space.

Fig. 7 illustrates an up-to-date equipment showing the disposition of the various parts such as air heating, forced draft, and steam superheating.

A. S. T. M. to Sponsor Exhibit at Meeting

The annual meeting of the American Society for Testing Materials will be held at The Stevens in Chicago, June 22 to 26. For the first time in its history, the society will sponsor an exhibit of testing apparatus and machines to be displayed in conjunction with the meeting. This exhibit is limited to equipment and apparatus used in the testing of materials and products, and recording and control equipment which is used in testing will be shown.

President of Pollock Company Dies

Porter Pollock, president of William B. Pollock & Company, makers of blast furnaces, Youngstown, O., died in that city on April 20. He was 67 years of age. Born at Youngstown, February 8, 1864, he was the son of William B. Pollock, founder of the company. In October, 1881, he entered into partnership with his father and became vice-president and general manager. He held these offices until the death of his father in 1913, when he became president.

The Boiler Maker

VOLUME XXXI NUMBER 5

PUBLISHED Monthly by the Simmons-Boardman Publishing Company, 34 North Crystal Street, East Stroudsburg, Pa., with Executive Offices at 30 Church Street, New York City.

Edward A. Simmons, President. Henry Lee, Vice-President. C. R. Mills, Vice-President. L. B. Sherman, Vice-President. Samuel O. Dunn, Vice-President. F. H. Thompson, Vice-President. Roy V. Wright, Secretary. John T. De Mott, Treasurer. George Slate, Business Manager.

Chicago: 105 W. Adams Street. Washington, D. C.: 17th and H Streets, N. W. Cleveland: Terminal Tower. San Francisco, Cal.: 215 Market Street.

Subscription Price: United States, Canada and Mexico, $2.00, Foreign Countries, $3.00 a Year. Single Copies, 35 Cents.

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THE BOILER MAKER is a member of the Associated Business Papers, Inc. (A. B. P.), and the Audit Bureau of Circulation (A. B. C.)

EDITORIAL STAFF: H. H. Brown, Editor. L. S. Blodgett, Managing Editor. W. Lumbord, Associate Editor.

Contents

Communication

Patch Around Blow-Off Flange

TO THE EDITOR:

One of our readers and writers desires to know where I obtained the constants that I used in my article as published in the December, 1930, issue of THE BOILER MAKER. In order to make the same clear to him and any others, the following formula is used:

$$\frac{2}{\sqrt{(\text{Sin Angle}^2 \times 3) + 1}}$$

As I understand it, Mr. Page, chief boiler inspector for the State of California, is responsible for the diagram used in applying patches in California, New York and many other states. This diagram does not appear in the A.S.M.E. Boiler Code, nor do I know of any place in said Code that deals with repairs made to boilers, said Code as I see it, dealing mainly in the construction of new boilers.

I have nothing to retract at this time in reference to the article as published heretofore in THE BOILER MAKER and I know that it is correct and may be relied upon to give safe results. I desire to take issue with the article as published in the April issue. I believe that entirely too much pressure is being allowed without taking into consideration the factor concerning the diagonal seam of the boiler in question.

I have several editions of the A.S.M.E. Boiler Code, but I do not find any place in them that refers to patches on boilers. Perhaps the author of the article in the April issue can enlighten us as to where he finds the factor 1.567 in the Code. Also where does he find his formula used for finding the girthwise distance of said patch.

It seems quite strange that when one figures out that a patch is no weaker than the original plates of the boiler, that they would not take into consideration the age of the boiler, for nothing can be figured out as per the Boiler Code unless it is known what the age of the boiler is, age being one of the governing factors in the formula used for finding working pressures of boilers.

If the reader requesting information will look on page 95 of the April issue of THE BOILER MAKER, he will find that the author of the article on diamond seams has used the same factors and formula as used by myself in the December article, this also giving the desired information.

Binghamton, N. Y. CHARLES W. CARTER, JR.

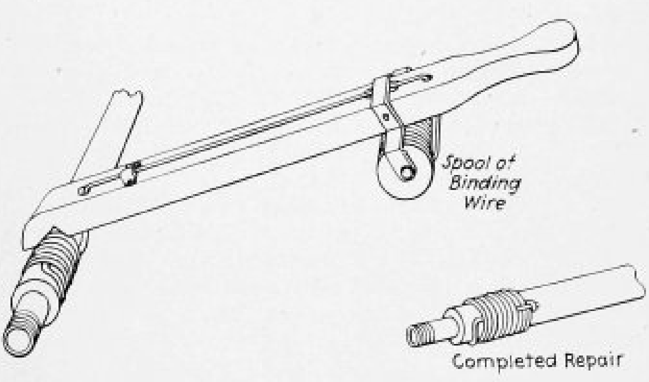
Hose-Binding Device

By Charles H. Willey

At a local quarry in Vermont where a great deal of steam and air hose is used and frequently quick repairs are needed, the work is done with a home-made hose-binding tool as shown in the illustration, and must stand an air pressure of 150 pounds.

The device is simply made from a hard wood stick and an iron strap for the wire reel. The front end of the stick is fitted with a V groove to guide the device. Two holes are drilled for the wire and a clamp is used to hold the wire in place. The spool holder is attached to the under side of the device as shown.

In use, the wire is started with one parallel layer along the hose and the rotating layers bind it in place. At the finish of the winding the ends are bent over one another or they are soldered when the job is done in the shop.



Simple device for binding air hose

Questions and Answers Pertaining to Boilers

By George M. Davies

This department is maintained for the purpose of helping those who desire assistance on practical boiler shop problems. Inquiries should bear the name and address of the writer. Anonymous communications will not be considered. The identity of the writer, however, will not be disclosed unless the editor is given special permission to do so.

Layout of Large Arc

Q. Please show, through THE BOILER MAKER, the method of finding the distance *A-B* on inclosed sketch. In other words, what is the correct method of scribing a large arc in this manner. Thank you for this and other valuable help.—G.P.S.

A.—The method of scribing a large arc as illustrated

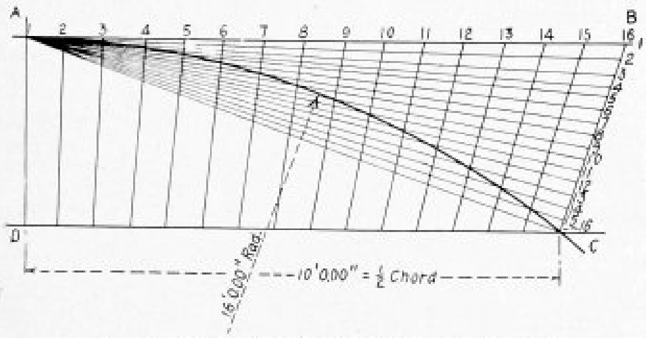


Fig. 1.—One method of scribing a large arc

in Fig. 1 is used for the developing of conical courses.

Fig. 2 illustrates a right circular conical course in which

A = diameter of large end on conical course.
B = diameter of small end on conical course.
C = length of course.
R = generating radius of whole cone.

$$a = \frac{A}{2} \qquad b = \frac{B}{2}$$

$$E = \sqrt{C^2 + (a - b)^2}$$

$$R = \frac{Ea}{a - b}$$

In developing a plate for a large conical course having but a slight taper, the length of the generating radius is such that it is not convenient to use.

Fig. 3 shows the method of laying out a true circular arc when the center of the radius is out of reach.

Draw center line *X-Y* and at *S*, any point on *X-Y*, erect a perpendicular. On this perpendicular step off the distance *s-t* which is equal to *H*. Assume *H* to be a value not less than one-half of the circumference of *A*, Fig. 2. Then step off on the center line from *s* the distance *s-r* which is equal to *G*.

$$G = R - \sqrt{R^2 - H^2}$$

Erect a perpendicular to the center line *x-y* at *r*. Connect *r-t* with a straight line. At *t* erect a perpendicular to the line *r-t* cutting the perpendicular drawn at *r* to the line *x-y* at *w*.

Divide the lines *s-t* and *r-w* into the same number of equal parts; five being taken in this case. Number the divisions on *s-t*, *1*, *2*, *3*, *4* and *5*; and on *r-w*, *1'*, *2'*, *3'*, *4'*, *5'*. Connect *1-1'*, *2-2'*, *3-3'*, *4-4'* and *5-5'*. Then at *t* erect a perpendicular to the line *s-t* cutting the line *r-w* at *v*. Divide *v-t* in the same number of equal parts as

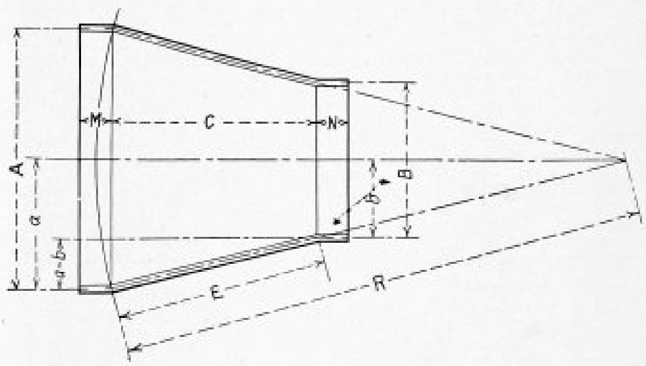


Fig. 2.—Right circular conical course

already taken for *s-t* and *r-w*. Number these points *1"*, *2"*, *3"*, *4"*, as shown. Connect each of these points with *r*. Where the line *r-1"* cuts the line *1-1'*, locates the point *e*; where *r-2"* cuts the line *2-2'* locates the point *f*; where the line *r-3"* cuts the line *3-3'* locates the

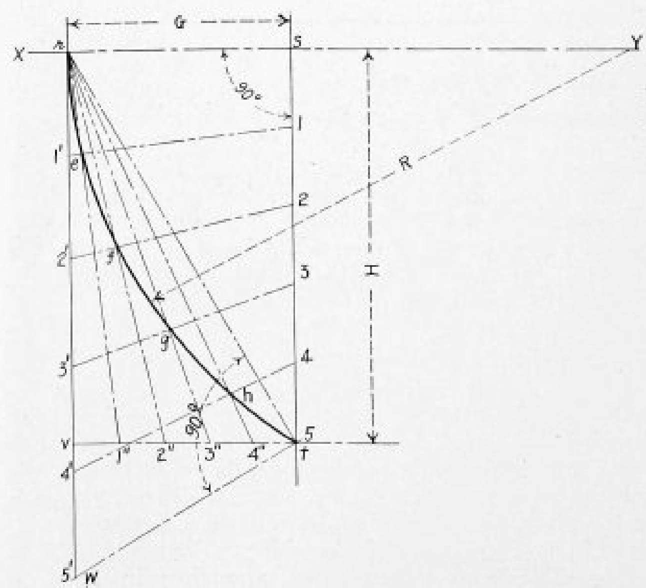


Fig. 3.—Method of laying out a true circular arc

point g and where the line r-$4''$ cuts the line 4-$4'$ locates the point h. Through the points r, e, f, g, h, and t draw a curve which will have a radius R.

Fig. 4 shows the development of the pattern for a conical course, using the curve developed in Fig. 3.

The lines x-y and r-t, Fig. 4, correspond to the center line and curve determined in Fig. 3.

Measure off on the arc r-t the exact length of one-half of the circumference of A, Fig. 2, as r-6. Divide the arc r-6 into any number of equal parts, six being taken in this case, number same from 1 to 6 as shown.

With the trams set with a radius equal to the distance E, Fig. 2, and with centers 1, 2, 3, 4, 5 and 6 scribe arcs. Draw arc o-p tangent to these arcs and

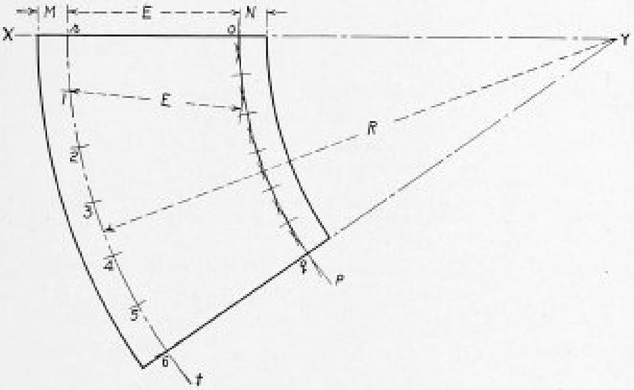


Fig. 4.—Development of pattern for conical course

lay off distance o-q the exact length of half the circumference of B, Fig. 2. Connect 6-q. Then add margins M and N, completing the development of the pattern for one-half of the conical course.

When the longitudinal seam is not on the top center line, lay the figure out as for a seam on the top center, except show the entire plate and locate the center lines to suit.

Thickness of Manhole Covers

Q.—As manufacturers of pressed steel manhead fittings and manhole saddles, we have been questioned a great deal regarding the thickness that a manhead cover should have in order to withstand various pressures. Along with other manufacturers of these products, we have been forced to more or less dodge this question, as we did not like to assume the responsibility of an answer, and it appears that the matter has not been settled by the Code Committee.

In order, therefore, to clear up this matter, we suggest the following questions:

(1) How thick should a pressed steel manhead cover, 11 inches by 15 inches or 12 inches by 16 inches, be in order to meet the Code requirements for the following working steam pressures: 150 pounds, 300 pounds, 400 pounds and 600 pounds.

(2) Should the gasket bearing surface be faced, especially for the higher pressures, in order to minimize the danger of leaks and seepage?

The writer believes that the answers to these questions would clear up a lot of doubt in the minds of many engineers who have to specify this material, and make it much easier for the manufacturers of these products to make intelligent recommendations when they are questioned by various boiler and tank fabricators.—F.E.M., Jr.

A.—In the addenda to the 1930 Boiler Construction Code, P—198 gives the following formula for flat heads:

The thickness required in unstayed flat heads which are unpierced and rigidly fixed and supported at their bounding edges by riveted or bolted attachments to shells of side plates, shall be calculated by the following formula:

$$t = a\sqrt{\frac{0.162\,P}{S}}$$

where, t = thickness of plate in head, in inches.

a = diameter, or short side of area measured to the center of the inside row of rivets or bolts, in inches.

P = maximum allowable working pressure, pounds per square inch.

S = allowable unit working stress, pounds per square inch $= \frac{TS}{5}$

TS = ultimate tensile strength stamped on the plates, as provided for in the specification for steel boiler plate, pounds per square inch.

It is practically impossible to give a formula for manhole covers, other than flat, due to the fact that commercial manhole covers are either pressed out or cast in various shapes, so that each one becomes an individual problem when determining its thickness for a given pressure.

It is my opinion that gasket bearing surfaces should be finished for pressures of 300, 400 and 600 pounds.

Flue and Flue Sheet Expansion

Q.—I would appreciate, if possible, your giving me the following information:

What is the expansion and contraction and the difference thereto of a 2-inch locomotive flue applied to a ½-inch back flue sheet with a 40-pound copper ferrule between the flue and the sheet? What action takes place with the copper ferrule in expansion and contraction of the flue, and is there any other metal that would have the same effect, or take the place of the copper? Any information you can furnish me will be appreciated very much. G.C.C.

A.—The linear expansion per unit length per degree F. for steel and copper is:

Steel = .00000636
Copper = .00000887

Copper ferrules are used at the firebox end where the heat is intense. Owing to frequent intervals of firing allowing an inrush of cold air through the firedoor the expansion and contraction is considerable.

Due to the rigidity of the tube sheet it does not expand or contract as quickly as the tubes; thus the difference in the coefficient of expansion of copper and steel has a favorable influence in keeping a uniform relationship between the tubes and the plate.

Copper, owing to its greater expansion than steel, when heated, tends to keep the tubes from leaking between the joints. Copper being a very soft metal is easily worked into the small crevices in the tube plate.

I do not know any other metal that is used in the place of copper for ferrules.

Shearing Strength of Welded Joints

Q.—Will you kindly give me an illustration on how to figure the shearing strength of a welded joint, especially spot and intermittent girth and head welds?—W.C.D.

A.—The strength of a welded joint depends largely upon the quality of the weld and the ability of the welder. The strength of a welded joint cannot be computed as in the case of a riveted joint. Therefore it must be based on actual tests.

A series of shear tests for welds made by Andrew Vogel, General Electric Company, Schnectady, N. Y., are summarized as follows:

A series of twelve specimens were made in accordance with recommended practice of the Committee of Standard Tests for Welds (American Welding Society). The series were divided into four groups of three specimens each, four welders of average ability were selected and each welder was directed to weld a group of three specimens. No special instructions were given, in order that the welds should indicate the average ability of each welder.

The tests were made in the usual manner and the results were recorded in the table below.

Specimen	Total stress	Stress per linear inch of weld	Average stress	General average stress
A—1	75,750	12,625		
A—2	81,300	13,550	13,217	
A—3	80,850	13,475		
B—1	81,400	13,567		
B—2	72,600	12,100	12,947	
B—3	79,050	13,175		
				13,252
C—1	88,050	14,675		
C—2	80,600	13,433	14,314	
C—3	89,000	14,833		
D—1	76,750	12,792		
D—2	76,700	12,783	12,536	
D—3	72,200	12,033		

It will be observed that the total load varies from 72,200 to 89,000 or from 12,000 to 14,000 pounds per linear inch. The welds were of average quality such as commonly used, and as a design value of 3000 pounds per linear inch for 3/8-inch weld is used, the result is a factor of safety of four or more.

Boiler Code Analysis

Q.—Will you kindly publish an illustration of Par. *P. 193*, revised as per addenda to A.S.M.E. Boiler Code Power Boilers Section I. W. C. D.

A.—An analysis of Par. *P. 193* of the 1930 A.S.M.E. Boiler Construction Code would require more space than is allotted to this department. However, if you have some particular boiler or problem you believe to be governed by this paragraph, I will be glad to analyse or calculate it for you.

Expanding Arch Tubes

Q.—The writer wishes to confirm the report received relative to the construction of certain locomotives of new type. As advised, on these particular locomotives the plug holes for arch tubes will not be in line as heretofore but rather that some special means will have to be provided to expand such arch tubes.

If you are acquainted with these facts, will you kindly enlighten the writer relative to same, stating if possible how much off center the plug holes will be as compared to the arch tube holes and also the approximate distance between the inner and outer sheets?—H.H.

A.—I am unable to obtain information as to the particular locomotives mentioned in the question.

However, if the writer has in mind arch tube holes that are offset 5/8-inch to 3/4-inch from the center line of the tubes, the same can be obtained with the standard method of expanding and beading the arch tubes as shown in Figs. 1, 2 and 3.

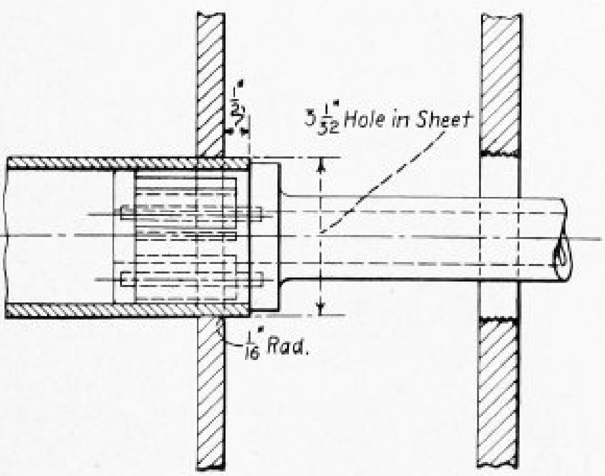


Fig. 1.—Chamfer outer edge of hole with 16-inch radius; apply tube and expand same with roller expander to fit 3 1/32-inch hole in sheet. The handle of the expander, being smaller than the hole in the outer sheet would allow the hole to be offset from the center of the tube and still permit the use of the expander

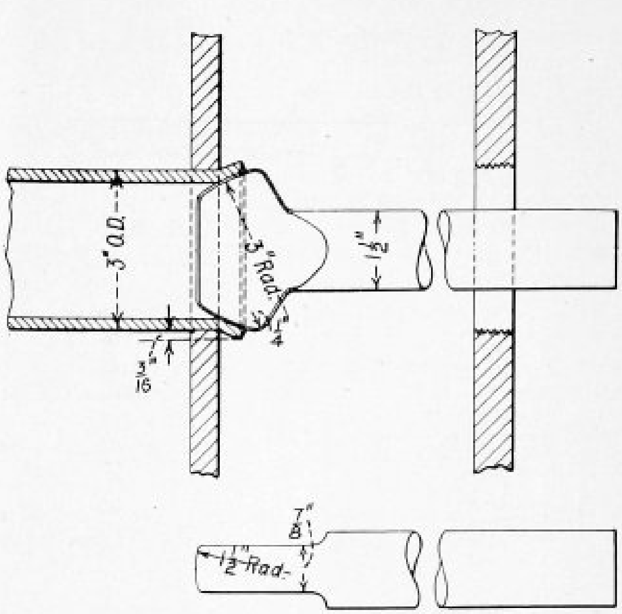


Fig. 2.—Bell out the tube to an amount equal to approximately the thickness of the tube using tool with contour shown

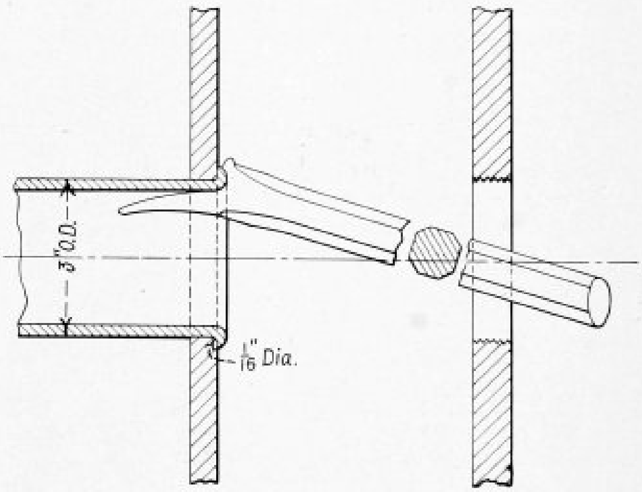


Fig. 3.—Bead over with tool similar to that shown

Blocks and Dies

Q.—Could you recommend a suitable book dealing with blocks and dies for pressing boiler plates, etc., locomotive flanged plates specially, showing various methods and also formulae for calculating the allowance to be made in the blocks for the shrinkage of the plates after pressing? I am a layerout in a locomotive shop and very interested in the flanging and fabrication of boiler plates. The articles in THE BOILER MAKER dealing with the Baldwin Locomotive Works touches this subject, but naturally no comment is made on the manufacture of the blocks themselves. F.C.

A.—"Die Making and Die Design," compiled and edited by Franklin D. Jones, The Industrial Press, New York, 1915, is a book on the design and practical application of different classes of dies for blanking, bending, forming and drawing sheet metal parts, also modern die making practise and fundamental principles of die construction.

This book, however, is general and does not deal especially with locomotive-boiler flanging. Locomotive builders have their own standard practice for the design of flanging dies, these practices being the results of years of experience with the particular problems they have to deal with and for this reason are not published outside of their own organizations.

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States and Cities That Have Adopted the A.S.M.E. Boiler Code

States

Arkansas	Missouri	Rhode Island
California	New Jersey	Utah
Delaware	New York	Washington
Indiana	Ohio	Wisconsin
Maryland	Oklahoma	District of Columbia
Michigan	Oregon	Panama Canal Zone
Minnesota	Pennsylvania	Territory of Hawaii

Cities

Chicago, Ill.	St. Joseph, Mo.	Memphis, Tenn.
Detroit, Mich.	St. Louis, Mo.	Nashville, Tenn.
Erie, Pa.	Scranton, Pa.	Omaha, Neb.
Kansas City, Mo.	Seattle, Wash.	Parkersburg, W. Va.
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States and Cities Accepting Stamp of the National Board of Boiler and Pressure Vessel Inspectors

States

Arkansas	Missouri	Pennsylvania
California	New Jersey	Rhode Island
Delaware	New York	Utah
Indiana	Ohio	Washington
Maryland	Oklahoma	Wisconsin
Minnesota	Oregon	Michigan

Cities

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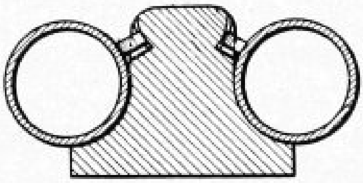
Erie, Pa.	Tampa, Fla.	Philadelphia, Pa.
Detroit, Mich.		

Selected Boiler Patents

Compiled by Dwight B. Galt, Patent Attorney, Washington Loan and Trust Building, Washington, D. C. Readers wishing copies of patents or any further information regarding any patent described, should correspond directly with Mr. Galt.

1,747,614. RETAINING MEANS FOR FURNACE-WALL BLOCKS. ERVIN G. BAILEY, OF EASTON, AND RALPH M. HARDGROVE, OF BETHLEHEM, PA., ASSIGNORS TO FULLER LEHIGH COMPANY, OF FULLERTON, PA., A CORPORATION OF DELAWARE.

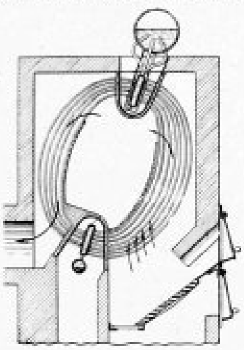
Claim.—In a furnace wall, watertubes, tile having a portion between said tubes extending beyond the center line thereof, recesses in the sides



of said extending portion, and rollers between said recesses and tubes for keeping said tile in place. Six claims.

1,743,111. WATERTUBE BOILER AND THE LIKE. GOTTLOB BURKHARDT, OF HERRENALB, GERMANY, ASSIGNOR TO JULIUS M. BURKHARDT, JOHN FRED. BURKHARDT, AND LANCE NICHOLSON, ALL OF BUFFALO, N. Y.

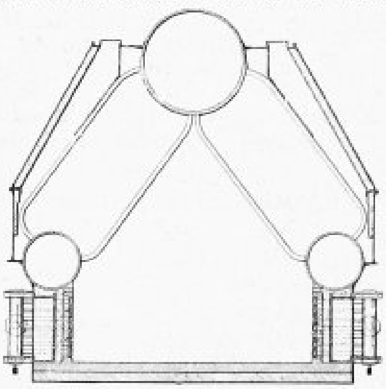
Claim.—In an upright boiler, in combination, a plurality of upper and a plurality of lower headers, groups of substantially bow-shaped axially



inclined, and substantially adjacently disposed and similarly arranged pipes, terminating in transverse alinement in the upper and lower headers on opposite sides thereof, trough-shaped connecting channels within and extending across the headers between the transversely alined terminals of the pipes, and heating means for the pipes. Three claims.

1,671,114. SUPERHEATER BOILER. WALTER F. KEENAN, JR., OF PELHAM, N. Y., ASSIGNOR TO FOSTER WHEELER CORPORATION, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

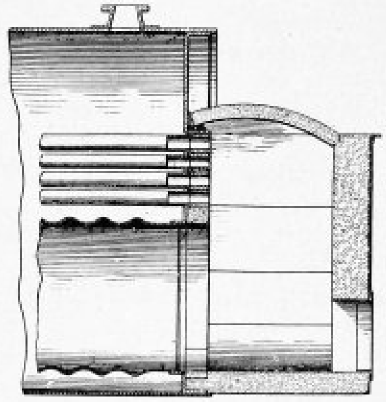
Claim.—The combination with a boiler comprising parallel water drums at the sides of the furnace combustion chamber and watertubes connecting



said drums to an upper steam and water drum, of means for superheating the steam generated in the boiler at approximately boiler pressure consisting of a radiant heat superheater located beneath each water drum and forming a corresponding portion of the wall of the combustion chamber. Three claims.

1,668,193. STEAM BOILER. CHARLES DE NOVO, OF OAK PARK, ILL.

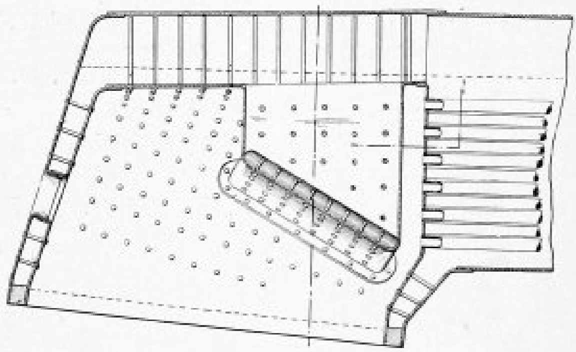
Claim.—In a boiler, the combination of an outer shell, a flue sheet, a combustion chamber adjacent one side of said sheet, flues extending through the sheet and leading from the chamber, and a wall of fire brick disposed within the combustion chamber and completely covering that part of the



said one side of the sheet which is contiguous thereto, said wall contacting directly with the flue connections and said part of the sheet and operating to maintain the connections and sheet at the same and a substantially uniform temperature, the bricks of said wall adjacent the flues being provided with holes extending therethrough and in communication with the flues. Two claims.

1,741,181. LOCOMOTIVE BOILER. CLARENCE E. BODINE, OF SEDALIA, MO.

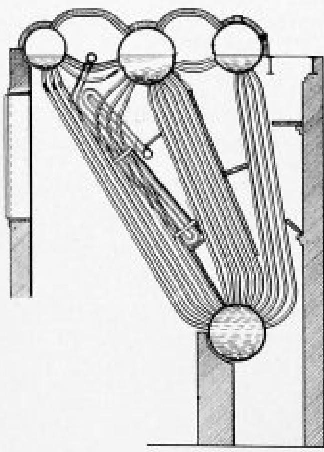
Claim.—A locomotive boiler embodying therein, a crown sheet, side sheets and a flue sheet, a transversely arched, flat tubular waterwall inclined downwardly and forwardly toward said flue sheet and opening at its sides



through said side sheets, and an upright flat tubular riser arranged longitudinally of said wall and opening at its ends through the top thereof and through the crown sheet respectively, the fore and aft ends of the riser both being substantially disposed in the planes of the like ends of the transversely arched waterwall at its mid portion. Three claims.

1,743,165. SUPERHEATER BOILER. ROBERT L. SPENCER, OF ST. LOUIS, MO., ASSIGNOR TO HEINE BOILER COMPANY, OF ST. LOUIS, MO., A CORPORATION OF MISSOURI.

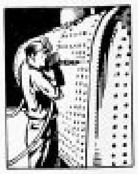
Claim.—A superheater boiler provided with a bank of upright watertubes arranged so as to form longitudinal lanes, and superheater elements in said



lanes arranged in close proximity to the combustion chamber, and disposed throughout substantially their entire length at an angle to the watertubes throughout substantially their entire length at an angle to the watertubes, thereby preventing said superheater elements from producing constricted gas areas in the tube bank. Seven claims.

The Boiler Maker

Reg. U. S. Pat. Off.



Master Boiler Makers

There can be little doubt in the minds of those interested in the construction and repair of locomotive boilers on the railroads throughout the country that a temporary loss to the progress of the art has been caused by the postponement of the annual convention of the Master Boiler Makers' Association until next year. Conditions beyond the control of anyone made necessary this curtailment of the activities of the association. Every member recognizes this fact.

What changes may occur in the organization before the next meeting cannot be predicted. In the meantime, however, it should be remembered that the association fulfills a function which could never be replaced if interest in its work were allowed to lapse.

The officers are making strenuous efforts to minimize the effect of the loss of this year's convention by issuing the committee reports and a statement of the affairs of the association. Every member should heartily support their work by maintaining a keen interest in the organization and by looking ahead to more active participation in its proceedings when the opportunity again is given them.

With this thought in mind and with the idea of making the work of the association more valuable than ever to the railroads of the country, no ground will be lost in the ultimate progress of the Master Boiler Makers' Association.

Boiler Manufacturers' Annual Meeting

In spite of the general low state of industry, and the boiler manufacturing branch in particular, the forty-third annual convention of the American Boiler Manufacturers' Association proved to have a decided optimistic reaction on the members present. This did not result from attempts at mutual sympathy but by three days of concerted attack on the technical and trade problems which must be considered now in order to prepare for better business. The entire meeting developed the feeling that the industry would face the turn when it came with its house properly in order and in a better position to recover more rapidly than from any similar depression of the past.

At this time another stage in the evolution of boilers and pressure vessels is being developed; namely, the consideration of proposed A.S.M.E. standards for the use of the fusion welding process in their construction. This subject, due to its vast importance, was thoroughly discussed. Full details appear in the report of the proceedings in this issue.

No single group of manufacturers of equipment in the country, in proportion to its size, can make better use of welding than the boiler and pressure vessel builders. For this reason, the adoption of welding standards by the American Society of Mechanical Engineers Boiler Code Committee in the near future demands the closest co-operation of the association, in order that no requirements may be established that will work hardship to the manufacturer when the code is enacted. To prevent this possibility, the Boiler Code Conference Committee of the association has endeavored to maintain constant contact throughout the development of the code and to present the attitude of the manufacturers on its various provisions. A closer relation than this is needed, however, if the code is to have the benefit of the individual ideas of members. Although the time remaining before the adoption of the code is short, every member should express his views on the matter, particularly if he has constructive criticism to offer.

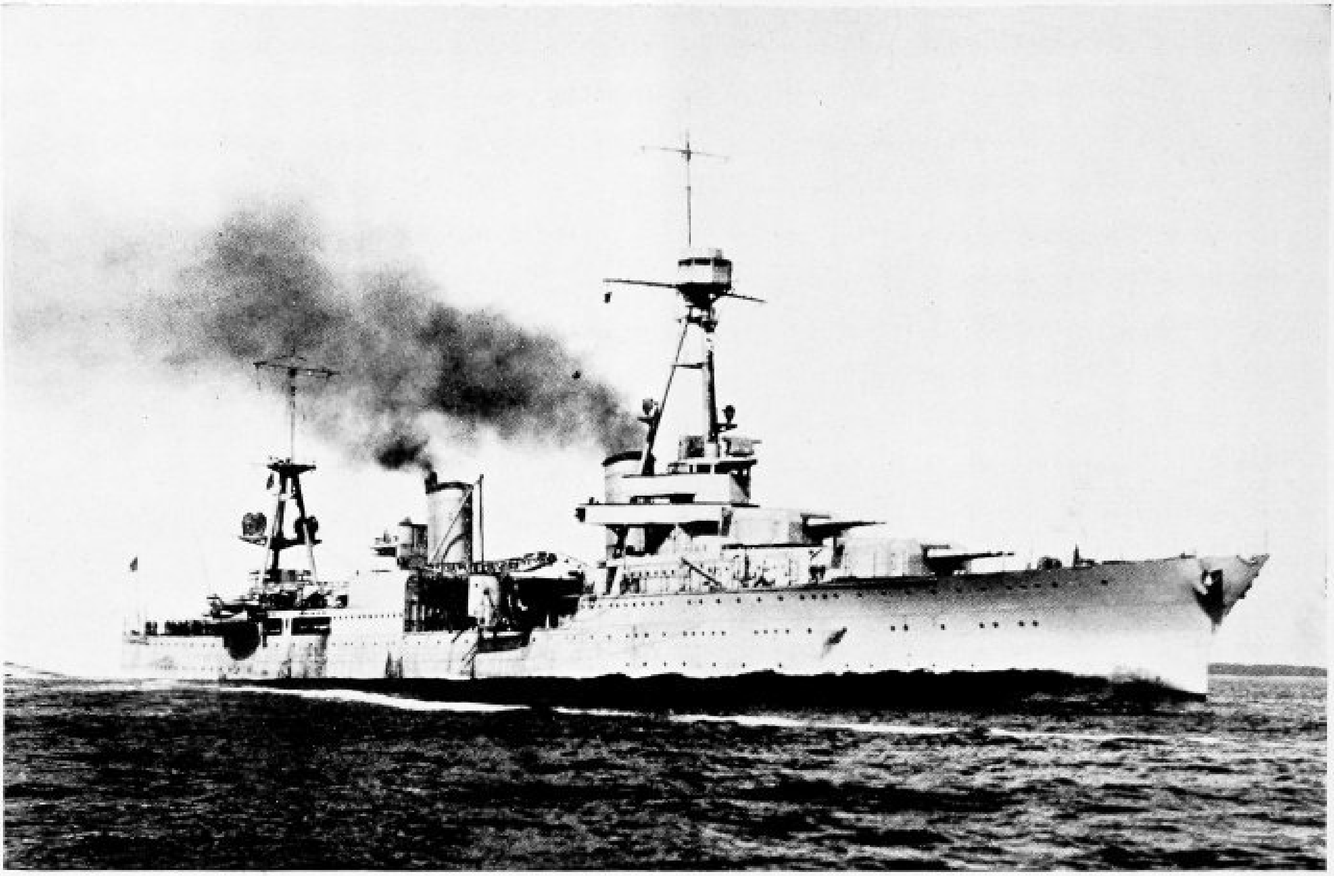
Not only this phase of the welding situation was considered, but occasion was taken to discuss the technical and practical manufacturing aspects of the new code. At a special evening session, Dr. Comfort A. Adams, professor at Harvard University, ably presented a complete outline of fusion welding developments since the inception of the process, with valuable suggestions for its introduction into the field of boiler and pressure vessel work on a wide scale.

Proposed Fusion Welding Rules

In commenting on the imminent adoption of proposed new Rules for the Fusion Process of Welding by the A.S.M.E. Boiler Code Committee, C. W. Obert, honorary secretary of the committee, for the benefit of readers of THE BOILER MAKER has suggested the reasons for the procedure followed throughout the development of the code in the following paragraphs:

The rules have been under preparation by the Boiler Code Committee for a period of several years. They have required an enormous amount of investigative effort and the committee has had much difficulty in reconciling conflicting interests and obtaining agreement on the main essentials thereof. Now the final draft of the new rules has been issued in the June issue of *Mechanical Engineering*, and also in this issue, with a limit date set for

(Continued on page 158)



Full steam on the new light cruiser Salt Lake City

Building and Inspecting Boilers for the U. S. Navy*

By Lieut. W. A. Brooks, U. S. N.

After it has been decided to lay down a new steam-propelled vessel, one of the first things to be done is to arrange for the building and delivery of the boilers. Present practice calls for the boilers to be "built into" the ship, that is, the boilers are located in the firerooms before construction of the vessel has progressed very far. This means that the boilers must be ordered, at times, even before the keel of the vessel is laid, for it takes, normally, from eight months to a year to complete a set of boilers. And of course before actual construction can be begun, proposals must be sent out and time allowed for the leading boiler manufacturers to make their bids, and for the successful bidder to be notified and the contract signed.

If for a direct Navy Department contract (as for vessels being built in Navy Yards), the proposal or schedule is sent out by the Bureau of Supplies and Accounts, although of course the engineering features have been determined by the Bureau of Engineering. The information given on the schedule, on which the manufacturer bases his bid, may be expected to include data as to the following:

(1) Type of boiler.†
(2) Limiting overall dimensions as to height, width, length.
(3) Pressure and superheat.
(4) Capacity of boiler in pounds of steam per hour.
(5) Limiting air pressure that may be used.
(6) Rate of oil-burning allowed in pounds of oil per hour per square foot of generating surface. (This will determine the amount of heating surface needed.)
(7) Efficiencies to be guaranteed.
(8) Limiting weight of boilers including water weights.
(9) And various items such as type of fuel, spare parts,

* Published through the courtesy of the *Journal of the American Society of Naval Engineers*.

† As nearly all naval vessels now in commission, and all new construction with the exception of Light Cruisers Nos. 32, 34 and 36 (which are to be equipped with sectional Express boilers of the round-header type) are equipped with Express boilers of the three-drum type, this article will deal especially with this type, although many of the following remarks apply equally well to other types.

evaporative and weight equivalents, penalties, payments, etc.

The manufacturers having made their bids on the basis outlined above, the bids are opened, evaluated and the award made to the successful bidder. The contract having been signed, it now becomes necessary to draft the general and detail drawings and submit them for approval.

In the case of vessels built by private shipyards, the yards themselves arrange for the purchase of the boilers, but of course they are restricted as to type, pressure, superheat, etc., by the terms of their own contract with the Navy Department for the building of the vessel. Some yards manufacture their own boilers, but such are at present in the minority.

In any case, the general and detail drawings (known as Type B drawings) are forwarded to the Bureau of Engineering for approval *via* the inspector of machinery concerned; that is, either the inspector at the shipyard, or the resident inspector at the boiler works, depending on whether or not the contract is let to a private yard or to a Navy Yard. It is the inspector's duty to check the drawings carefully to see that they are in accordance with the General Specifications for Machinery, the Bureau of Engineering Standards and the contract. This involves such points as tubes, tube holes, riveting, shaping of sheets and heads, flanges, pitch circles, rolling tubes, thickness of casings, insulating material, furnace brickwork, arrangement of fittings and in general all features of construction, including leaflet specifications entered in the bills of material. The inspector will confer with the contractor as to any discrepancies found, and by mutual agreement most of the discrepancies will be eliminated. In any case, any discrepancies still remaining will be commented on by the inspector in his letter forwarding the drawings to the Bureau. The Bureau, in its action on the drawings, will either approve the drawings or indicate what changes it will require the contractor to make. Copies of approved drawings are retained by all parties concerned. Subsequent alterations to approved drawings are either passed on by the inspector concerned, or by the Bureau, depending on the magnitude of the alteration.

With approved drawings on hand, the boiler manufacturer proceeds to order the boiler material. Copies of all purchase orders are furnished to the resident inspector, who checks them against the approved drawings and, in cases where applicable, the acceptable list also, as, when material appears on the acceptable list, such material must be ordered from manufacturers whose material has passed prescribed tests and is found on this list. The order having been approved by the inspector, it is forwarded to the Inspector of Naval Material of the district in which manufacture is to take place. The latter officer then accomplishes the inspection and forwards shipping reports, certifying the material, to the inspector with whom the order originated.

The inspector at the boiler works thus finds himself with all the materials of construction on hand, fully inspected at the place of manufacture, with the exception of certain commercial material which does not require full inspection, and which he himself will inspect as to dimensions, workmanship, surface defects, etc.

Probably the most important material entering into the construction of a boiler is the boiler plate from which the drums are made. The leaflet specification lists three grades of boiler plate, but Grade B is the one most commonly used. This plate must be made by the open hearth process. Tensile strength may vary between 55,000 and 65,000 pounds per square inch, with the yield point at least half the tensile strength, and the elongation in eight inches must be at least 22 percent. The plate must be flat, free from welds, buckles, brick or scale marks, slag or other foreign substances, brittleness, hard spots, scabs, laminations, snakes or other injurious defects. It must also pass a bend test by being bent cold 180 degrees around a pin whose diameter depends upon the thickness of the boiler plate.

Information on engineering practices of the United States Navy is not generally made public. The fact that the present article discloses the procedure followed in equipping a naval vessel with boilers and the requirements which such boilers must meet makes it unusual. The highest standards of boiler construction and inspection are maintained for such boilers, and the procedure followed as outlined by the author indicates good practice when dealing with boilers for any purpose. The details are naturally different but the principles of care and good workmanship should be applied to the construction of every boiler, whether marine or otherwise.

With all the material on hand, shop orders are issued by the manufacturer and the actual work of fabrication begins. The first thing to be done is to plane the tube sheets, wrapper sheets, butt straps and drum head plates to the required dimensions. All the above parts are required to be bent to shape while hot, but in some instances exceptions are made for the wrapper sheets and butt straps, and they are then bent cold. In either case the parts are formed to shape in hydraulic presses.

After being bent to shape, the tube sheets, wrapper sheets and butt straps are assembled in position and the rivet holes drilled. In this connection it should be noted that it is forbidden to punch rivet holes. After the holes are drilled, the parts are disassembled and all burrs removed, the parts sandblasted, reassembled, and while held accurately in position, all rivet holes are faired by reaming. The drum shell is then ready for riveting, which is done by hydraulic presses or bulls. Pressures used and times of holding same, as required by the General Specifications, are as follows:

1¼-inch rivets, 80 tons pressure, held 24 seconds.
1-inch rivets, 65 tons pressure, held 20 seconds.
¾-inch rivets, 50 tons pressure, held 15 seconds.

Drum heads are flanged while hot, and as required, pierced for manhole—with flange turned in for manhole seat—and bumped for water gage fittings and feed connection. The outside of the drum heads and the inside of the drum shells are machined to fit each other, drilled while assembled, disassembled, burrs removed, sandblasted, reassembled, reamed and riveted. Drum seams are required to be double or treble riveted, except for the water drums, where single riveting is permitted. All seams and rivets are lightly calked on the inside, but no calking is permitted on the outside. With the drums assembled and riveted, they are given a hydrostatic test of one and a half times working pressure, and must be absolutely tight at this pressure.

Drums are checked for dimensions, roundness and straightness, and are then laid out for drilling. Openings for safety valve and main steam nozzles, downcomers, retubing handholes, bottom and surface blow valves, try cocks, etc., are first drilled. Then the tube holes are drilled in both steam and water drums by means of large multiple drill presses. This drilling will leave circumferential grooving in the holes, and probably a shoulder on the long side. To remove the shoulders and a part of the grooving, the holes are twice reamed, first with a rose reamer and next with a fluted reamer. Some grooving will still remain, but will do no harm unless it is radial or spiral; in fact, the circumferential grooving will actually aid the tube in holding, after the tube is expanded in the tube sheet. After the reaming, the edges of the holes are carefully rounded by hand or machine tools, both inside and outside, in order to prevent cutting or scratching the tubes in the tubing process. Tube holes are permitted to have a positive tolerance of 0.015 inch for 1-inch tube holes and 0.019 inch for 1¼-inch tube holes. These tolerances are checked by means of "go" and "no go" gages.

The water drums are now ready to receive the saddles. The drums are carefully leveled and centered, and the saddles fitted. This job must be carefully done in order that the boilers may fit the foundations in the vessel.

The drums are now ready to be set for tubing. Heavy foundation frames of structural iron are prepared to receive the water drums, which are bolted down to the foundation by means of the saddles. The water drums must be carefully leveled, with center lines parallel to each other and in exact location with respect to each other. Special cast iron erection frames are then clamped on, with fore and aft and diagonal braces to hold them in position. Then the steam-drum is placed in cradles at the top of the frames and accurately located by means of heavy set screws which screw through the frames. When this drum has been leveled, centered and angled with respect to the water drums, it also is clamped in position. Superheater supporting guides are welded to the drums, and the boiler is now ready for tubing.

Boiler tubes may be either cold drawn or hot rolled, but in either case must be seamless. If cold drawn, tubes must be annealed as a final process. Tubes must be straight and free of all defects. The defects to be particularly avoided are tears, snakes, slivers, injurious scratches, rings, seams, pits and sinks in cold-drawn tubes; and slivers, scratches, seams and scale pits in hot-rolled tubes. A tolerance of 10 percent over and nothing under the calculated weight is allowed. The finished tube must be circular within 0.02 inch and not less than the gage specified. A tolerance of ± 0.010 inch diameter is permitted for tubes of not more than 1¼-inch diameter. Where working pressures do not exceed 400 pounds, the specified thickness of tubes is 0.095 inch for 1-inch tubes and 0.109 inch for 1¼-inch tubes. All tubes are inspected at the place of manufacture as to the above considerations, and given specified flattening, flanging and expanding tests; and in addition are each given a hydrostatic test of 1500 pounds. In addition to the factory inspection, all tubes must also be inspected for surface defects immediately before installation in the boiler. Their ends are cropped to the exact length desired, rounded, polished for a distance of about five inches from each end and are then bent to the required radius or shape.

The tubes having been prepared as above for installation, they are inserted in the tube holes, radius or shape checked, end clearances fixed, and the ends expanded into the tube sheets by the parallel-rolling method. This method consists of using a tapered mandrel and tapered rolls of such dimensions that the result is a tube wall uniformly reduced in thickness, with parallel sides. In the taper-rolling method, formerly used, one part of the tube was reduced in wall thickness more than another part, tending to create a fin inside the tube where the expanding stopped; prolonged over-rolling might result in actually cutting the tube in two at the inner edge of the tube sheet. Another advantage of parallel-rolling is that a longer seat is produced, and hence there is less danger of leaks developing or of the tube pulling out. After the expanding is completed, the tube end is belled from $\frac{1}{16}$ inch to ⅛ inch by means of either a drift or a belling roll. A few tubes will be found split after the rolling and belling, and these are cut out and replaced at once.

If downcomers are a part of the design (and the present General Specifications require them—to be approximately equal, in cross-sectional area, to the effective area of the fireside rows of tubes), they are bent to shape, cut to length, and rolled and belled into the drums. Several successive expandings with each set of rolls slightly larger than the one preceding will likely be found necessary in order to obtain a good seat for these large tubes.

After the generating tubes and downcomers are installed, drum openings are closed and a hydrostatic test pressure of one and one half times working pressure is applied. It is likely that some leaks will appear, either due to defects developed during the bending of the tubes, or to insufficient expanding. Defective tubes are cut out and renewed, and tubes leaking around the tube sheets are given a light re-rolling. The tests are continued until the boiler is absolutely tight for a considerable period of time, in order that no small leaks may be overlooked.

Superheat is now reappearing in the latest Navy boilers. The superheater, as usually built, is composed of the superheater boxes, tubes, baffles and supports. The boxes are made by taking very heavy round tubing, squaring it and drawing out necks for the flanges to which are bolted the connections for the wet and superheated steam. Plugs are welded into the ends of the boxes in order to close them. The boxes are then drilled for the tube holes and hand holes. The hand holes are made oval in a special machine, and faced for the hand hole seats. The necks on the boxes are then expanded into the grooved flanges, and either welded or beaded over at the top, the flanges then being faced. The superheater is tubed by expanding the tubes into the tube sheet, the tubes being held in position by passing through a support or guide plate, in which holes slightly larger than the outside diameter of the tubes have been drilled. After this, the ferrules or baffles are installed in the boxes or tube ends as called for, their purpose being to obtain equal steam distribution in the superheater tubes. The hand hole plates are next fitted, inlet and outlet connections blank-flanged, and the superheater given a hydrostatic test of one and one-half times working pressure in order to check the tightness. After this test has been successfully passed, the superheater is installed in the boiler.

The next step is to install the internal fittings, that is, the dry pipe with safety valve and superheater connections, the feed pipe and its connection, surface blow pipe and connection, baffles and hangers. Next, the manhole plates must be checked up. When properly centered, there must be no more than $\frac{1}{16}$-inch clearance between the rim of the manhole and the inturned flange of the drum head. Also, the face of the seat and the seat of the manhole plate must be parallel within a tolerance of ±0.003 inch, without the gasket in place. Finally, each manhole dog is carefully fitted and the dogs and plate indelibly marked to show to what hole they have been fitted.

After this, the boiler is given another hydrostatic test of one and a half times working pressure to insure tightness of all joints and parts. Following this, the pressure parts are oiled, inside and outside, with a preservative mixture. The mixture giving the best results consists of 50 percent Japan drier, 30 percent gasoline and 20 percent corn oil. This mixture dries quickly, and because of its varnish-like consistency, is an excellent preservative.

With the pressure parts O. K., the work of putting on the lower side casings, brick pans, fire front, back casing, upper side casings, front casings, etc., begins. Angles are first welded to the steam and water drums, these angles serving as anchors from which the casings, brick pans, etc., receive support. The fire front or front plate, which carries the burners, is made from ½-inch plate, but the remaining plates are not over ⅛ inch in thickness, except for the brick pans, which are at least ¼-inch thick.

Casing panels are used to cover the front sides and back of the boiler in the wake of the tubes. A boiler casing panel consists of an inner wall of steel plate, suitably flanged all around, against which is fitted a course of uncalcined diatomaceous earth bonded with long fiber asbestos, at least 2½ inches in thickness, over which is fitted 1/32 inch galvanized steel plate. Sheet asbestos inside the flanges prevents the galvanized sheets from making contact with the flanges—this to reduce the heat transfer. Asbestos millboard, ¼-inch thick, is used to line the inner surfaces of all casing panels which are likely to encounter high temperatures. All joints are rendered airtight by inserting metal-covered asbestos strips between the casing flanges.

The present approved method of laying the brickwork of a boiler is as follows:

(1) For the floor, a 1-inch course of insulating material is laid against the brick pan. Over this is laid a 2½-inch course of calcined diatomaceous earth brick of standard size. Over the two insulating courses are laid two courses of 1¼-inch standard split fire brick at right angles to each other. A $\frac{1}{16}$-inch opening is required between bricks and a ¼-inch opening between outside bricks and the side walls, all openings being filled up with suitable loose, dry fire clay.

(2) For the side and back walls, a 1-inch course of insulating material is placed next to the casings, then a 2½-inch course of calcined diatomaceous earth brick of standard size laid on edge, and lastly, a 4½-inch course of refractory fire brick of standard size and approved type.

(3) The front wall is built in the same manner and of the same materials as the side wall, except around the oil burner openings, where either plastic refractory or special shapes are used for building up the burner cones. If special shapes are used, the space between the special shapes and the regular firebrick will be filled in with plastic, which will also be used to finish off walls, smooth up courses and fill up crevices caused by intersection of the metal parts with the brickwork. It is customary, however, not to lay up the plastic, nor put in the cone brick until just before the boiler is ready to be lighted off, as it is essential to thoroughly bake the plastic firebrick soon after its installation.

The soot blowers are next fitted and installed. The soot blower elements, running the length of the tube banks, are fitted with expanding nozzles, to increase the steam velocity. The location of the nozzles is carefully worked out so that steam does not impinge directly on the nearest row of tubes, but is directed between the tubes of that row. The intention of the above is of course to prevent erosion of the tubes nearest the steam jet. The soot blower heads are attached to the boiler casings, which are reinforced at these points, and the soot blower elements are carried in guides or bearings clamped to the tubes. Elements are made of special heat-resisting alloy, of calorized steel, or of plain steel, according to their proximity to the furnace. The soot blowers installed in all the latest boilers have elements that can not only be rotated but can also be moved fore and aft a definite amount, usually equal to the tube pitch.

The oil burners are usually installed after the boiler is in the vessel. The burners might be damaged in handling the boiler, and they also add weight which can be avoided. The 10,000-ton class of light cruisers are all fitted with Cuyama-type burners, twelve, thirteen or fourteen to a boiler. The burners are equipped with three sizes of sprayer plates, intended for full power, cruising and port uses, respectively. The actual sizes furnished are 2908 and 3008 for full power, 3208 or 3908 for cruising and 4408 or 4808 for port use. In designing the boiler, the projected center lines of the burners must not be nearer than 24 inches to a side wall or furnace bottom, nor less than 30 inches from the nearest point of a tube bank; and the inner edges of the burner openings must not overlap. These conditions, in an Express boiler, will determine the size of the front plate, and hence, indirectly, the amount of furnace volume, since in most cases, when the above conditions have been fulfilled, the resultant furnace is actually larger than is absolutely necessary for good combustion.

Boilers, when completely assembled, are shipped, if possible, *via* inland waterways. Ocean shipment of such large units (they weigh approximately sixty tons) may result in damage to the boiler in case heavy weather is encountered. As assembled boilers can be shipped from the east coast to the west coast only *via* the Panama Canal, it is good practice to ship boilers in the "knocked-down" condition, and assemble same at destination, as was done very successfully in the case of the boilers for the cruisers *Chicago* and *Louisville*. However, when inland waterways can be utilized, complete assembly at the place of manufacture is considered preferable.

At some time before turning the boilers over to the operating personnel of the vessel they must be boiled out in order to eliminate the preservative with which they were coated before leaving the manufacturer's plant. If this were not done the result would be warper, blister or burned-out tubes when the boilers were put in service, not to mention other complications along the path of the steam. If corn-oil preservative has been used, the ordinary methods of boiling out with boiler compound and/or kerosene will not suffice. It will be found necessary to resort to the use of some proprietary compound, of which several are on the market, in order to eliminate all the preservative.

After the boiler has been installed in the vessel, and usually after the external valves and fittings have been assembled on the boiler, a hydrostatic test of one and one-quarter times the working pressure is applied to determine if any leaks have developed as a result of moving and shipping the boiler. Also, a hydrostatic test at working pressure is applied for twenty-four hours to determine the pressure drop over that period, a drop of over 10 percent being considered unsatisfactory. Following the satisfactory completion of the above tests, and of course after the remaining brickwork and oil burners are installed, steam is raised in the boiler and a steam tightness test at one and a quarter times working pressure is conducted for a period of at least one hour. If any leaks develop on this test they must be corrected before steam and water joints are lagged. Lastly, a smudge test of the casing is made, using a pressure of at least one inch of water. There must be only negligible leaks at this pressure.

The boiler having passed the smudge test, its complete inspection has been accomplished, and it is now ready to be turned over to the operating personnel of the vessel.

Curve Determines Analyses of Best Welding Steels

One of the greatest stumbling blocks in the universal application of arc welding has been the porosity in the weld or deposited metal, and the problem of eliminating this porosity has indeed been a baffling one. What causes one weld to be solid and dense and to be free from porosity and the next to be porous? The answer probably is—variability in the steel itself.

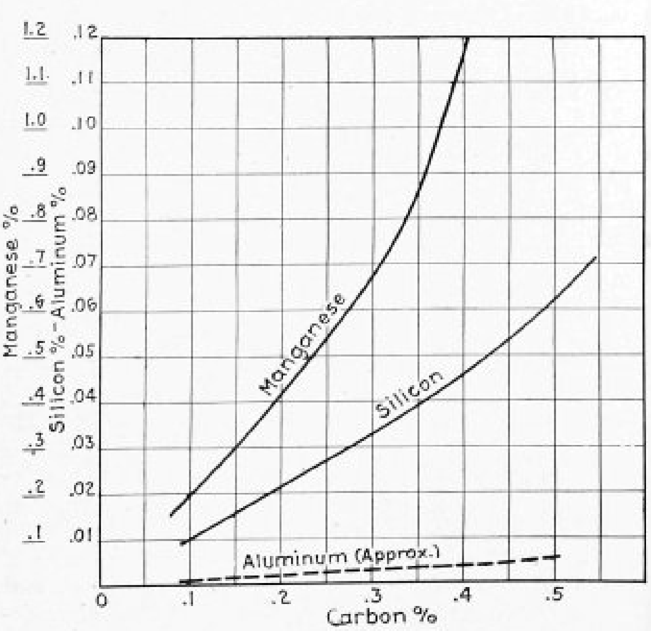
This great variance in the weldability of commercial grades of steel which has been so baffling, has recently been solved as a result of an extensive research conducted by Wilmer E. Stine of the research laboratories of The Lincoln Electric Company, Cleveland, O. The solution is in the form of a graphic formula, known as the Lincoln-Stine equilibrium curve, by which the exact specifications for steels of good weldability can be determined. It is claimed by welding authorities that the result of Stine's work will prove as great a boon to electric-arc welding as ethyl gasoline did to the production of high-compression motors.

Heretofore the difficulties encountered in producing sound welds in various grades of steel were believed to be due to the electrodes and process employed. Wilmer E. Stine thought otherwise, and proceeded to investigate on the basis that the difficulty lay within the steel itself. Due to his intimate knowledge of metals acquired from 12 years service in the United States Navy as associate materials engineer, Stine realized that research beyond the usual analyses of steels was necessary. Data was collected from the steel producers as to exact conditions and methods under which the steel samples to be tested were made. With this information thousands of samples of steel were welded, tested and analyzed. The results of this research when plotted formed the Lincoln-Stine equilibrium curve.

How to determine the correct proportions of the elements in the steel for best welding becomes a simple matter with the use of the accompanying graphic formula. For example, if steel having 0.20 percent carbon is required, the Lincoln-Stine equilibrium curve shows that the silicon content should be approximately 0.021 percent; the manganese, 0.40 percent. If the steel has been deoxidized in manufacture by the addition of aluminum, the amount of this element present should not be more than 0.002 percent. Thus, for any required carbon content of steel, correct proportions of silicon, manganese and aluminum can be specified to insure steel of best welding qualities.

In arc welding steels, produced according to specifications indicated by the Lincoln-Stine equilibrium curve, there is no chemical reaction when the temperature of the metal falls to the point only slightly above the temperature at which the steel solidifies. It is only when such chemical equilibrium is obtained that minimum porosity of weld metal is assured, which in turn means denser, stronger, tougher welds.

In conducting the research Stine also felt that in steels not having the proper proportions of elements for good welding, chemical equilibrium at the proper temperature might be brought about by the use of a corrective flux or autogenizer fused into the steel during the welding process, and during the research developed fluxes or autogenizers for this purpose. Thus, when it is found that the composition of the steel on hand does not meet the requirements indicated by the graphic formula, the steel can many times be satisfactorily welded when such balancing flux or autogenizer is applied.



Lincoln-Stine equilibrium curve

Eric H. Ewertz Awarded Miller Medal

Eric Harold Ewertz, consulting engineer, New York City, has been awarded the Samuel Wylie Miller Memorial Medal for 1930 by the American Welding Society for his pioneering in the development and application of arc welding. Born in Sweden, Mr. Ewertz came to this country at the age of 20 years, a graduate in mechanical engineering. In 1903, he became general manager of the Victor Metals Company, Weymouth, Mass. In 1912, Mr. Ewertz became interested in electric arc welding and succeeded in his experiments at Fore River to demonstrate its practicability. In 1918, Mr. Ewertz was appointed a member of the Emergency Fleet Corporation Welding Committee. He was also in charge of all welding development for the Bethlehem Shipbuilding Corporation, Ltd. In 1928 he established his consulting welding engineering practice in New York City, specializing in ship construction, steel structures and storage tanks. He was formerly president of the American Welding Society.

Boiler Manufacturers Discuss Welding at Annual Meeting

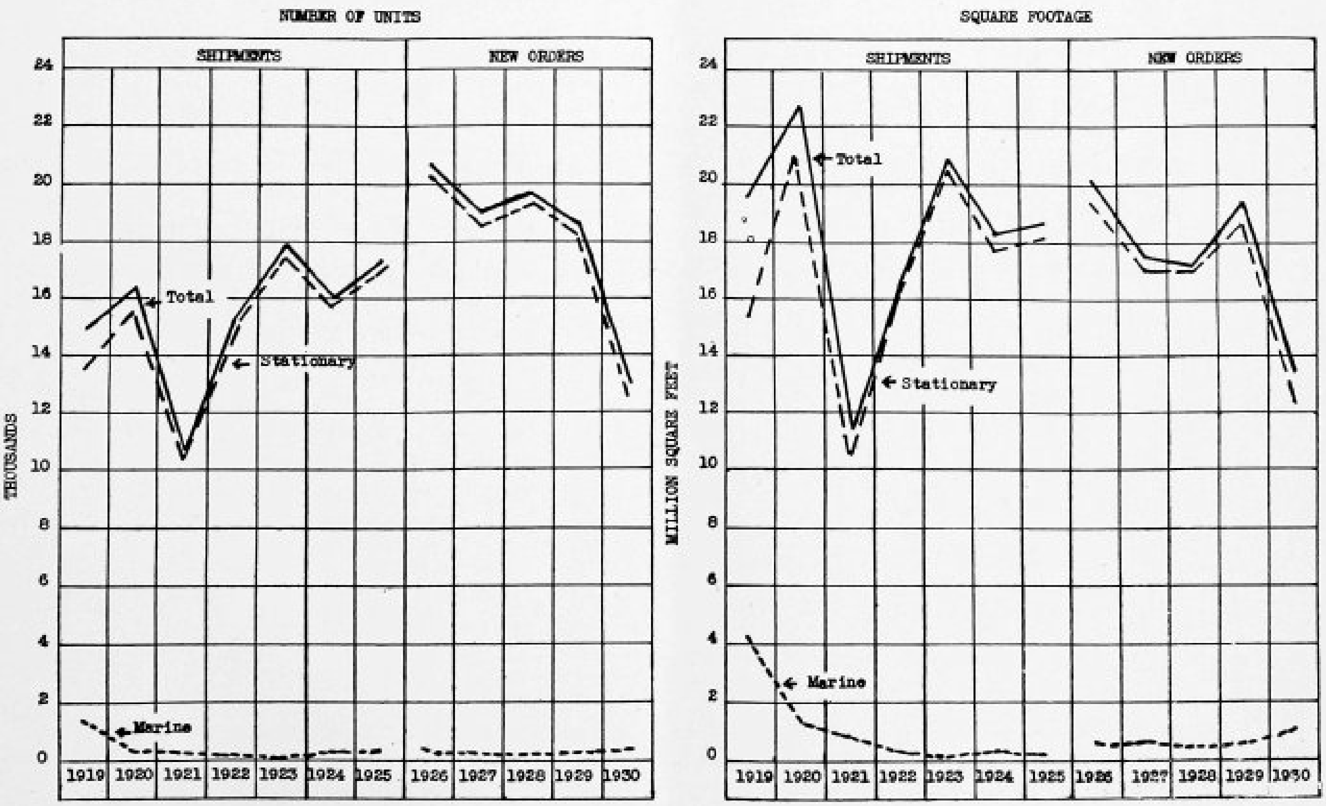
Aside from a discussion of special trade problems, which at this time are of particular importance to the industry, the outstanding consideration at the forty-third annual convention of the American Boiler Manufacturers' Association was the subject of the application of fusion welding to the construction of boilers and pressure vessels. The meeting was held at Skytop Lodge, Skytop, Pa., from May 25 to 27, with about 50 members and associate members in attendance.

At the opening of the general session Monday, May 25, H. H. Clemens, president of the association, reviewed the current trend of the industry and offered constructive suggestions for future action of the organization. An abstract of his remarks follows:

President's Address

Our activities for the past year have followed closely those of other years in that we have kept in close touch and rendered assistance to the A. S. M. E. Boiler Code Committee, American Uniform Boiler Law Society, the National Board of Boiler and Pressure Vessels Inspectors, various smoke regulation committees, and other organizations working along lines closely identified with ours. The most active work at the present time is with the A. S. M. E. Boiler Code Committee on Fusion Welding, a subject you will hear ably discussed later on in our program.

Our most serious effort of service to our industry during the year was the attempt of the power boiler manufacturers to form a trade association with a program of activities similar to that of the wide number of such associations already functioning. You will recall, our former president, H. E. Aldrich, most urgently recommended in his last year's address, that such activities be undertaken. In December a meeting was held in Washington of two committees, one on organization, headed by Owsley Brown; the other on trade practice conference, headed by William C. Connelly. These committees met at the United States Chamber of Commerce building where, with the able assistance of Phillip P. Gott, manager of the Trade Association Department of the United States Chamber of Commerce and his staff, representatives of the Federal Trade Commission and of the United States Department of Commerce, a most comprehensive plan of organization and code of practice was worked out. This program and code of practice were submitted to all manufacturers in our industry and later, after some modification, agreed upon at a meeting held in New York City. All manufacturers whether members of the American Boiler Manufacturers' Association or not were invited to attend this meeting and have a voice in the deliberations. Mr. Gott then drew up for us several suggested forms of constitutions and by-laws necessary to the working out



Charts summarizing production of steel boilers from 1919 to 1930 inclusive

Table 1.—Steel Boiler orders for April, 1931 compared with preceding months

New orders for 689 steel boilers were placed in April, 1931, according to reports submitted to the Bureau of the Census by 73 manufacturers, comprising most of the leading establishments in the industry, as compared with 630 boilers in March, 1931, and 1017 boilers in April, 1930.

NEW ORDERS—ALL KINDS

	1930		1931	
Month	Number	Sq. ft.	Number	Sq. ft.
January	942	1,081,749	598	576,723
February	873	938,906	516	622,343
March	977	1,263,709	630	664,784
April	1,017	1,070,093	689	825,203
Total (4 Mos.)	3,809	4,354,457	2,433	2,689,053
May	1,283	1,329,748		
June	1,360	1,588,553		
July	1,309	1,410,096		
August	1,371	1,356,751		
September	1,254	1,282,388		
October	1,189	851,525		
November	777	709,322		
December	814	587,053		
Total (Year)	13,166	13,469,893		

Totals for first four months and New Orders, by Kind, placed in April 1930-1931

	1930		1931		April, 1930		April, 1931	
Kind	No.	Sq. ft.	No.	Sq. ft.	No.	Sq. ft.	No.	Sq. ft.
Stationary:								
Total	3,731	4,068,259	2,347	2,366,425	1,001	1,007,223	665	692,606
Watertube	373	2,063,432	226	1,122,364	93	442,477	57	329,276
Horizontal return tubular	250	390,771	154	184,644	70	97,276	42	49,932
Vertical fire tube	423	133,321	231	59,893	98	27,571	59	13,358
Locomotive (not railway)	76	57,504	39	41,433	24	19,268	24	31,090
Steel heating[1]	2,045	925,426	1,404	689,923	566	271,510	406	200,329
Oil country	312	353,187	177	196,377	93	107,393	42	47,677
Self-contained portable[2]	168	117,541	95	57,208	40	30,260	29	17,949
Miscellaneous	54	27,077	21	14,583	17	11,468	6	2,995
Marine:								
Total	78	286,198	86	322,628	16	62,870	24	132,597
Watertube	41	257,910	48	297,923	8	59,988	17	127,530
Pipe	2	2,236	4	5,240	....	....	2	2,242
Scotch	30	22,755	24	9,795	8	2,882	5	2,825
2 and 3 flue	...	....	....	....	....	....	...	......
Miscellaneous	5	3,297	10	9,670	....	....	...	......

[1] As differentiated from power.
[2] Not including types listed above.

of the proposed program, and these were submitted to us at the mid-winter meeting in Cleveland.

We regret to report that with all the careful thought and planning, the entire project was tabled, for the time being, when it was found that for various reasons enough finances to properly and effectively launch such a program would not be available. We sincerely hope that this condition will soon change.

So you may better appreciate the present condition, of the industry I submit the following comparative figures of boiler sales as between the first four months of 1929, the last normal year in our industry, and the first four months of the present year:

	Square Feet Heating Surface		
Type of Boiler	1929	1931	Percent Normal
Stationary total	5,588,411	2,366,425	42.5
Watertube	2,795,847	1,122,364	40.2
Horizontal return tubular	533,698	184,644	34.5
Vertical firetube	156,980	59,893	38
Locomotive (not railroad)	52,114	41,433	79.5
Steel heating	1,590,911	689,923	43.2
Oil country	289,846	196,377	67.8
Self-contained portable	139,940	57,208	41.2
Miscellaneous	29,075	14,583	50

If we excluded from this list the locomotive (not railroad) steel-heating and oil-country boilers, it is plainly apparent that the remainder of the field is running only 40 percent of normal and from all present indications, this average is not likely to change during the remainder of the year.

For your further information on this important phase of our discussions, the courtesy of W. S. Stewart, Director of the United States Bureau of Census permitted us to obtain an early release on boiler sales as reported to his department for the month of April and also statistics and charts showing the volume of business in the industry from 1919 to date. (Tables 1 and 2).

I hope every member of our organization will give more than passing thought to the problem, as represented by these figures and as a result we can have a more united support than in the past in working it out. Particularly is it necessary to have the active aid and guidance of the larger units in our group; lacking their support the smaller ones cannot by themselves accomplish much for the general good of all.

The need of such an organization as ours is so important and its record of forty-three years is of such a character, that I am sure we can with the return of general business confidence, successfully work out the problems we have left uncompleted.

In connection with the subject of trade associations, an excellent article appeared in the May 14 issue of *Printer's Ink*, entitled "This Year's Challenge to Trade Associations," by C. B. Larrabee. For the information of members of the association, this article is reprinted on page 161 of this issue of THE BOILER MAKER.

Following Mr. Clemen's address A. C. Baker, secretary and treasurer, read his report.

Smoke Prevention Conference Committee

George W. Bach, chairman of the conference committee, working with the Smoke Prevention Association, reported that considerable activity had been shown by those interested in smoke prevention during the past year. Contact with the national association on this matter has been re-established so that the American Boilers Manufacturers' Association will be represented at the annual convention of this group. Joint committee work also has been undertaken after a lapse of some months. At the next meeting of the association a comprehensive report of the smoke-prevention situation and the part to be played by the manufacturers, will be possible.

W. C. Connelly, chairman of the Cost Accounting Committee then reported as follows:

Cost Accounting Committee Report

Since 1913 this association has had a Cost Finding Committee which has at practically every annual meeting for the past eighteen years presented a report urging upon all of our members the necessity of proper cost accounting in order to keep the industry on a basis that would permit the ordinary profit to which its members are entitled.

In view of the fact that many reports on cost accounting methods have been made at prevous meetings, some of which have gone into great detail, this report will be more or less a repetition.

Your committee believes it very necessary again to urge that the question of proper cost finding be considered. The total volume of boiler horsepower purchased during the past few years has greatly decreased from the volume of business placed annually between the years 1921 and 1925. No doubt every boiler manufacturing plant has produced a lesser amount of horsepower during the calendar year 1930 and up to the present time in 1931, than they did even in the years 1928 or 1929. With the decreased amount of horsepower, or reduction in sales, and with probably a very small, if any, reduction in the overhead, it is very neces-

Table 2.—Comparative summary of number and square footage of steel boilers

Report based on data reported to the Bureau of the Census by 81 identical manufacturers (8 of which have gone out of business since 1927) for the following periods: Shipments—1919 to 1925, inclusive. New Orders—1926 to 1930 inclusive.

	Shipments							New Orders				
	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930
GRAND TOTAL:												
Number	15,125	16,185	10,840	15,665	17,969	16,081	17,508	20,688	19,108	19,672	18,526	13,166
Square feet....	19,728,734	22,595,217	11,353,637	16,434,184	20,927,679	18,140,855	18,406,132	20,048,412	17,796,272	17,684,811	19,468,534	13,469,893
STATIONARY:												
Total—												
Number	13,741	15,674	10,580	15,510	17,863	15,899	17,300	20,388	18,870	19,441	18,286	12,909
Square feet....	15,562,009	20,988,487	10,368,798	16,150,694	20,788,315	17,826,361	18,140,395	19,455,430	17,143,663	17,144,880	18,859,278	12,336,486
Watertube—												
Number	2,190	2,932	1,024	1,444	1,921	1,554	1,603	1,631	1,329	1,315	1,650	1,070
Square feet....	8,417,101	12,313,194	4,103,580	6,928,664	10,513,809	8,859,544	8,337,184	8,143,491	7,142,383	6,909,982	9,409,526	5,562,877
Horizontal return tubular—												
Number	2,855	3,255	2,186	2,983	3,078	2,328	2,039	2,184	1,882	1,513	1,366	879
Square feet....	3,586,168	4,366,513	2,692,037	3,538,547	3,614,389	2,909,296	2,634,605	2,700,686	2,281,168	1,884,401	1,830,028	1,179,486
Vertical fire-tube—												
Number	3,499	4,205	2,514	3,253	3,009	2,011	2,065	2,286	1,959	1,726	1,649	1,140
Square feet....	850,793	1,153,069	576,363	978,881	981,350	588,655	630,711	632,470	534,514	495,674	485,574	340,470
Locomotive (not railway)—												
Number	527	577	333	519	711	684	476	480	375	392	284	167
Square feet....	261,277	281,556	223,138	355,984	447,443	474,048	285,922	279,980	214,405	263,201	226,043	145,251
Steel heating as differentiated from power boilers—												
Number	2,458	2,522	3,013	5,324	6,863	7,763	9,333	11,025	11,203	12,685	11,438	8,081
Square feet....	1,367,816	1,696,811	1,898,880	3,187,229	3,835,466	4,067,629	4,992,480	5,571,605	5,361,151	6,152,393	5,233,481	3,546,144
Oil country—												
Number	1,548	1,188	1,016	1,257	1,350	798	966	1,749	1,328	956	1,142	994
Square feet....	764,064	718,791	579,771	712,439	824,790	471,954	726,464	1,413,420	1,089,990	900,317	1,168,817	1,135,099
Self-contained, portable—												
Number	662	993	492	725	923	751	812	1,019	652	680	589	438
Square feet....	311,720	455,803	292,029	446,598	565,210	451,746	529,513	710,132	441,684	462,627	406,559	310,027
Miscellaneous—												
Number	2	2	2	5	8	10	6	14	142	174	168	140
Square feet....	3,070	2,750	3,000	2,352	5,858	3,489	3,516	3,646	78,268	76,285	99,250	117,132
MARINE:												
Total—												
Number	1,384	511	260	155	106	182	208	300	238	231	240	257
Square feet....	4,166,725	1,606,730	984,839	283,490	139,364	314,494	265,737	592,982	652,609	539,931	609,256	1,133,407
Watertube—												
Number	931	191	101	55	16	67	53	92	71	99	127	172
Square feet....	3,430,142	867,002	671,038	174,609	46,581	229,754	136,823	406,190	512,333	467,084	506,167	1,072,103
Pipe—												
Number	33	11	9	9	12	8	11	8	3	3	10	3
Square feet....	36,914	11,612	10,683	14,569	16,338	7,180	11,909	7,495	3,462	3,623	11,119	3,217
Scotch—												
Number	254	275	120	56	50	77	118	177	139	112	91	75
Square feet....	648,741	702,074	283,561	70,381	57,243	57,642	98,564	162,617	122,376	59,649	77,577	54,159
2 and 3 flue—												
Number	31	28	22	24	19	26	21	19	15	13	3	....
Square feet....	23,520	23,482	14,940	17,452	10,585	17,364	13,915	13,281	4,002	5,577	2,180	....
Miscellaneous—												
Number	135	6	8	11	9	4	5	4	10	4	9	7
Square feet....	27,408	2,560	4,617	6,479	8,617	2,554	4,526	3,399	10,436	3,998	12,213	3,928

sary that all of us have our cost-accounting methods in A-1 shape for accuracy.

Auxiliary Equipment

No meeting of the auxiliary equipment committee, headed by A. C. Weigel, chairman, was held during the past year. In an informal report, however, Mr. Weigel called attention to recent action taken by the Midwest Stoker Association, a branch of the national association of stoker manufacturers, in recommending standard setting heights for various types of steel boilers.

It developed later in the meeting, during the Wednesday session, that the standard setting heights as recommended by the Midwest Stoker Assocation conformed very closely with those adopted by the American Boiler Manufacturers' Association several years ago. It will be possible to rectify any discrepancies. The recommended setting heights are shown in Table 3.

At the conclusion of the discusson on the subject of setting heights H. E. Aldrich, chairman of the American Society of Mechanical Engineers' Boiler Code Conference Committee submitted the following report:

As the work of the A.S.M.E. Boiler Code Committee is generally well known to our members, your committee report in this connection is brief. It is largely one of making the special actions of the Boiler Code Committee a matter of record in our minutes.

A glance through the various codes brought out by the A.S.M.E. Boiler Code Committee will immediately convince one of the wide diversification of their activities. In other words, the Power Boiler Code is but one of the eight or nine codes, prepared by the committee and issued as separate sections of the A.S.M.E. Boiler Code.

In the Fall of 1930 the Power Boiler Code and the Unfired Pressure Vessel Code were republished, containing all of the revisions that had been adopted to that

Table 3.—Recommended setting heights for heating boilers equipped with mechanical stokers

Firebox Boilers

Actual Load	2500	5000	7500	10000	12500	15000	20000	25000	30000
A	18"	18"	20"	20"	22"	22"	24"	24"	24"
B	42"	48"	54"	60"	66"	72"	78"	84"	84"

A = Distance from bottom of Water Leg to floor.
B = Distance from Crown Sheet to bottom of Water Leg.

Compact Welded Boilers

Actual Load	2500	5000	7500	10000	12500	15000	20000	25000	30000
A	18"	18"	20"	20"	22"	22"	24"	24"	24"
B	30"	33"	36"	42"	45"	48"	54"	60"	60"

A = Distance from bottom of Water Leg to floor.
B = Distance from Crown Sheet to bottom of Water Leg.

Horizontal Return Tubular Boilers

H.P....	50	75	100	125	150	175	200	225	250	275	300
A	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-0"	7'-6"	8'-0"	8'-6"	9'-0"	9'-0"

A = Distance from bottom of shell to floor.
H.P. = Installed horsepower.

In the case of the firebox or compact welded type boilers the desired setting height can be obtained by combining the A and B dimensions. The load ratings shown for this class of boilers are actual developed loads in square feet of equivalent cast iron steam radiation and are not manufacturers' rating.

The setting heights given for horizontal return tubular boilers may be used for developed loads up to 50 percent above normal rating. These were prepared by the Midwest Stoker Association as a guide for Architects and Consulting Engineers in determining the head room requirements for heating plants.

date. However, as the fabrication of boilers and pressure vessels is making progress with resultant changes, the same as the development of all machinery, so the Boiler Code Committee finds it necessary through the issuing of interpretations and revisions to clarify and amplify the various codes to meet present-day requirements. In the 1931 April issue of *Mechanical Engineering* was published another important list of revisions.

It is the suggestion of your committee that the engineering departments of every boiler manufacturing company carefully follow all interpretations and revisions as published. The importance of this has been emphasized many times in the past.

One of the most important activities ever carried on by the A.S.M.E. Boiler Code Committee has been the development and promulgation of the Fusion Welding Code for Pressure Vessels and Power Boilers. Your committee on welding will undoubtedly report on this in detail. We merely wish to mention that the successful development of this code was due to the fine co-operation of trade associations, manufacturers of welding equipment, fabricators of welded pressure vessels, welding consultants, the American Welding Society, insurance companies, and others. An enormous amount of work has been involved. It seems proper to mention E. R. Fish, honorary member of this association and chairman of the Unfired Pressure Vessel Sub-Committee, as one who took an important part in this development.

In closing, your committee reports that all matters referred to it by members during the past year received attention.

Uniform Boiler Law Society Committee

No formal report was presented, as the committee submitted its annual report during the mid-winter meeting. H. E. Aldrich, chairman of the committee stressed the importance of all member companies of the association extending support to the American Uniform Boiler Law Society.

Following this report S. Mensonides in the absence of the chairman of the Feedwater Studies Committee, K. Toensfeldt, read a report to the association as follows:

Work of Feed Water Studies Committee

During the year studies were made on the influences that cause moisture in steam, with the purpose of establishing some safe standards which may be adopted by boiler manufacturers. Such standards should at least include limitations in steaming capacity of the drums, giving consideration to the type of boiler and circulator connections, and to the influences that cause foaming and priming of boiler waters. Because of the meager data at hand, and the limitation of time and funds of the past year, but little progress was made. It is hoped that some results will be available in the coming year.

Following is the state of the progress of the Boiler Feed Water Studies Committee of the Joint Research Committee representing the six societies affiliated in this work, as submitted by S. T. Powell, its chairman.

"During the year 1930 the work of the Boiler Feed Water Studies Committee was greatly delayed owing to the serious illness of the chairman for about five months. Active work on the committee has again been resumed and at the present time two lines of study are being carried forward. These are: Research studies on priming and foaming of boiler waters. Standardization of water analysis applicable to boiler feed use.

"For more than a year negotiations have been under way to establish a research Fellowship at the Ohio State University under Professor C. W. Foulk. Research on this problem has been conducted at the University and the contributions made by the Boiler Feed Water Studies Committee will be to further this work which already has been most enlightening. The delay in active co-operation between the committee and Professor Foulk has been due to the difficulty of compiling a satisfactory agreement which would not involve either the research worker or the committee in a patent controversy.

"On authorization of the executive committee and in co-operation with the Research Committee of the American Society of Mechanical Engineers, the committee has now prepared the articles of agreement which with minor changes, appear to be satisfactory to all parties concerned. The Research Committee is to contribute to Professor Foulk $1000 to assist him in his priming and foaming studies. Should the research worker be granted a patent as a result of his work, all contributors to the Boiler Feed Water Studies fund will be entitled to shop rights. This appears to be the most satisfactory method of controlling the situation and is based on mature judgment of the American Society of Mechanical Engineers Research Committee and a number of legal opinions obtained through the Research Committee. It is anticipated that the agreement will be signed by the chairman and the officials of the Ohio State University shortly, since the agreement is now in such form as to be satisfactory to all parties. Progress reports will be issued by the committee as the results are obtained and will be published by the American Society of Mechanical Engineers and other societies affiliated in this work.

"C. H. Fellows, chemist for the Detroit Edison Company, has accepted the chairmanship of the Committee on Standardization of Water Analysis in place of Harold Farmer of the Philadelphia Electric Company who resigned a few months ago. This committee is being reorganized and co-operation and contact has been made with the American Society for Testing Materials for the purpose of standardizing methods of analysis for water for feed water and other industrial uses. It has been agreed by the executive committee that in order to facilitate the work of this Standardization Committee some research work must be carried on in order intelligently to formulate standard test methods. Consideration is being given to the establishment of a fellowship, where controversal methods of analysis now in use may be tested and their value and accuracy definitely established. The appointment of a research worker to carry on this work will be delayed until Mr. Fellows' committee has been reorganized.

"It was agreed at the last meeting of the executive committee that the best results would probably be obtained by concentrating on the work of these two committees, since there is a need for accurate knowledge on these subjects."

In discussing this report it was pointed out that a number of companies working independently have gone very far towards developing standard requirements for feed water. In fact some of them stipulate the analysis of waters to be used in their boilers.

The work of this committee is of great importance to the manufacturers, especially those who build larger, high-pressure, high-temperature units. The vast majority of companies up to now have done little to standardize this phase of their business. The committee should, therefore, have the assistance of every company so that in the near future it will be possible to include a clause in the standard contracts covering water requirements.

The report of the membership committee indicates but little change in the status of the association. The very few companies which discontinued their membership were replaced by others during the year so that the total is approximately the same as before. The Foster Wheeler Company, which recently purchased the D. Connelly Boiler Company, has taken over the membership of the latter in the American Boiler Manufacturers' Association.

Next in the order of business was the presentation of the Welding Committee's report by A. C. Weigel, chairman. The report follows:

Report of Welding Committee

At our last meeting in Cleveland, there were quite some discussions of the proposed code for fusion welding as issued in the December and March issues of *Mechanical Engineering*. The three subjects particularly discussed at that time were—qualifications of welders, stress relieving, and non-destructive testing. The writer consulted with various members of our committee, although not able to call a meeting at which all could be present before the April meeting of the A.S.M.E. Boiler Code Committee. The writer attended the meeting of the Boiler Code Committee as your representative.

Your chairman wishes to report on these questions as follows:

The Boiler Code Committee finally proposed a form of test requirement that will leave the entire matter exclusively in the hands of the manufacturer, who is to be held solely responsible. The welder cannot under this plan go to work on A.S.M.E. Code vessels until he has been tested by the manufacturer and proven his ability; his approval by one manufacturer is not to carry any weight with any other manufacturer. The writer believes that it is the intention of the Code Committee to handle this entire matter in a way that will be satisfactory to the manufacturers.

The question of stress relieving also received a very long and intense discussion at the meeting. The recommendations for including rules to permit of special mechanical treatment of the welded joint as a substitute for stress relieving by heating were carefully studied, but they did not seem to have the support of sufficient technical data or evidence to warrant inclusion in the code at this time, of provisions for such a method. The committee did, however, authorize the insertion of a clause in the stress relieving requirement that will provide for the omission of the stress relieving by heat treatment if it can be demonstrated that the mechanical treatment suggested will relieve the locked-up stresses resulting from the welding operation.

Our secretary has mailed to each and every member of our association, copies of the preprints of the revised proposed code which will appear in the June issue of *Mechanical Engineering*. While this proposed code may be subject to additional revisions, we feel that it is about what will be adopted.

Discussion of Welding Committee Report

As a result of criticism of the previously published requirements for qualification of welders, the Boiler Code Committee, in a final draft of the proposed code, has considerably altered this section. Under the present requirements the responsibility for the quality of welding rests with the manufacturer rather than with the operator. This matter is specifically mentioned in the following extract from the proposed Code:

II. *Grades B and C Test Requirements. a* Each manufacturer shall be responsible for the quality of the welding done by his organization and shall conduct tests of the welders to determine their ability to produce welds which will meet the required tests. An authorized inspector shall have the right at any time to call for and witness the making of test specimens by any welder and to observe the physical tests. The tests conducted by one manufacturer shall not qualify a welder to do work for any other manufacturer.

The tests of a welder made by the manufacturer shall be effective for a period of six months only, at the end of which time a repetition of the tests shall be made.

Each welder shall be assigned by the manufacturer an identifying number, letter, or symbol, which shall be stamped on all vessels adjacent to and at intervals of not more than 3 feet along the welds which he makes either by hand or by machine, or a permanent record may be kept by the manufacturer of the welders employed on each joint which shall be available to the inspector, and in such case the stamping may be omitted.

The manufacturer shall maintain a permanent record of the welders employed by him, showing the date and result of the tests and the identification mark assigned to each. These records shall be certified to by the manufacturer and accessible to the inspector.

From the standpoint of the insurance companies, official action on the code is quite essential, since such companies act as a focal point at which failures and weaknesses of boilers and pressure vessels concentrate, and some standard on which to base their findings should be available. Wherever there is an explosion or failure, the insurance company is vitally concerned. For protection against loss of life, as well as monetary loss, every manufacturer should assure himself constantly of the quality of workmanship of his welders. To do this, proper standards must be established and these standards must apply throughout the industry. With these conditions satisfied, the manufacturer has some basis on which to guarantee the products which he sells.

Naturally since each shop will develop its own technique and use special materials, welding currents, and the like, the experience that a welder may have in one shop will not necessarily qualify him to operate in other shops. These men, therefore, must qualify by test and their work must be identified on the vessels produced. Many firms now require this.

In discussing stress-relieving, it was pointed out that some means for compensating for welding strains caused by alternately heating and cooling portions of the vessel must be provided. This is especially important in heavier vessels. Mechanical methods of stress-relieving, such as applying over-pressure, appear to be of value, as is the heating method of relieving strains. This matter will be reported upon at a later meeting.

On the subject of non-destructive testing of welds, the work the Hartford Steam Boiler Inspection & Insurance Company has carried out on this line was mentioned. Test specimens have been supplied by a number of manufacturers in the form of 33 plates, 3 feet by 3 feet, which represent a great variety of welding methods, equipment and materials. Samples from these plates have been X-rayed at the Watertown Arsenal but the specimens have not as yet been cut up to make a direct comparison with the negatives. In this collection of samples the X-ray has shown some good, some average and some very poor welds. Further comparative study will demonstrate the value of the method to this company's satisfaction.

The use of iron flour in the magnetic system of examination was explained. This method of test offers a comparatively simple and inexpensive way of gaining some knowledge of the character of welded work. It has not been highly developed as yet, so that no definite conclusions can be reached. The hydrostatic test, while useful, is not at all conclusive.

The A. S. M. E. Boiler Code Committee received comparatively little comment on the proposed code but, in the final form, it will be found to include all constructive criticisms and suggestions that were worthy of consideration. The specifications as adopted will require work to be well done, which is the best assurance of safety in pressure vessel construction.

It was stated that, at a meeting of the Boiler Code Committee, representatives of the Babcock & Wilcox Company reported on the cost of X-raying the welded drums of boilers built for new cruisers of the United States Navy. These drums, having a thickness of 1⅞ inches, were X-rayed at a cost for material of about 10 cents per foot and labor 20 to 24 cents per foot, making the total cost of the examination less than 40 cents per foot. Of the drums examined all but three were passed. Of these three only one was rejected. This experience with the X-ray has done more than anything else to justify its use. An analysis of the metal in the rejected drum absolutely confirmed the X-ray interpretation.

Chas. E. Gorton, chairman of the American Uniform Boiler Law Society, emphasized the point that above all things the Code Committee was working for a practical welding code with the fundamental idea of protecting the manufacturer. At present there are seven states waiting for the code to be issued. Action on the part of the Boiler Code Committee has become necessary for if the code were not forthcoming many of the states would take the matter into their own hands and issue requirements of their own.

The Code Committee is open-minded on the question of tests. If time develops better methods than are now available with the X-ray, the gamma-ray, magnetic methods, and the like, they can be approved. At the present, the X-ray seems to be the most satisfactory. Both the electric and gas welding interests have worked closely with the Code Committee and have agreed to accept the code as issued.

C. W. Obert, honorary secretary of the A. S. M. E. Boiler Code Committee, reviewed a study of first-hand conditions in shops, where welding is being done, in many parts of the country. Conspicuous efforts were made by the Code Committee to place the matter of tests for welders in the hands of the manufacturer and in its present form the proposed code accomplishes this desirable end. If the exact wording of this section does not meet with entire approval, it can yet be altered so that it will.

From experience and study of the Union Carbide & Carbon Research Laboratories of Long Island City, a great deal has been learned on the matter of stress-relieving. It has been fairly well determined what develops in a joint when welded and how the stresses build up, but the best methods of relieving them have not as yet been discovered. Many companies are carrying on strain-gage measurements and it has been found that when plate passes 1 inch in thickness it does not relieve itself readily. In the lighter gages, ⅜ inch, ½ inch, ⅝ inch and ¾ inch, particularly longitudinal joints, the stresses cause deformation of shape of the vessel and thus relieve themselves. Above 1 inch in thickness the tendency towards deformation begins to cease. The point has been fixed by the Code Committee, at 1½ inches thickness, above which other treatment for stress-relieving is necessary. The experience of manufacturers with strain-gage measurements will establish definite knowledge on this matter in the near future.

At the present time the X-ray is taking the lead in the non-destructive testing of welds. The Union Carbide & Carbon Corporation has been experimenting for ten years with the X-ray and it is interesting to discover that the tests being made at the Watertown Arsenal bear out their experience with this method. At present the X-ray is practically indispensable to a proper knowledge of conditions in a weld. The Boiler Code Committee, however, is taking a broad view of this matter of testing and is anxious to know further of the results from magnetic analyses. The gamma-ray shows exactly the same things as the X-ray but a tremendous cost is involved if metallic radium be used. Radiographs may also be produced for a very limited time by exposing plates to emanations from tubes of gas which have absorbed radium rays. Such tubes may be obtained from hospitals supplying radium-emanating substances for medical purposes. These tubes are comparatively inexpensive but, as noted, do not last more than two or three days.

With regard to the X-raying of welded joints in plate 2 inches thick, Mr. Obert stated that the rate of examination is about 2½ to 3 feet an hour. It is a comparatively simple matter also for an inspector to interpret an X-ray plate. Since a negative cannot be altered, the conditions shown by it may easily be compared with definite standard plates showing all types of welds,—good, average and bad. Minor porosity does not weaken the weld unless there are too many porous spots in a group or one large void. These porous spots definitely show on the film. A weld containing defects of this character would not be passed.

Many companies have been using artificial methods for aging vessels in order in a short time to determine what the life of a vessel might be. In such a test the vessel is pumped from zero to its working pressure repeatedly. A great deal has been learned from experience with this method of test but the data have not as yet been released for publication.

This concluded the discussion on the subject of welding, which was followed by E. G. Wein who reviewed the situation on government contracts which at present allows unreliable contractors to submit bids and, in many cases on the basis of these bids, to receive an award. A committee from the association will investigate the matter in the various governmental departments involved in order to provide for segregation of equipment bids thus allowing the individual manufacturers to handle their portion of a contract directly.

The remainder of this session was devoted to routine work, including a report of the committee on resolutions by George W. Bach, the appointment of a nominating committee, discussion of proposed minor changes in the constitution and the like.

At the evening session Dr. Comfort A. Adams, president of the Welding Engineering and Research Corporation, New York, and professor at Harvard University, gave a most interesting outline of the history and methods of fusion welding and the application of this process to the construction of pressure vessels. This address, together with the subsequent discussion, will be published in full in a later issue.

The entire session on Tuesday, May 26, was devoted to a special meeting of the power group of manufacturers.

The final session was opened Wednesday morning with H. H. Clemens presiding. Resolutions were introduced on the death during the past year of Dr. S. W. Parr of the University of Illinois, C. S. Blake, chairman of the board, Hartford Steam Boiler Inspection & Insurance Company, and Charles O. Hebbard, president of the International Boiler Works, East Stroudsburg, Pa. At this time a resolution on the transfer of the D. Connelly Boiler Company membership in the association to the Foster Wheeler Company, New York, was read together with a personal tribute to W. C. Connelly who has been so actively engaged in the welfare of the American Boiler Manufacturers' Association.

Final discussion of the proposed setting heights for boilers as adopted by the Midwest Stoker Association was carried out at this point.

After further general discussion of various matters the nominating committee submitted the following names of members who were duly elected to fill office for the coming year:

President—H. H. Clemens, Erie City Iron Works, Erie, Pa.

Vice-President—S. G. Bradford, Edge Moor Iron Company, Edge Moor, Del.

Secretary-Treasurer—A. C. Baker, 801 Rockefeller Building, Cleveland, O.

Executive Committee (three years)—Homer Adams, Fitzgibbons Boiler Company, Inc., New York; George W. Bach, Union Iron Works, Erie, Pa.; G. S. Barnum, The Bigelow Company, New Haven, Conn. (Two years)—Owsley Brown, Springfield Boiler Company, Springfield, Ill.; F. W. Chipman, International Engineering Works, Framingham, Mass.; W. C. Connelly, Foster Wheeler Company, Cleveland, O. (One year)—J. G. Eury, Henry Vogt Machine Company, Louisville, Ky.; A. C. Weigel, Combustion Engineering Corporation, New York; E. G. Wein, E. Keeler Company, Williamsport, Pa.; *Ex-officio*, H. E. Aldrich, Wickes Boiler Company, Saginaw, Mich.

During the course of the convention an excellent program of social events including golf tournaments, the annual banquet and other activities was arranged.

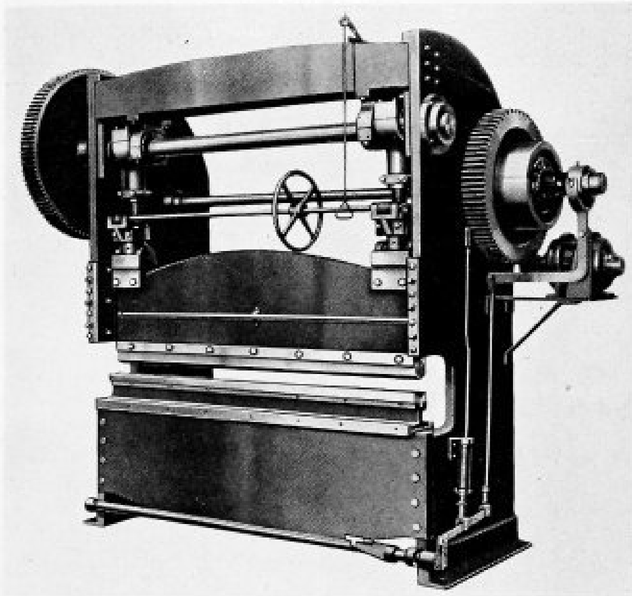
Registration at A.B.M.A. Meeting

The following members and associates were registered at the forty-third meeting of the American Boiler Manufacturers' Association:

Adams, Dr. Comfort A., Harvard University, Cambridge, Mass.
Addams, Homer, Fitzgibbons Boiler Company, New York, N. Y.
Aldrich, H. E., Wickes Boiler Company, Saginaw, Mich.
Bach, George W., Union Iron Works, Erie, Pa.
Barnum, G. S., Bigelow Company, New Haven, Conn.
Barnum, S. H., Bigelow Company, New Haven, Conn.
Bateman, W. H. S., W. H. S. Bateman Company, Philadelphia, Pa.
Blodgett, L. S., THE BOILER MAKER, New York, N. Y.
Bradford, S. G., Edge Moor Iron Company, Edge Moor, Del.
Broderick, J. H., Broderick Company, Muncie, Ind.
Brown, C. H., Lukens Steel Company, Coatesville, Pa.
Brown, J. R., Reliance Gage Column Company, Cleveland, O.
Cardwell, G. A., Lukens Steel Company, Coatesville, Pa.
Carson, W. S., Globe Steel Products Company, Cleveland, O.
Champion, D. T., Champion Rivet Company, Cleveland, O.
Chipman, F. W., International Engineering Works, Framingham, Mass.
Clemens, H. H., Erie City Iron Works, Erie, Pa.
Conlon, W. T., Superheater Company, New York, N. Y.
Connelly, W. C., D. Connelly Boiler Company (Foster Wheeler), Cleveland, O.
Daniels, C. M., Bethlehem Steel Company, Bethlehem, Pa.
Davis, E. Tyler, Tyler Tube & Pipe Company, Washington, Pa.
Dickson, R. B., Kewanee Boiler Corporation, Kewanee, Ill.
Eury, J. G., Henry Vogt Machine Company, Louisville, Ky.
Felker, G. F., Crosby Steam Gage & Valve Company, Charlestown, Mass.
Ferguson, W., Travelers Insurance Company, Hartford, Conn.
Finnerty, Dr. John M., Montclair, N. J.
Fish, E. R., Hartford Steam Boiler Inspection & Insurance Company, Hartford, Conn.
Gorton, Chas. E., American Uniform Boiler Law Society, New York, N. Y.
Hutchinson, Ely, *Power*, New York, N. Y.
Huyette, Paul B., Paul B. Huyette Company, Philadelphia, Pa.
Huyette, S. Lewis, Paul B., Huyette Company, Philadelphia, Pa.
Johnston, J. T., Johnston Bros., Ferrysburg, Mich.
Lally, R. R., Globe Steel Tubes Company, Detroit, Mich.
Low, Fred, *Power*, New York, N. Y.
Mensonides, S., Farrar & Trefts, Inc., Buffalo, N. Y.
Obert, C. W., Union Carbide & Carbon Research Laboratories, Long Island City, N. Y.
Rosencrantz, ——, Combustion Engineering Corporation, Cleveland, O.
Simon, E. F., Ohio Boiler & Machine Company, Cleveland, O.
Snow, N. L., Diamond Power Specialty Company, New York, N. Y.
Taylor, E. H., International Boiler Works, Stroudsburg, Pa.
Tudor, C. E., Tudor Boiler Manufacturing Company, Cincinnati, O.
Tudor, M. J., Tudor Boiler Manufacturing Company, Cincinnati, O.
Waring, B. G., Yarnall Waring Company, Chestnut Hill, Pa.
Weigel, A. C., Combustion Engineering Corporation, New York, N. Y.
Wein, E. G., K. Keeler Company, Williamsport, Pa.

Light-Type Press Brake

A new light-type press brake now being made by the Dreis & Krump Manufacturing Company, Chicago, Ill., has been designed to fill a definite need in the production of many sheet metal products. This machine is



Light-type press brake for sheet metal work

built entirely of arc-welded steel. The gear wheel is also made of welded steel section and the housings are made of one piece with a deep gap which allows work longer than die length to be passed through the machine from left to right. The ram is of the one-piece type with a loose clamping bar for quick changing of tongued dies. The bed is built of two plates with 1½-inch standard spacing between the plates to make possible the use of the press for multiple punching with an inexpensive punching attachment. The eccentric shaft is one-piece forged high-carbon steel.

The machine is operated with a friction clutch and can be stopped at any point on the up or down stroke. The fly-wheel and clutch are one unit and run on Timken roller bearings. Adjustment of the ram is provided with a hand wheel in the front center of the press; motor adjustment can be furnished if desired.

The machines are furnished with arrangement for direct motor drive either by gearing as illustrated or V-belt drive. The brakes are being made in four capacities and in lengths from 3 to 8 feet.

George G. Landis has been advanced to the position of chief engineer of The Lincoln Electric Company, Cleveland, Ohio. Mr. Landis is a graduate of Ohio State University where he completed the course in Electrical Engineering. Upon graduation he entered the employ of the General Electric Company where he engaged in the design of small motors. He later went to the Westinghouse Electric & Manufacturing Company as sales engineer for central station equipment. He came to The Lincoln Electric Company eight years ago when he was placed in charge of the company's experimental activities. He was later placed in charge of electrical design of both motors and arc welders, and later was given charge of mechanical design.

F. M. Feiker Appointed Director of Commerce Bureau

Frederick M. Feiker, trade journalist of New York, has been appointed director of the Bureau of Foreign and Domestic Commerce, United States Department of Commerce, to succeed William L. Cooper, who will resume his former position as commercial attaché at London, England. Mr. Feiker was born in Northampton, Mass., on June 14, 1881. He received the degree of Bachelor of Science in electrical engineering from the Worcester Polytechnic Institute in 1904. Mr. Feiker has been associated with various technical and industrial publications since 1906. In 1921 he obtained a leave of absence from the McGraw-Hill Company, of which he was vice-president, to become assistant to the secretary of commerce, subsequently serving in various capacities in this department and on special committees relating to it. More recently, Mr. Feiker was managing director of the Associated Business Papers, Inc.

Proposed Fusion Welding Rules

(Continued from page 145)

further discussion on June 15. Immediate attention should be given to this important matter and any further criticism or comment desired should be sent in to the Boiler Code Committee office of the American Society of Mechanical Engineers at once.

The previous printings of these new rules have of course been widely and extensively criticized. The Boiler Code Committee has taken advantage of these invited expressions of opinion and revised many parts and sections thereof, in the effort to render the rules satisfactory to the majority. The requirement for "qualification of welders" for instance, has been so modified that the manufacturer of the vessel is caused to assume full responsibility for its integrity, but the formality of a test of each welder working on the vessel is retained in a way that is considered practical for the employes, which fully meets the views of the inspection authorities. In addition, the manufacturers who have protested against the requirement for stress relieving by heat treatment of the welded vessel and have urged the committee to provide for a mechanical treatment of the vessel to relieve the locked-up stresses from the welding operations, have been given the assurance that a special committee has been appointed to investigate carefully their claims. If the mechanical treatment proposed proves itself worthy of consideration, provisions therefor will be incorporated in the new rules. Many other instances of like nature could be quoted to indicate the willingness of the committee to co-operate with the critics of the new rules insofar as possible.

On the other hand, the question of the non-destructive test in the code has not been so simple. In spite of the fact that such a test is called for only for the highest type of welded vessels (class 1) and for welded steam boiler drums, a number of manufacturers protested against it as an unnecessarily expensive and restrictive requirement that will hamper the welding industry. Yet the inspection authorities and the users appear to be unanimous in their insistence that such an unquestionable form of inspection shall be applied to determine the integrity of the welded joints before they are subjected to such severe duty. To the latter view, the committee has acceded and some form of non-destructive test is to be required for such vessels. These tests are now practically limited to the X-ray and the gamma-ray (radium) methods, as the various forms of magnetic analysis do not appear to have proven their practicability for the purpose of exploring welded joints in thick plates. An immense amount of study is now being given to the magnetic methods, however, and it is not too much to expect that soon we will have the magnetic and radiographic methods of analysis on a par.

It is possible and quite probable that the new fusion welding code may not be entirely pleasing to every manufacturer, as the Boiler Code Committee has obviously been painstaking in its effort to surround welded construction with such unquestionable safeguards as the inspection authorities, governmental departments, insurance companies and users have for so long a time demanded. These will naturally cause some welding concerns to introduce improved methods, if they weld pressure vessels to meet the A. S. M. E. Code requirements. It should be considered that the rigidity of these new rules is the result of the demands of inspection authorities and users.

The boiler and pressure vessel industry needs a welding code—in fact, the demand for a welding code has been insistent for over ten years. It is therefore urgent that the industry find some way to accept the new rules that have been promulgated by the Boiler Code Committee. If in working under them relief is found necessary from any particular requirement, the committee will be found ready and willing, as always, to listen to and consider a complaint. The new welding code is admittedly incomplete; there are a number of details to be given further investigation, such as the provision for stress relieving by mechanical treatment mentioned above, and also the question of welded construction for operation under high-temperature conditions. These will, however, be studied for further consideration and rules therefore probably added to the code later on. The committee has done a monumental work in securing quite general agreement on the new rules as published, and is entitled to great credit, as they will constitute when issued, the first complete code for welded pressure vessel construction that has ever been formulated in any country of the world.

New Catalogues

The Nuveyor ash conveyor system, its field of application, description, principle of operation, special features and advantages, is described in a 20-page booklet prepared by the United Conveyor Corporation, Chicago, Ill. The description is well illustrated and special sections are devoted to the operation of the device with mechanical exhausters and steam exhausters.

A bulletin describing welded steel construction for machinery and equipment parts, made from the product of the world's largest plate mill, has been prepared by Lukenweld, Inc., a division of Lukens Steel Company, Coatesville, Pa. The advantages of rolled steel construction are fully discussed.

Three catalogues describing high-speed snagging equipment have been prepared by the Norton Company, Worcester, Mass. These bulletins illustrate in detail, together with specifications, the 30-inch floor-stand machine, the 16-inch swing-frame machine and the 24-inch swing-frame machine.

Locomotive Boiler Strength Formulas *

By C. J. Zusy and G. M. Davies

P-24.—When boiler shells are cut to apply steam domes or manholes the net area of metal, after rivet holes are deducted, in flange and liner, if used, must not be less than the area required by these rules for a length of boiler shell equal to the length removed. The dome flange shall be considered to include the vertical portion of dome up to top of flange radius as shown cross-sectioned in Fig. 10.

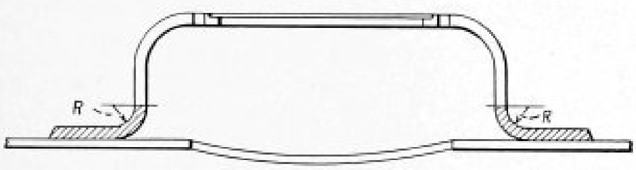


Fig. 10.—Portion of dome to be considered as a dome flange

P-25.—In the case of holes in boiler sheet, roof sheet and all unstayed surfaces other than dome and manholes, reinforce all holes for injector checks and blow-off cocks.

P-26.—Reinforce all other holes over 3¼ inches diameter in shell, firebox roof and all unstayed surfaces, the diameter of which exceeds 4½ times the thickness of the plate.

(a).—Do not reinforce holes over 3¼ inches diameter whose diameter does not exceed 4½ times the thickness of the plate, nor holes 3¼ inches diameter and under. For reinforcing, use an internal liner not less than 75 per cent of the plate in thickness and riveted in such manner that the shear of rivets gives added strength of not less than 82 percent of metal removed by hole.

P-27.—All patches on boiler shells shall be designed so that the strength of the patch does not fall below the strength of the longitudinal seam in the same course.

Table 5—Maximum Allowable Pitch, in Inches, of Screwed Stays, Ends Riveted Over, for Flat Plates

Pressure pounds per square inch	Thickness of plate, inches						
	5/16	3/8	7/16	1/2	9/16	5/8	11/16
	Maximum pitch of staybolts, inches						
100	5.590	6.708	7.826	....	....	....	....
110	5.331	6.396	7.462	....	....	....	....
120	5.103	6.124	7.144	....	....	....	....
125	5.000	6.000	7.000	....	....	....	....
130	4.903	5.883	6.864	....	....	....	....
140	4.725	5.670	6.614	7.586	....	....	....
150	4.564	5.477	6.390	7.590	....	....	....
160	4.419	5.303	6.187	7.349	....	....	....
170	4.287	5.145	6.003	7.129	....	....	....
180	4.167	5.000	5.833	6.928	7.794	....	....
190	4.056	4.867	5.678	6.743	7.587	....	....
200	3.953	4.743	5.534	6.573	7.394	....	....
225	3.727	4.472	5.218	6.197	6.971	7.746	....
250	3.536	4.243	4.950	5.879	6.614	7.349	....
300	3.227	3.873	4.519	5.367	6.037	6.708	7.372

Table 6—Maximum Pitch Using 150 for Value of C

Pressure pounds per square inch	Thickness of plate, inches				
	3/8	7/16	1/2	9/16	5/8
	Maximum pitch of staybolts, inches				
150	6.000	7.000	8.000	9.000	10.000
160	5.809	6.777	7.745	8.714	9.682
170	5.636	6.575	7.514	8.454	9.393
180	5.477	6.390	7.302	8.215	9.128
190	5.331	6.219	7.108	7.996	8.885
200	5.196	6.062	6.928	7.794	8.660
210	5.070	5.916	6.761	7.606	8.451
220	4.954	5.780	6.605	7.431	8.257
230	4.845	5.653	6.460	7.268	8.075

P-28.—The maximum allowable working pressure for various thicknesses of braced and stayed flat plates and those which rules require staying as flat surfaces with braces or stays of uniform diameter symmetrically spaced, shall be calculated by the formula:

$$P = \frac{C \times T^2}{p^2}$$

where P = maximum allowable working pressure, pounds per square inch.

T = thickness of plate in sixteenths of an inch.

p = maximum pitch measured between straight lines passing through the centers of the staybolts in the different rows, which lines may be horizontal, vertical or inclined, inches.

C = 125 for stays screwed through plates not over 7/16-inch thick with ends riveted over, see Table 5.

C = 135 for stays screwed through plates over 7/16-inch thick with ends riveted over, see Table 5.

C = 150 for stays screwed through plates and fitted with single nuts outside of plate, see Table 6.

C = 165 for stays with heads not less than 1.3 times the diameter of the stays, screwed through plates or made a taper fit and having the heads formed on the stays before installing them and not riveted over, said heads being made to have a true bearing on the plate.

(a).—If flat boiler plates not less than 5/16-inch thick are strengthened with doubling plates securely riveted thereto and having a thickness of not less than 2/3 T, then the value of T in the formula shall be three-quarters of the combined thickness of the boiler plate, and doubling plates, but not more than one and one-half times the thickness of the boiler plate, and the values of C given above may also be increased 15 percent.

(b).—When two sheets are connected by stays and but one of these sheets requires staying, the value of C is governed by the thickness of the sheet requiring staying.

(c).—Where values for screwed stays with ends riveted over are required for conditions not given in Table 5, they may be computed from this formula and used, provided the pitch does not exceed 8½ inches.

P-29.—When channel irons or other members are securely riveted to the boiler heads, the stress on such members shall not exceed 12,500 pounds, per square inch. In computing the stress, the section modulus of the member shall be used without addition for the strength of the plate. The spacing of the rivets over the supported surface shall be in conformity with that specified for staybolts.

If the outstanding legs of the two members are fastened together so that they act as one member in resist-

* This is the fourth of a series of articles entitled "Locomotive Boiler Strength Formulas." The first appeared in the March issue.

ing the bending action produced by the load on the rivets attaching the members to the head of the boiler, and provided that the spacing of those rivets attaching the members to the head is approximately uniform, the members may be computed as a single beam uniformly loaded and supported at the points where the through braces are attached.

P-30 (a).—The maximum spacing between centers of rivets or between the edges of tube holes and the centers of rivets attaching the crowfeet of braces to the braced surface, shall be determined by the formula in Par. 28, using 150 for the value of C, see Table 6.

(b).—The maximum distance between the edges of tube holes and the centers of other types of stays shall be determined by the formula in Par. 28, using the value of C given for the thickness of plate and type of stay used.

(c).—The maximum spacing between the inner surface of the shell and lines parallel to the surface of the shell passing through the centers of the rivets attaching the crowfeet of braces to the braced surface shall not exceed p as determined by the formula in Par. 28, using 150 for the value of C, see table 6, plus the outside radius of the flange.

(d).—The maximum distance between the inner surface of the shell and the centers of braces of other types, shall not exceed p as determined by the formula in Par. P-28, using that value of C which applies to the thickness of plate and type of stay as therein specified, plus the outside radius of the flange.

P-31 (a).—When the edge of a stayed plate is flat and is fastened by riveting, the distance from the center line of the rivets to a line through the centers of the nearest row of stays may be made to equal the pitch of the stays as given in Table 5 plus twice the thickness of the plate.

(b).—When the edge of a flat stayed plate is flanged and riveted, the distance from the center of the outermost stays to the inside of the supporting flange shall not exceed the pitch of the stays as given in Table 5 plus the inside radius of the flange.

P-32.—The stress on staybolts shall be calculated using the least cross-sectional area of the stay and the maximum pitching.

$$S = \frac{A \times BP}{a}$$

where, S = stress in pounds per square inch.
A = area supported by staybolts in square inches.
BP = boiler pressure in pounds per square inch.
a = least cross-sectional area of the staybolt.

If desired, the least cross-sectional area of the body of the bolt without deducting the telltale hole, may be deducted from the area supported by the staybolt.

(To be continued)

J. K. Aimer has been appointed assistant general manager of sales for the Reading Iron Company, with offices at 230 Park Avenue, New York. W. S. Shiffer was appointed assistant to the general manager of sales.

Daniel H. Deyoe of the industrial engineering department of the General Electric Company, a director and member of the American Welding Society and a figure for many years identified in electric arc welding activities, died in Schenectady recently, at the age of 55. Mr. Deyoe was a graduate of Union College, class of 1898, and joined the General Electric organization in the same year. He became affiliated with the industrial engineering department in 1906.

Baldwin Acquires Cramp-Morris Properties

The Baldwin Locomotive Works, Eddystone, Pa., has purchased the subsidiaries of Cramp-Morris Industrials, Inc., which include I. P. Morris & De La Vergne, Inc.; De La Vergne Engine Company; Cramp Brass & Iron Foundries Company, all of Philadelphia, Pa.; the Federal Steel Foundry Company of Chester, Pa., and the Pelton Water Wheel Company of San Francisco, Cal.

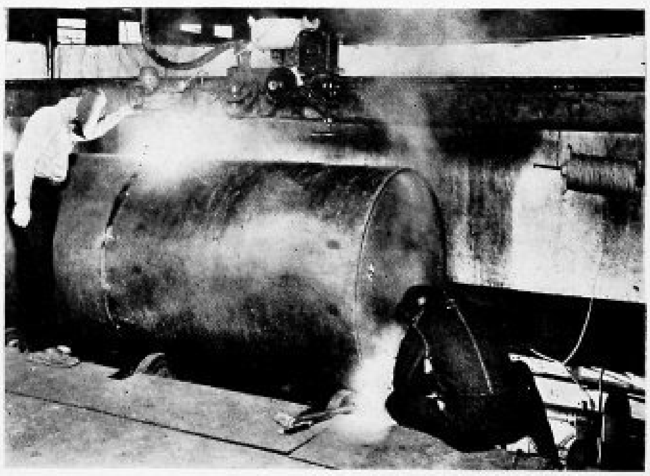
While plans for the disposition of the newly acquired properties have not yet been completed, a gradual absorption is contemplated and, where practicable, it is anticipated that machinery and assets will be removed to the Eddystone, Pa., plant, from which point all activities in the future will be directed.

With the transfer of its subsidiaries to Baldwin, the Cramp-Morris Company has divested itself of its major assets. The old William Cramp & Sons shipyard is not included in the deal and that property will continue in the process of liquidation. Prior to 1927 the companies just acquired by Baldwin were either subsidiaries or non-marine departments of the William Cramp & Sons Ship & Engine Building Company.

H. Birchard Taylor, president of the Cramp-Morris properties, is expected to join the Baldwin group, and policies of conducting research and experimental work followed in the development of Cramp-Morris products will be carried on with increased facilities under Baldwin management.

I. P. Morris & De La Vergne, Inc., manufacturers of hydraulic turbine machinery, represents a consolidation of the I. P. Morris Company and the De La Vergne Machine Company, formerly of New York, but recently moved to Philadelphia and consolidated with the operations of the I. P. Morris Company. The De La Vergne Machine Company for many years designed and constructed refrigerating machinery and was one of the first concerns in the United States to develop Diesel engines. The Pelton Water Wheel Company designs and constructs hydraulic turbine machinery and valves; the Federal Steel Foundry Company specializes in high-grade commercial steel castings, and the Cramp Brass & Iron Foundries Company operates a cupola iron foundry, an electric iron foundry and one of the largest brass foundries in the United States.

* * *



Courtesy Lincoln Electric Company

Automatically arc welding both head and girth seams by the Electronic Tornado Process in the plant of the Novelty Steam Boiler Company, Baltimore, Md.

This Year's Challenge to Trade Associations*

By C. B. Larrabee

"The direction in which we are heading is the way to chaos . . . chaos caused mainly by lack of a plan eventuating from constructive business leadership."—*Dean Wallace B. Donham, author of "Business Adrift."*

"The programs of most trade associations are inadequate for the urgent needs of the next ten years—because they have really been inadequate for the past ten. . . . Trade associations must start anew or they will not survive."—*O. H. Cheney, former vice-president, Irving Trust Company.*

"Either competition will fall to the level of vicious fighting and trade demoralization or it must adopt a practical plan of co-operation. Men working together sincerely for a common end and a common purpose can so organize their energies that problems fade before them and limitations recede."—*Charles F. Abbott, executive director, American Institute of Steel Construction, Inc.*

Times that try men's souls also try trade association pocketbooks Thus at the present time there are a number of associations which, when business was good, were going somewhere rapidly, but now that business is what is conservatively termed "off" they find themselves with depleted reserves and budgets that in some cases are microscopic.

In addition to this they are meeting on all sides the caustic criticism so well voiced by Mr. Cheney. There is no use blinking at facts. Trade associations faced the depression unprepared and failed miserably to measure up to their opportunities. As the Chinese would say, they have lost face, and as the Chinese know, once one has lost face he has lost something difficult to regain.

It is natural, then, that there should be a great deal of discussion about the future of the trade association. It is unfortunate that so much of this discussion centers about the next ten years and not about the next year. It is in the next year that much of the history of the next ten years will be written, just as Charlemagne started the history of the World War when he partitioned his empire more than 1000 years before Serajevo.

It is, of course, comfortable to talk about ten years hence. It gives speakers the opportunity to overlook the pressing problems of today which, to put it baldly, many associations haven't the intestinal fortitude to face. It is unfortunate that these problems are of that nature which is best characterized as "too hot to handle." Associations whose policies have been to see, hear and speak no evil find themselves suddenly forced to hear, see and speak carloads of it. It is the kind of business evil that pricks stuffed shirts and reveals the stuffing to be only air.

This article is not written for association secretaries. They have been attacked plentifully but theirs is not the blame.

"No trade association is stronger than its members." Again I am quoting Mr. Cheney. "Business men like to have trade associations, but they do not, at heart, want their trade associations to do anything. . . . In actual practice most associations accomplish what they do in spite of their members, not because of them."

The next year stands ahead of business and throws down its gauntlet with the challenge, "What are you going to do about it?" If we could personify the year we might see it smiling contemptuously but confidently, certain that business through its trade associations hasn't the courage to deal with the problems that call for cooperative work.

This is an age of programs. Governments adopt programs for this and that. Publications suggest programs to be followed by their readers. Any speaker who wishes to get the ear of his audience can be sure of a hearing if he suggests a program. Therefore it is excusable to suggest that there are certain items that cry for inclusion on trade association programs for the next year. They are not nice items. Some of them are distinctly nasty. But they arise out of conditions in business that must be corrected. One wonders cynically if there are any trade associations with the courage to tackle them. It will be so much more comfortable to take the long view, which overlooks conveniently the morass in which we are.

There is no use in suggesting an extensive program. Any one of the items is probably too large an order for most trade associations as they have been constituted in the past. Here, then, are problems, few in number, which threaten to plunge business further into uncertainty unless corrected and which can be corrected only by co-operative effort on the part of industrial units.

Certain phases of these problems skirt the edges of illegal practice. However, associations, burned by the Federal Trade Commission and other government agencies, are likely to be a little too fearful of the fire. Even where the items on the program do suggest possible legal complications, there is no valid reason why associations should feel that there is no excuse for discussion if not for action. They have discussed even more delicate subjects when these subjects were not likely to tread on members' toes.

1. *Non-profiteers.* Non-profiteering is a term the writer coined about a year ago to cover the practice of selling at or below cost in order to cut under competitors' prices and get business away from them on an unprofitable basis. Trade associations are probably better able to handle this subject than they are to handle any of the other delicate subjects that face them. Many of the associations have made a great deal of research into cost accounting and issue bulletins regularly to their members dealing with costs and selling prices. At least it will not

* From an article published in the May 14, issue of *Printers Ink.*

seem entirely revolutionary if these associations go a step further and build upon their cost information in an effort to eliminate non-profiteering.

The basis of non-profiteering is desperation. Company A, with a large plant and a group of workers already discontented under part-time conditions, bids for business. It knows its costs and knows the costs of Company B and Company K. Therefore it makes a bid on a non-profit basis—sometimes a loss basis.

Rationalizing, as executives are tempted to do nowadays, the directors of Company A assure themselves that all they have in mind is the altruistic purpose of keeping the factory open and providing work for their employees. In far too many cases the real reason is to be found in the hope that if they once get the business away from Companies B and K, they will hold it and some happy day, when conditions are right, they'll get their profits.

Non-profiteering always has one of two parents—desperation or ignorance. It is an economic crime because under any possible system of business ethics it means the eventual disruption of an industry and the eventual loss of money to many companies in the industry.

2. *The advertising allowance.* Tut! Tut! Also sh-sh! Isn't the advertising allowance a legitimate award made to a distributor for giving extra service? The answer is "Seldom—if ever."

Too much has been written in Printers' Ink and other publications about the advertising allowance to make it necessary to stress its evils here. The undeniable fact is that the allowance has become a vicious abuse in some of our greatest industries and that as applied by a number of manufacturers it is as uneconomical as it is unethical.

The advertising allowance—ah, there's an item if the trade associations are really looking for something constructive to put on their programs for 1931-32.

3. *Price wars.* We are now reaching a subject that should be discussed only against a backdrop showing Uncle Tom's idea of heaven and to the accompaniment of deep blue music. We all know by this time that philanthropists, fresh from righteous battles against the inherent dolish "viciousness of unemployment insurance," have rushed back to their plants to lower prices so that it will be possible for consumers to buy again in large quantities. How unjust to attack them because in lowering their prices they are inadventently starting price wars!

Don't take this to mean that price reductions aren't in order. There are, however, price cuts and price cuts. There is the cut based on reduced costs and there is the cut based on the warlike principle of putting the other fellow where he won't come back for a long while. It is these latter cuts that associations may like to consider some warm morning when the nice summer rain whispers, "No drought." Or perhaps the rain is whispering that indestructible truism, "No one ever wins a price war."

4. *Bad dealer policies.* Oh, yes, there are plenty of them—dozens. The automotive industry, for instance, is still trying to get over what happened in the days when dealers took what they were told to take and were made to like it. It has learned its lesson perfectly well but other industries have failed to profit by that lesson and in desperation are repeating the mistake. In the grocery and drug industries there has been plenty of double-crossing of independents to play ball with the chains and not so much vice versa. Full-line forcing, in its more legal aspects, is a subject with many pleasant angles. Most certainly bad dealer policies belong on the agenda.

5. *Free goods bunk.* Here is a subject that promises a lot of fun. "One dozen free with every dozen you buy." "Twelve cartons free for every window installed." When business is bad the free deal flourishes (although at that it does pretty well, thank you, when business is good).

It would be a wholesome thing for several industries if the free goods bunk were debunked. That ought to be a red hot item for our 1931-32 program.

6. *Abuses of advertising.* Ask any publisher and he'll put this as Item 1 on the program. Read what Frank Braucher, vice-president of The Crowell Publishing Company, told the American Association of Advertising Agencies about competitive copy. Ask your dentist or your doctor about medical and scientific claims being made. Ask your competitor—but maybe you already have. Finally, compare your industry's advertising with that code of ethics it drew up a couple of years ago.

7. *Miscellaneous.* That's a good comfortable item which we probably wont ever have to come to because our program is already a little too warm to hold in either hand. However, if anything is left over after the other six items have been discussed there are few things left to talk about. Sales policies, for instance. Research, maybe. Legislation, certainly.

"There should be no doubt, no hesitation, in the acceptance and the application of wholesome co-operative effort among competitors." The speaker is Charles F. Abbott, executive director of the American Institute of Steel Construction, Inc. "It offers the only way to a larger business, a better business and satisfactory profits. There is no other answer. Either competition will fall to the level of vicious fighting and trade demoralization, or it must adopt a practical plan of co-operation. Men working together sincerely for a common end and a common purpose can so organize their energies that problems fade before them and limitations recede."

They can, but will they have the foresight and the courage to do so?

Bending Angle Bars

By George Gardner

Angle iron in bending (other than in a special machine) has a tendency, in fact does, bend two ways. In setting a beam to a curve, for example, it pays to put in enough reverse bend before bending the actual curve. The amount and direction of this reverse bend can only be acquired by experience. In setting to a mold or template a good deal of time can be saved, if, when the bar is near its shape, the template be applied and rolled edgewise along the bar, then the places needed to be bent to finish the bend, can be marked in chalk. The amount to open or close, as the case may be, can also be noted.

In bending angles hot, especially ship or barge frames and long curves, the fact that the heel of the bar is thicker than the flange, means a difference in expansion and contraction between the two, and causes the angle to change its shape while cooling. This must be allowed for in bending. When the standing flange is on the outside of the curve, the bar will open on cooling, and it will close when the standing flange is on the inside of the curve. The amount of spring to put into an angle is largely a matter of judgment and experience. As an example, in an angle 40 feet long one and a half times the width of the flat flange would not be too much.

A.S.M.E. Specifications for Fusion Welding

It is the policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the Rules and its Codes. Any suggestions for revisions or modifications that are approved by the committee will be recommended for addenda to the Code, to be included later on in the proper place in the code.

The following proposed revisions have been approved for publication as addenda to the Code. These are published below with the corresponding paragraph numbers to identify their locations in the various sections of the Code and are submitted for criticisms and approval from any one interested therein. Communications should reach the Secretary of the Boiler Code Committee, 29 West 39th Street, New York, N. Y. not later than June 15, 1931, in order that they may be presented to the Committee for consideration.

RULES FOR THE FUSION PROCESS OF WELDING

The following paragraphs will replace the present Pars. U-67 to U-79 in the Code, and supersede the material published in the December, 1930, issue of MECHANICAL ENGINEERING *and the March, 1931, issue of* THE BOILER MAKER *under the heading "Proposed Specifications for Fusion Welding."*

U-67. Pressure vessels may be fabricated by means of fusion welding provided the construction is in accordance with the requirements for material and design as required by this Code and the fusion welding process used conforms to the specifications for the grade of welding required for each class of vessel.

Fusion-welded pressure vessels shall be classified according to the following schedule. The grade of welding required for each class shall be as indicated.

Class 1. All vessels covered by this Code, constructed in accordance with the rules for this class, may be used for any purpose. These vessels shall meet Grade A test requirements. The joint efficiency *E* for this class shall be taken as 90 percent.

Class 2. All vessels covered by this Code may be included in this class, excepting those containing lethal gases or lethal liquids and/or those containing liquids operating at a temperature of 250 degrees F. or above (this exemption does not include vessels containing steam only). The maximum pressure at which any vessel in this class may be operated is 400 lb. per sq. in., and/or the maximum temperature 730 degrees Fahrenheit, provided the plate thickness as required by the permissible stress allowance does not exceed 1½ in. These vessels shall meet Grade B test requirements. When Grade B test requirements are used, the joint efficiency *E* shall be taken as 80 percent.

Class 3. All vessels covered by this Code, not exceeding ⅝ in. plate thickness and used for the storage of gases or liquids except water at temperatures not exceeding their boiling temperature at atmospheric pressure, and at pressures not to exceed 200 lb. per. sq. in., and/or not to exceed a temperature of 250 degrees. F. may be included in this class, excepting those containing lethal gases or liquids. These vessels shall meet Grade C test requirements. The strengths of the joints shall be calculated on a maximum unit joint working stress $(S \times E)$ at right angles to the direction of the joint as follows:

Double-welded butt joints for all joints.........	8000 lb.
Single-welded butt joints for girth or head joints	6500 lb.
Double full-fillet lap welds for girth joints only...	7000 lb.
Spot or intermittent welds for girth or head joints	5600 lb.

For single-welded butt joints for longitudinal joints and for material of thickness of less than ¼ in., the maximum unit joint working stress $(S \times E)$ shall not exceed 5600 lb. per. sq. in.

The allowable working stresses on the joints in pounds per square inch for different temperatures are given in Par. U-20.

NOTE: It does not follow that any vessel in which the plate thickness does not exceed ⅝ in. is necessarily limited to Class 3. Any vessel welded to meet Grade A test requirements would be included in Class 1, and if welded to meet Grade B test requirements it would be included in Class 2.

The above classification gives the general features governing the classes into which the various vessels will be placed. The Boiler Code Committee will prepare a list indicating the classes into which the vessels for various uses shall be grouped.

U-68. *Material. a* The materials used in the fabrication of any fusion welded pressure vessel covered by this Code shall conform to Specifications S-1 for Steel Boiler Plate, or S-2 for Steel Plates of Flange Quality for Forge Welding, of Section II of the Code (1930 Edition). Shells fabricated from lap-welded butt-welded, or seamless pipe shall conform to Specification S-18 for Welded and Seamless Steel Pipe. The carbon content in all such material shall not exceed 0.35 percent.

b Material for manhole frames, nozzles, and other pressure connections which are to be joined to the shell or heads by fusion welding shall, when forged or rolled, comply with the specifications given for shell plate and heads as to chemical and physical properties, and be of good weldable quality. Steel castings and commercial nozzles may be used only when the material has been proved to be of good weldable quality.

c If, in the development of the art of welding, other materials than those herein described become available, specifications may be submitted for consideration.

U-69. *Definitions. a Fusion Welding.* A process of welding metals in the molten, or molten and vaporous, state without the application of mechanical pressure or blows.

b Fillet Weld. A fusion weld of approximately triangular cross-section whose throat lies in a plane disposed approximately 45 degrees with respect to the surfaces of the parts joined.

c Throat. The minimum thickness of a weld along a straight line passing through the bottom of the cross-sectional space provided to contain a fusion weld.

d Double-Welded Butt Joint. A double-welded butt joint is one formed by the fusion of two abutting edges with a filler metal added from both sides of the joint and with reinforcement on both sides. A joint with filler metal added from only one side is considered equivalent to a double-welded butt joint when and if means are provided for accomplishing complete penetration and reinforcement on both sides of the joint.

e Single-Welded Butt Joint. A single-welded butt joint is one formed by the fusion of two abutting edges with all the filler metal added from one side of the joint with a reinforcement on the side from which the filler metal is added.

NOTE: For additional definitions see "Welding and Cutting Nomenclature, Definitions and Symbols," published by the American Welding Society.

U-70. *Longitudinal Joints.* Longitudinal joints on Classes 1 and 2 vessels shall be of the double-butt type and shall be reinforced at the center of the weld on each side of the plate by at least 1/16 in. up to and including ⅝ in. plate, and up to ⅛ in. for heavier plates, and if not removed shall be built up uniformly from the surface of the plate to a miximum at the center of the weld. Particular attention is called, however, to the importance of the provision that there shall be no valley or groove along the edge of or in the center of the weld, but that the deposited metal must be fused smoothly and uniformly into the plate surface at the top of the joint. The finish of the welded joint must be reasonably smooth and free from irregularities, grooves, or depressions. The reinforcement for a single-welded butt joint shall be not less than 1/16 in. The reinforcement may be machined off, if so desired. The longitudinal joints of Class 3 vessels may be of the single-butt type for plate thickness of ¼ in. and less, or double-butt type for any thickness up to ⅝ in., or they may be of the lap type for ⅜ in. and under. If of the lap type the throat dimension of each of the welds shall not be less than ¾ *T*, where *T* represents the thickness of the plate. Both edges of the lap shall be welded and the surface overlap shall not be less than $4T$.

U-71. *Circumferential Joints.* *a* Circumferential joints on Class 1 vessel shall be of the double-welded butt type. Circumferential joints on Class 2 vessels shall be of the double-butt type except for thicknesses of ⅝ in. or less, in which case they may be of the single-butt type. Circumferential joints on Class 3 vessels may be of the butt or lap type. The details of all these joints shall conform to the requirements for longitudinal joints, as given in Par. U-70.

b Dished heads concave to the pressure when used on Class 3 vessels may be inserted with a driving fit and fillet welded inside and outside, except that for vessels 20 in. in diameter or less the heads may be welded on the outside only. The welds shall be located at a distance not less than twice the thickness of the head from the point of tangency of the knuckle.

c Heads concave to the pressure and/or plate edges at girth seams to be attached by butt joints shall be alined as truly as possible. If the deviations are more than permitted by the limitations of Par. U-74, corrections shall be made by reforming the shell or head, whichever is out of true, until the errors are within the limits specified. The edges of head and girth seams shall be kept so spaced that they shall be separated at the point of welding enough to insure thorough penetration of the weld metal.

U-72. *Dished Heads.* Dished heads convex to the pressure shall have a flange not less than 1½ in. long and shall be inserted into the shell with a driving fit and welded as shown in Fig. U-7*B*.

Dished heads concave to the pressure shall have a length of flange not less than 1 in. for shells not over 24 in. in diameter. For vessels over 24 in. in diameter this length shall be not less than 1½ in.

U-73. *Inlet and Outlet Connections.* To be same as present Par. U-77 (1930 Edition).

U-74. *Preparation for Welding.* The plates or sheets to be joined shall be accurately cut to size and formed. In all cases the forming shall be done by pressure and not by blows, including the edges of the plates forming longitudinal joints of cylindrical vessels.

Particular care should be taken in the layout of joints in which fillet welds are to be used so as to make possible the fusion of the weld metal at the bottom of the fillet. Great care must also be exercised in the deposition of the weld metal so as to secure satisfactory penetration.

If the thickness of the flange of a head to be attached to a cylindrical shell by a butt joint exceeds the shell thickness by more than 25 percent (maximum ¼ in.), the flange thickness shall be reduced at the abutting edges.

The edges of the plates at the seams shall not have an offset from each other at any point in excess of one-quarter of the thickness of the plate, except for plates in excess of ¾ in. in thickness, in which the offset must not be more than 10 percent (maximum ⅛ in.) for longitudinal seams, or 25 percent (maximum ¼ in.) for girth seams.

In all cases where plates of unequal thicknesses are abutted, the edge of the thicker plate shall be reduced in some manner so that it is approximately the same thickness as the other plate. The design of welded vessels shall be such that bending stresses are not brought directly upon the welded joint. Corner welds must be avoided unless the plates forming the corner are properly supported independently of such welds.

Bars, jacks, clamps, or other appropriate tools may be used to hold the edges to be welded in line. The edges of butt joints must be so held that they will not be allowed to lap during welding. Where fillet welds are used, the lapped plates shall fit closely and be kept together during welding.

The surfaces of the sheets or plates to be welded must be cleaned thoroughly of all scale, rust, oil, or grease for a distance of not less than ½ in. from the welding edge. A steel-wire scratch brush may be used for removing light rust or scale, but for heavy scale, slag, and the like a grinder, chisel, air hammer, or other suitable tool shall be used that will clean to bright metal. When it is necessary to deposit metal over a previously welded surface, any scale or slag therefrom shall be removed by a roughing tool, a chisel, an air chipping hammer, or other suitable means to prevent inclusion of impurities in the weld metal. Grease or oil on the welding edges may be removed with gasoline, lye, or the equivalent.

The dimensions and shape of the edges to be joined shall be such as to allow thorough fusion and complete penetration.

Where welding is applied from both sides of the plates to be joined, the joint on the second side must be chipped, ground, or melted out, so as to secure a clean surface of the originally deposited weld metal, prior to the application of the first bead of welding on the second side. Such chipping, grinding, or melting out shall be done in a manner that will insure proper fusion of the weld metal.

If the welding is stopped for any reason, extra care must be taken, when re-starting, to get full penetration to the bottom of the joint and thorough fusion between the weld metal and the plates and to the weld metal previously deposited.

Where single-welded butt joints are used, particular care must be taken in alining and separating the edges to be joined so that complete penetration and fusion at the bottom of the joint will be assured.

U-75. *Stress Relieving.* All Class 1 fusion-welded vessels shall be stress relieved. Class 2 fusion-welded vessels shall be stress relieved in accordance with the following:

> All welds shall be stress relieved where both the wall thickness is greater than 0.55 in. and the shell diameter less than 20 in.
>
> For other wall thicknesses and shell diameters, stress relieving shall be required for all welds where the ratio of the diameter to the cube of the shell thickness is less than 118.

Where stress relieving is required, it shall be done by heating uniformly to at least 1100 degrees Fahrenheit, and up to 1200 degrees Fahrenheit or higher if this can be done without distortion. The structure or parts of the structure shall be brought slowly up to the specified temperature and held at that temperature for a period of at least one hour per inch of thickness, and shall be allowed to cool slowly in a still atmosphere.

The structure shall be stress relieved by any of the following methods:

a Heating the complete vessel as a unit.

b Heating a complete section of the vessel (head or course) containing the part or parts to be stress relieved before attachment to other sections of the vessel.

c In cases where the vessel is stress relieved in sections, stress relieving the final girth joints by heating uniformly a circumferential band having a minimum width of 6 times the plate thickness on each side of the welded seam in such a manner that the entire band shall be brought up to the temperature and held for the time specified above for stress relieving.

> NOTE: A committee has been appointed to consider the question of allowing stress relief by pressure or other means.

U-76. *Hydrostatic and Hammer Tests.* *a* All fusion-welded pressure vessels shall be subjected to the hydrostatic pressure as prescribed for riveted vessels, and while subject to this pressure a thorough hammer or impact test shall be given. This impact test shall consist of striking the sheet at 6-in. intervals on both sides of the welded joint and for the full length of all welded seams. The weight of the hammer in pounds shall approximately equal the thickness of the shell in tenths of an inch, and the blow shall be struck with a force equivalent to an 8-ft. free fall of the hammer head. The edges of the hammer shall be rounded so as to prevent defacing the plates. Following this test, the pressure shall be raised to not less than twice the maximum allowable working pressure and held there for a sufficient length of time to enable an inspection to be made of all seams and connections. The maximum allowable working pressure in each case shall be that at atmospheric temperature, based on actual dimensions of the vessel and plate thicknesses as determined by the formula in Par. U-20.

> NOTE: A proposal has been made to limit the weight of the hammer to 12 lb.

Pinholes, except on longitudinal seams, may be calked, filled with a plug not to exceed ¼ in., or welded by the metal-arc process without preheating, or they may be melted out and rewelded by any process, provided the metal around the pinhole is preheated to a dull red for a distance of at least 4 in. all around it. Any preheating means may be used, such as a flange fire, gas or oil burner, or a welding torch. The preheating should be done slowly, so the heat will get well back into the plate and expand it thoroughly. After welding, the vessel should be reheated in the vicinity of such weld until the heat has equalized in the dull-red spot, and then slowly cooled.

Pinholes in longitudinal seams must be repaired only by chipping or machining, or melting out the defect and rewelding with the above precautions in regard to preheating and reheating, except that with metallic-arc welding, preheating and reheating are not required. Cracks in welds shall only be repaired by cutting out the weld and rewelding the entire seam.

Vessels requiring stress relieving must be stress relieved after any welding repairs have been made.

After repairs have been made, the vessel shall again be tested in the regular way, and if it passes the test the inspector shall accept it. If it does not pass the test the inspector can order supplementary repairs, or, if in his judgment the vessel is not suitable for service, he may permanently reject it.

U-77. *Inspection.* The inspector may designate stages of the work at which he wishes to inspect the welded joints of a Class 1 vessel, and the manufacturer shall either submit the drum for inspection in such partly completed condition, or as an alternative he may permit the inspector to witness stages of the welding operation at such times as the inspector may select.

Class 2 pressure vessels shall be inspected at least twice, and Class 3 pressure vessels shall be inspected at least once, during contruction and before the hydrostatic test.

For Class 2 vessels the first inspection shall be made during the welding of the longitudinal joint. At this time the inspector shall inspect the plate material and the fit-up of the work, and observe the workmen to see that only welders who have passed the test requirements are employed on the work of welding. A second inspection shall be made during the welding of the circumferential joints. At this time the inspector shall check any new material being used which may not have been examined at the time of the first inspection, also the fit-up of the vessel at this stage of construction, and again observe the welding operators to see that only welders who have passed the test requirements are employed.

For Class 3 vessels one inspection shall be made during the welding of the longitudinal joint. At this time the inspector shall check the plate material and the fit-up of the work, and observe the workmen to see that only welders who have passed the test requirements are employed.

Every pressure vessels covered by this Code shall also be inspected at the time of the hydrostatic-pressure and hammer tests.

The manufacturer shall certify that the welding has been done only by welders who have passed the test requirements and that the same materials and technique used in making the tests were employed.

U-78. *Holes.* No unreinforced holes shall be located in a welded joint. When an unreinforced hole in the plate is located near a welded joint, the minimum distance between the edge of a hole and the edge of a joint shall be equal to the thickness of the plate when the plate thickness is from 1 in. to 2 in. With plates less than 1 in. thick, this minimum distance shall be 1 in. With plates over 2 in. in thickness, the minimum distance shall be 2 in.

U-79. *Specifications for Testing Welds.* I. *Grade A Test Requirements. a. Test Plates for Longitudinal Joints.* Two sets of test plates of the dimensions shown in Fig. 2 from steel of the same specifications as the drum plates, prepared for welding, shall be attached to the shell being welded, as in Fig. 1, one set on each end of one longitudinal seam of each drum so that the edges to be welded in the test plates are a continuation of and duplication of the corresponding edges of the longitudinal seam in the shell. Weld metal shall be deposited in the test plates continuously with the weld metal deposited in the longitudinal joint of the shell. As an alternate method, detached test plates may be welded as in the case of circumferential joints.

b Test Plates for Circumferential Joints. When test plates are welded for the longitudinal joints, none need be furnished for circumferential joints in the same vessel provided the welding process, procedure, and technique are the same. Where a vessel has only circumferential joints, two sets of test plates of the same material as the shell shall be welded in the same way as a detached test plate for a longitudinal joint.

c The test plates shall be so supported that warping due to welding shall not throw the finished test plate out of line by an angle of over 5 degrees.

Where the welding has warped the test plates, they shall be straightened cold before being stress relieved. No nozzle shall be attached by welding without stress relief as required by Par. U-75. The test plates shall be subjected to the same stress-relieving operation, as required by Par. U-75, preferably by placing within the parent vessel.

d Test Specimens. The inspector shall select one of the two welded test plates, from which the coupons for tension and bend tests and for specific gravity determinations shall be removed as shown in Fig. 2.

e Tension Tests. Two types of tension-test specimens are required, one of the joint and the other of the weld metal. The tension specimen of the joint shall be transverse to the welded joint, and shall be the full thickness of the welded plate after the outer and inner surfaces of the weld have been machined to a plane surface flush with the plate. When the capacity of the available testing machine does not permit testing a specimen of the full thickness of the welded plate, the specimen may be cut with a thin saw into as many portions of the thickness as necessary, each of which shall meet the requirements.

Each tension specimen should fail in the plate, but if failure occurs in the weld metal or along the line of fusion between weld metal and the plate, then the tensile strength shall not be less than the minimum of the specified tensile range of the plate.

The tension-test specimen of the weld metal shall be taken entirely from the deposited weld metal and shall meet the following requirements:

Tensile strength = at least that of the minimum of the range of the plate which is welded;
Elongation, minimum = 20 percent.

The dimensions of the specimen shall conform to those given in Fig. 3. However, should it not be possible below certain plate thicknesses to obtain a specimen of the weld metal, this test may be omitted.

f Bend Tests. The bend-test specimen shall be transverse to the welded joint of the full thickness of the plate and shall be of rectangular cross section with the width 1½ times the thickness of the specimen. When the capacity of the available testing machine does not permit testing a specimen of the full thickness of the welded plate, the specimen may be cut with a thin saw into as many portions of the thickness as necessary, each of which shall meet the requirements. The inside and outside surfaces of the weld shall be machined to a plane surface flush with the plate. The edges of this surface shall be rounded to a radius equal to 10 percent of the thickness of the plate. The specimen shall be bent cold under free bending conditions until the least elongation measured within or across approximately the entire weld on the outside fibers of the bend-test specimen is 30 percent.

When a crack is observed in the convex surface of the specimen between the edges, the specimen shall be considered to have failed and the test shall be stopped. Cracks at the corners of the specimen shall not be considered as a failure. The appearance of small defects in the convex surface shall not be considered as a failure if the greatest dimension does not exceed 1/16 in.

g Chemical Analysis and Specific Gravity of Weld Metal. Specimens shall be taken from the weld metal of the joints. A chemical analysis shall show not over 0.03 percent of nitrogen as iron nitride, the nitride content to be determined by the modified Allen method of the Bureau of Standards (Scientific Paper No. 457, U. S. Bureau of Standards). The specific gravity specimens shall, if possible, be 2 in. long and ⅝ in. in diameter, as shown in Figs. 2 and 3. The minimum specific gravity shall be 7.80.

Note: The Boiler Code Committee may omit one or both of these test requirements from the final specifications.

h Retests. Should any of the tests other than these specific gravity tests fail to meet the requirements by 10 percent or less, retests shall be allowed on specimens cut from the second welded test plate.

Should any of the tests other than these specific gravity tests fail to meet the requirements by more than 10 percent, no retests shall be allowed. The retest shall comply with the requirements. For either of the tension retests, two specimens shall be cut from the second test plate, and both of these shall meet the requirements.

When there are more than one specimen of the same type and when one or more of the group specimens fail to meet the requirements by 10 percent or less, the retest shall be made on an entire group of specimens which shall meet the requirements.

Should the specific gravity obtained on the specific gravity specimen be less than 7.75, no retest shall be allowed. Should the specific gravity lie between 7.75 and 7.80, a retest shall be allowed. The retest shall show a specific gravity of not less than 7.80.

i Non-Destructive Tests of Vessel. For plate thicknesses 2½ in. and less, every portion of all longitudinal welded joints and of one circumferential welded joint, or one circumferential welded joint where there is no longitudinal joint, of the stress-relieved structure shall be radiographed by a sufficiently powerful X-ray apparatus under a technique which will determine quantitatively the size of a defect with a thickness greater than 2 percent of the thickness of the base plate. Photographic prints of the X-ray films shall be submitted to the inspector. Vessels of a wall thickness over 2½ in. need not be X-rayed until such a time as evidence is submitted to the Boiler Code Committee that the X-ray or similar means are developed that can be commercially applied to greater thicknesses. A manufacturer must demonstrate his ability to produce sound welds by constructing Class 1 vessels, and the joints of which are X-rayed, in order to be permitted to construct Class 1 vessels with a shell thickness over 2½ in. without X-ray examination.

Note: The removal of the words "stress relieved" from this paragraph has been suggested in order to permit the X-ray examination of vessels before stress relieving.

It is contemplated that the manufacturer should demonstrate his ability to produce sound welds in unfired pressure vessels, the joints of which are X-rayed, of a thickness approaching 2½ in. before being permitted to construct drums or shells of a thickness over 2½ in. without X-ray examination. It has been proposed that the minimum thickness for demonstrating this ability be made 2 in.

Radiograph No. 1 shows the desired type of print in which the presence of the welded joint can be detected only with great difficulty. This type represents excellent weld metal with a specific gravity of 7.80 to 7.85.

Radiograph No. 2 indicates the presence of some porosity of the weld metal in the joint. This porosity, however, is not excessive, and radiographs of this type shall be acceptable.

Radiograph No. 3 represents a porous condition in the weld metal which is not desirable.

Radiograph No. 4 represents a serious defect in a welded joint. This defect represents a slag inclusion or cavity extending longitudinally along the wall of the joint. A radiograph of this kind indicates a weld that is not acceptable. However, a radiograph showing a defect of this kind in which the length of the defect is less than $\frac{1}{3}T$, where T is the thickness of the joint and where these defects are separated from each other by at least $2T$ of solid weld metal, indicates a weld that shall be acceptable, provided such defects shall not average more than one per foot for any one seam.

A description of the X-ray technique employed shall be submitted with the radiographic prints to the inspector, this record giving:

1 The thickness of the plate
2 The distance of the film from the rear of the joint
3 The distance of the film from the source of X-rays
4 The voltage impressed on the tube
5 The current flowing through the tube
6 The time of exposure
7 The type of film used
8 The type of intensifying screens.

The locations of the reference markers, the images of which appear on the film, shall be accurately and permanently stamped on the outside surface of the vessel near the weld so that a defect appearing on the X-ray print may be accurately located in the actual welded joint.

To determine whether the X-ray technique employed is detecting defects of a thickness 2 percent or greater than the thickness of the base plate, a piece of sheet steel of a thickness equal to 2 percent of the base plate and containing a hole shall be placed alongside the welded joint so that its image is obtained on the X-ray film but still does not interfere with the image of the welded joint. The image of the hole in the sheet should be obtained on the X-ray film.

II. *Grades B and C Test Requirements. a* Each manufacturer shall be responsible for the quality of the welding done by his organization and shall conduct tests of the welders to determine their ability to produce welds which will meet the required tests. An authorized inspector shall have the right at any time to call for and witness the making of test specimens by any welder and to observe the physical tests. The tests conducted by one manufacturer shall not qualify a welder to do work for any other manufacturer.

The tests of a welder made by the manufacturer shall be effective for a period of six months only, at the end of which time a repetition of the tests shall be made.

Each welder shall be assigned by the manufacturer an identifying number, letter, or symbol, which shall be stamped on all vessels adjacent to and at intervals of not more than 3 ft. along the welds which he makes either by hand or by machine, or a permanent record may be kept by the manufacturer of the welders employed on each joint which shall be available to the inspector, and in such case the stamping may be omitted.

The manufacturers shall maintain a permanent record of the welders employed by him, showing the date and result of the tests and the identification mark assigned to each. These records shall be certified to by the manufacturer and accessible to the inspector. (A sample data-report sheet appears on page 167.)

b Test Plates. Class of Material. Material for test plates shall conform to Specification S-1 for Steel Boiler Plate, except that where other materials permitted for construction are employed for test plates, the tests for welders shall be considered as applying only to such materials.

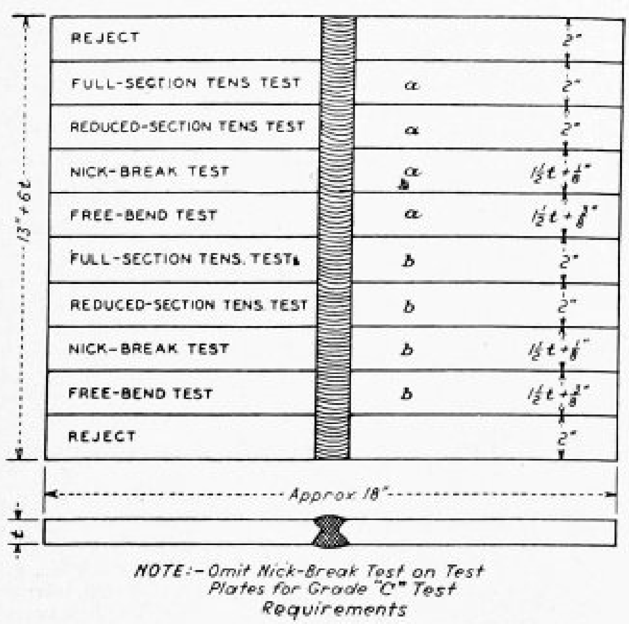


FIG. 4 TEST-PLATE DIMENSIONS AND SPECIMEN LOCATIONS

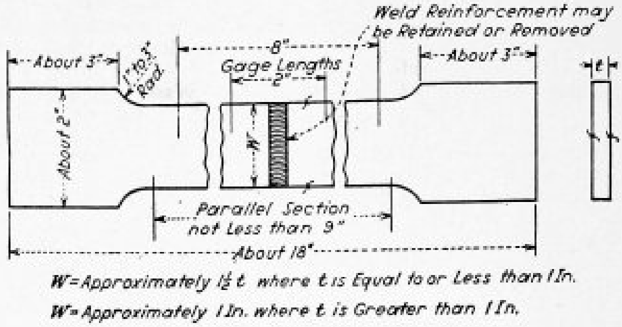


FIG. 5 TENSILE-TEST SPECIMEN

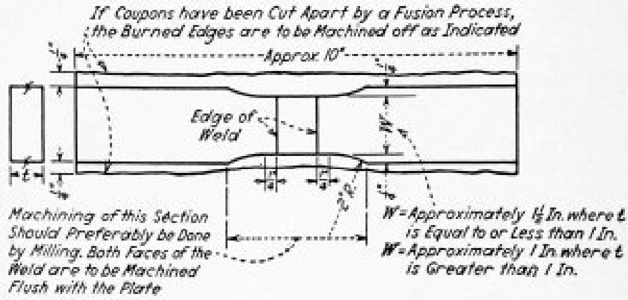


FIG. 6 WELD-METAL TENSILE-TEST SPECIMEN

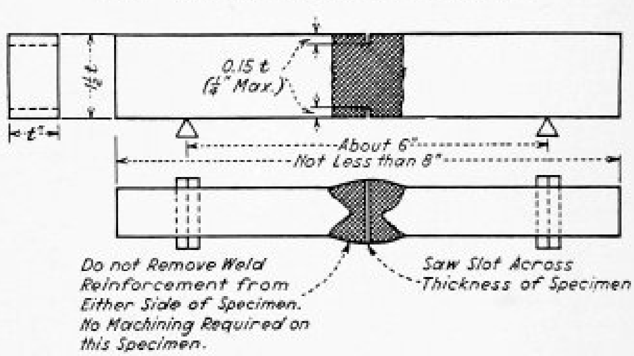


FIG. 7 SPECIMEN FOR NICK-BREAK TEST

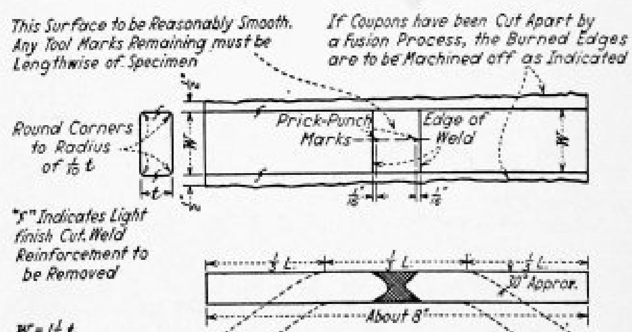


FIG. 8 SPECIMEN FOR FREE-BEND TEST

Thickness of Material. Test plates shall be made in at least two thicknesses as follows:

For Grade B test requirements, ⅝ in. and 1½ in.
For Grade C test requirements, ¼ in. and ⅝ in.

Where the maximum thickness employed in construction under these rules is less than the limit permitted in either Grade B or Grade C test requirements, test plates of the maximum thickness for which approval is desired, may be substituted for the 1½-in. test plate in Grade B test requirements and the ⅝-in. test plate in Grade C test requirements.

Where Grade B test requirements are to be employed for thicknesses less than ⅝ in., a ¼-in. test plate shall also be made.

Type of Joint. For Grade B test requirements, the type of joint shall be the double-welded butt joint. For Grade C test requirements, the type of joint shall be the single-welded butt joint for the ¼-in. test plate and the double-welded butt joint for test plates having a thickness greater than ¼ in. The preparation of the edges of the test plate for welding shall be the same as to be employed in construction.

Procedure of Welding. The test plates shall be welded under the same procedure as to be employed for construction. The process of welding, size and type of welding rod, number of welding layers, position in which the welding is done, etc., shall be the equivalent of that to be used for construction. Only such accessories to or supplements of the welding procedure, for example, the employment of weld backing-up strips or reheating of the test plates for stress relief or heat treatment, shall be employed in the production of the test plates as will be required for construction.

External Appearance and Reinforcement of Weld. The external appearance of the welds and the amount of weld reinforcement shall conform to the requirements for construction, and the maximum reinforcement for the test plates shall not exceed the minimum required for construction.

Test-Plate Dimensions, Number of Test Specimens, and Specimen Location. Two full-section tensile-test specimens, two reduced-section tensile-test specimens, two nick-break-test specimens, and two bend-test specimens shall be required from each test plate, except that the nick-break-test specimens are not required for Grade C test requirements.

The required dimensions for the test plates and specimen location shall be as given in Fig. 4.

c Test Specimens. Full-Section Tensile-Test Specimen. The shape and dimensions of the tensile-test specimen shall be as shown in Fig. 5, with the weld at the center. It will usually be unnecessary to machine the top and bottom surfaces of the specimen. A 100,000-lb. capacity tensile testing machine will be satisfactory for testing all specimens. Swivel specimen holders should be used to insure, in so far as possible, axial loading. Data shall be recorded on the ultimate strength; stress (lb. per sq. in.) computed from the area of the base-metal section.

Reduced-Section Tensile-Test Specimen. The shape and dimensions of the test specimen shall be as shown in Fig. 6. The top and bottom sides of this specimen should be machined to "clean up" the surfaces. The data to be recorded in connection with the reduced section tensile-test specimens shall be the same as for the full section tensile-test specimens.

Nick-Break-Test Specimen (for Grade B test requirements only). The shape and dimensions of the specimen shall be as shown in Fig. 7. The specimen is to be suitably supported as shown in Fig. 7 and broken by a sudden blow or blows applied at the center of the weld. The blow should preferably be applied by a power hammer or falling weight, and be of sufficient intensity to cause a sharp, sudden fracture of the specimen through the nicked portion.

Bend-Test Specimen. The dimensions of the specimen shall be in accordance with Fig. 8. The length may vary with the thickness of the piece and is unimportant, provided it is long enough to permit the bending operation. The bend in the specimen may be started by holding the specimen in a vise about one-third from the end, producing an initial bend at this point with hammer blows. Another bend about one-third from the other end may be produced in the same manner.

The specimen with the initial bend at each end is then placed as a strut in a vise or compression machine and pressure applied gradually (that is, without shock) at the ends until failure occurs in the outside fibers of the bend specimen. When a crack is observed in the convex surface of the specimen between the edges, the specimen shall be considered to have failed and the test shall be stopped. Cracks at the corners of the specimen shall not be considered as a failure. The appearance of small defects in the convex surface shall not be considered as a failure if the greatest dimension does not exceed 1/16 in.

The performance of the specimen is evaluated by measurement of the outside-fiber elongation. This measurement may be made by means of a flexible scale. The elongation shall be recorded in percent.

MANUFACTURERS' SAMPLE DATA REPORT FOR GRADES B AND C FOR TEST REQUIREMENTS

Manufacturer ....
Location ....Date of Test...................
Welder ....Symbol ....Number ....
Grade of Welding ....Welding Process or Trade Name ....

	Test Plate Number 1	2	3	4
1. Type of Preparation				
2. Thickness of Material				
3. Class of Material				
4. Position of Welding				
5. Size of Welding Rod				
6. Type of Welding Rod				
7. Amperage and Voltage				
8. Size of Welding Tip or Tips				
9. Number of Welding Layers				
10. Reinforcement				
11. Appearance of Weld				
Full-Section Tensile Test				
a. Lb. per sq. in.				
b. Lb. per sq. in.				
Reduced-Section Tensile Test				
a. Lb. per sq. in.				
b. Lb. per sq. in.				
Nick-Break Test				
a. Appearance				
b. Appearance				
Free-Bend Tests				
a. Percent				
b. Percent				

The undersigned manufacturer certifies that the statements made in this report are correct and that the test plates were prepared, welded, and tested in accordance with the requirements of the A.S.M.E. Code for Unfired Pressure Vessels.

Date ....19.. Signed ....
(Manufacturer)

d Grade B Test Results. The minimum requirements for Grade B test results are as follows:

Tensile Tests. Each full-section tension specimen should fail in the plate if the weld reinforcement is retained, but if failure occurs in the weld metal or along the line of fusion between the weld metal and the plate, then the tensile strength shall not be less than the minimum of the specified tensile range of the plate used. For the reduced-section tension-test specimens the tensile strength shall not be less than 95 percent of the minimum of the specified tensile range of the plate used.

Bend Test. The ductility requirement by the free-bend-test method shall be at least 20 percent for electric-arc welding and at least 15 percent for oxy-acetylene welding.

Nick-Break Test. The nick-break test for soundness of the weld shall show in the fractured surface complete penetration through the entire thickness of the weld, absence of oxide or slag inclusions, and a degree of porosity not to exceed the following: Six gas pockets per square inch of the total area of the weld surface exposed in the fracture, the maximum dimension of any such pocket not to be in excess of 1/16 in.

X-ray tests of the test plates may be substituted for the nick-break test.

Grade C Test Results. The minimum requirements for Grade C test results are as follows:

Tensile Tests. Each full-section tension specimen should fail in the plate if the weld reinforcement is retained, but if failure occurs in the weld metal or along the line of fusion between the weld metal and the plate, then the tensile strength shall not be less than 90 percent of the minimum of the specified tensile range of the plate used. For the reduced-section tension-test specimen the tensile strength shall not be less than 85 percent of the minimum of the specified tensile range of the plate used. In no case shall the tensile strength be less than 42,000 lb. per sq. in.

Bend Test. The ductility requirement by the free-bend-test method shall not be less than 10 percent.

Specifications for Fusion Welding of Drums or Shells of Power Boilers

The rules for fusion welding of drums or shells of power boilers shall be the same as for Class 1 vessels in the Code for Unfired Pressure Vessels, except that the requirements for Non-Destructive Tests shall be as follows:

Non-Destructive Tests. For plate thicknesses of 3 in. and less, every portion of all longitudinal and circumferential welded joints of the stress-relieved structure shall be radiographed by a sufficiently powerful X-ray apparatus under a technique which will determine quantitatively the size of a defect with a thickness greater than 2 percent of the thickness of the base plate. Photographic prints of the X-ray films shall be submitted to the inspector. Vessels of a wall thickness over 3 in. need not be X-rayed until such a time as evidence is submitted to the Boiler Code Committee that the X-ray or similar means are developed that can be commercially applied to greater thicknesses. A manufacturer must demonstrate his ability to produce sound

(Continued on page 170)

The Boiler Maker

VOLUME XXXI NUMBER 6

PUBLISHED Monthly by the Simmons-Boardman Publishing Company, 34 North Crystal Street, East Stroudsburg, Pa., with Executive Offices at 30 Church Street, New York City.

Edward A. Simmons, President. Henry Lee, Vice-President. C. R. Mills, Vice-President. L. B. Sherman, Vice-President. Samuel O. Dunn, Vice-President. F. H. Thompson, Vice-President. Roy V. Wright, Secretary. John T. De Mott, Treasurer. George Slate, Business Manager.

Chicago: 105 W. Adams Street. Washington, D. C.: 17th and H Streets, N. W. Cleveland: Terminal Tower. San Francisco, Cal.: 215 Market Street.

Subscription Price: United States, Canada and Mexico, $2.00, Foreign Countries, $3.00 a Year. Single Copies, 35 Cents.

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THE BOILER MAKER is a member of the Associated Business Papers, Inc. (A. B. P.), and the Audit Bureau of Circulation (A. B. C.)

EDITORIAL STAFF: H. H. Brown, Editor. L. S. Blodgett, Managing Editor. W. Lumbard, Associate Editor.

Contents

Communication

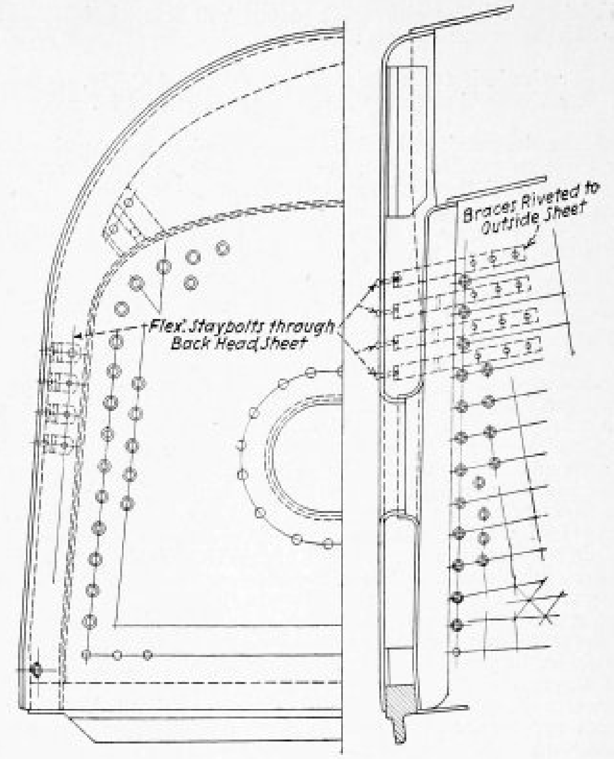
Cracks in Locomotive Boilers

TO THE EDITOR:

After a careful perusal of the informative article in your April issue, on the subject of "Cracks in Locomotive Boilers" particularly that section of it dealing with cracks in the back head sheet, I am prompted to submit to you a description of a method of reinforcing the unstayed area of the back head, which will, I believe, entirely eliminate this very common defect.

The scheme will be readily understood by reference to the accompanying sketch. Several flat braces with one end bent at right angles, spaced to clear the staybolts in the side sheets and offset to clear the rivet heads in the knuckle are shown riveted to the inside of the wrapper sheet. These braces are so placed that the bent ends come near enough to the back head to receive flexible staybolts inserted through the head. The center line of the holes in the braces is about midway between the knuckle and the first row of stays in the back head.

The outstanding advantage of this method of bracing



Method of reinforcing unstayed backhead area

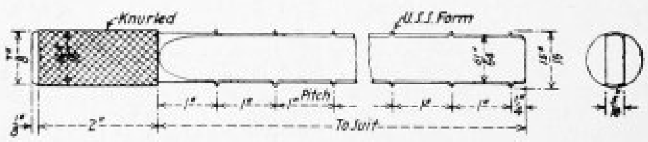
is that it supports the head firmly and yet allows it to expand and contract freely.

Applied to new boilers, or old boilers when renewing the side sheets, it would remove the cause of cracks, inward and outward motion of the sheet resulting from changes in pressure and temperature.

Glace Bay, N. S. MURDOCK MCNEIL

Gage for Testing Pitch of Threads

A simple but effective gage for checking the pitch of threads on staybolts, taps, etc., is shown in the drawing. The gage is made to suit any specific application desired, the pitch of the threads being the distance between each of a series of raised thread-like points on the gage. These are raised to a height which is equal to the depth of the threads on the bolt or tap for which



Gage designed to check the pitch of threads on staybolts

the gage is designed. The points are $\frac{3}{16}$-inch long and are located on opposite sides of the gage for convenience when the gage is in use.

The length of the gage is made to suit any particular application for which the gage may be designed. It has a knurled handle, 2 inches long and 15/16 inch in diameter. When in use the gage is laid along the threads of the bolts or tap, as the case may be, and the raised pitch points will all fall in its respective thread if the pitch is correct.

Questions and Answers Pertaining to Boilers

This department is maintained for the purpose of helping those who desire assistance on practical boiler shop problems. Inquiries should bear the name and address of the writer. Anonymous communications will not be considered. The identity of the writer, however, will not be disclosed unless the editor is given special permission to do so.

By George M. Davies

Neutral Axis of Rolled Plates

Q.—I wish to submit a question I have had in mind a long time. It is regarding the neutral line of rolled plates. First, I must explain I am a layerout where extreme accuracy is demanded and no matter how large or small a job may be it must be correct to less than .01 inch.

The job in question is a half-inch plate 230 inches inside diameter and made in four pieces. Figuring on the neutral line each piece would be 181.032 inches. These plates were cut and planed exact yet when rolled were each .09 inch long. I have always noticed similar results, especially on plates rolled to large diameters.

I know 3.1416 and center of plate is all right for the average job but as I say our work *must* be right, hence my question: Should the neutral diameter change with the thickness of plate and diameter to be rolled?

I trust I have made myself clear or I will be glad to explain further. Thanking you for any information you may give. G. P. S.

A.—It is difficult to lay out plates for rolling to large diameters and secure the accuracy desired in the question due to irregularities in the thickness of the plate and in the bending operations.

The allowance for curvature depends upon the diameter of the curve and the thickness of the plate. The allowance can be calculated but it often happens that some changes are necessary in order to provide for the irregularities in the thickness of the plate and in the bending operations.

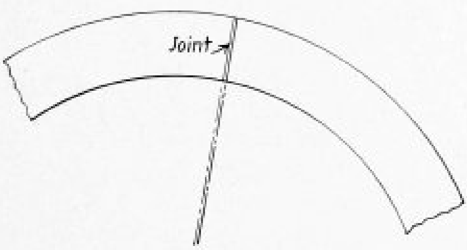


Fig. 1.—Perfect joint in plate

The inside circumference is supposed to shorten and the outside is stretched in the rolling operation. The line midway between the inside and outside is supposed to be the same length after the plate is rolled as before, and therefore this is called the neutral axis.

If the calculation is made on the neutral diameter, then theoretical results would apply in practice. However, there is a difference between the length of the inside circumference and the outside one, that a special allowance should be made in order that the two edges of the plate will roll together.

The desired condition is shown in Fig. 1 when the two edges match perfectly.

In Fig. 2 is shown the condition where the edges meet at the neutral point, but overlap at the inside circumference, and fail to meet at the outside circumference.

In this instance the ends of the plate were cut square, and there was not enough compression on the inside or enough stretch outside.

Fig. 3 indicates the form of plate when cut according to the calculated length for the inside circumference, the neutral circumference and the outside circumference.

It will be seen that the distance between the lengths of the inside circumference and the outside one is twice

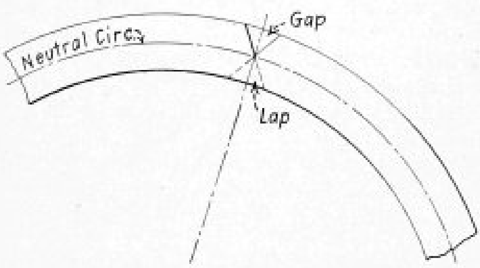


Fig. 2.—Result of not allowing for thickness of plate

the thickness of the plate multiplied by 3.1416 or it is the thickness of the plate multiplied by 6.28.

Instead of using this fractional value and making some allowance for the irregularity that may be due to the plate and the rolling operation some plate workers recommend the use of a factor of 7.

Taking the problem of a 230-inch cylinder, made of ½-inch plate, the inside circumference is 230 × 3.1416, the neutral circumference is 230½ × 3.1416 and the outside circumference is 231 × 3.1416. It should be noted that the plate must be cut for the outside length. The difference between the inside and the outside length is 1 × 3.1416 or 2 × the thickness × 3.1416, which equals the thickness × 6.28. It is recommended that a factor of 7 be used in order to insure that the outside circumference will be long enough to satisfy the requirements.

It will be noted that the illustrations are made on the basis of rolling the cylinder in one piece; however, the

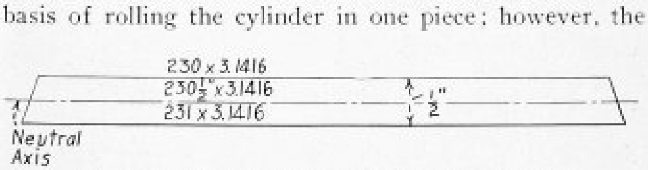


Fig. 3.—Layout of plate according to neutral axis

conditions would be the same irrespective of the number of plates used by dividing the inside, neutral and outside circumferences by the number of plates used and laying out the plates as shown in Fig. 3.

Strength and Stress

Q.—I shall appreciate receiving an answer to the following questions:
1. What is the difference between ultimate strength, and stress?
2. What is the difference between tensile strength and tensile stress?
3. Is there a book published known as "Boiler Patches and Repairs"?

4. Does the construction of oil refinery equipment come under the A. S. M. E. Boiler Code? J. L. W.

A.—(1) *Ultimate strength* is the maximum power to resist force. It is a general expression for the measure of maximum capacity of resistance, possessed by solid masses or pieces of various kinds, to any causes tending to produce in them a permanent and disabling change of form or positive fracture.

Ultimate stress is the maximum force, or combination of forces which produce a strain; or the maximum force exerted in any direction or manner between contiguous bodies, or parts of bodies and taking specific names according to its direction or mode of action, as thrust or pressure, pull or tension, shear or tangential stress. This force tends to produce a permanent and disabling change of form or positive fracture.

From the above definitions, ultimate strength is the maximum power of an object to resist the forces tending to produce a permanent change of form or positive fracture while ultimate stress is the maximum force required to produce a permanent change of form or a positive fracture in an object.

(2) *Tensile strength* is the cohesive power by which a material resists an attempt to pull it apart in the direction of its fibers, this bears no relation to its capacity to resist compression.

Tensile stress is the force which, steadily and slowly applied in a line with the axis of a test piece, just overcomes the cohesion of the particles and pulls it into separate parts.

(3) I am unable to find any record of a book published known as "Boiler Patches and Repairs."

(4) Any power boiler or unfired pressure vessel, irrespective of its purpose, should be constructed to Section I, for power boilers, and Section VIII for unfired pressure vessels, of the A.S.M.E. Code in all cities and states having adopted the A.S.M.E. Code for both power boilers and unfired pressure vessels.

Loss of Steam Pressure

Q.—Will you kindly give me a formula for ascertaining the approximate loss in steam pressure between the boiler of a locomotive and the cylinders? To illustrate, what would be the pressure on the pistons of a locomotive carrying 200 pounds steam pressure, superheated steam? Would similar conditions obtain with a saturated locomotive?

I will greatly appreciate your favoring me with this formula, and, if consistent, would be glad for you to quote me an example using a 2-8-2 Mikado-type locomotive with the usual throttle and dome connections. M. A. J.

A.—Formulas for determining the drop in pressure of steam passing through pipes can be found in any engineering handbook.

Considering the various passages from the dome to the cylinders as pipes an approximate drop in pressure could be determined.

The usual method of determining the pressures obtained at the various points on the locomotive is by test.

A test conducted by the Engineering Experiment Station of the University of Illinois on a Mikado-type locomotive gave the following results:

The locomotive used for the test was Illinois Central Railroad engine No. 1742 of the Mikado or 2-8-2 type, built in 1915 by the Lima Locomotive Works.

Its principal dimensions are as follows:

Total weight in working order	282700 pounds
Weight on leading truck	26300 pounds
Weight on drivers	218300 pounds
Weight on trailing truck	31800 pounds
Cylinders (Simple), diameter and stroke	27 inches x 30 inches
Diameter of drivers	63 inches
Firebox (length and width)	120⅝ inches x 84 niches
Grate area	70.4 square feet
Boiler pressure	185 pounds per square inch
Rated tractive force (m.e.p. = 0.85 bp)	54588 pounds
Heating surface, area of firesides, surface of all heat-transmitting boiler parts, square feet	
Tubes and flues	3401.2 square feet
Firebox	235 square feet
Arch tubes	31.6 square feet
Total water evaporating surface	3667.8 square feet
Superheater	1074.4 square feet
Total including superheater	4742.2 square feet

Steam taken from dome through throttle into Type A superheater to the steam pipes.

The results of the test were as follows:

	Average Actual Speed			Steam pressure, pounds per square inch, gage		Indicator data		
Test No.	Rev. per minute	Miles per hour	Average actual cutoff percent	In boiler	In branch pipe at cylinders	Steam chest pressure	Initial pressure	Pressure at cutoff
2702	80.04	14.34	24.7	180.4	176	184.7	180	131.8
2703	80.04	14.34	24.8	179.8	176.1	185	179.9	133.5
2706	80.03	14.33	24.8	179.8	178.6	191.6	181.6	135.7
Averages	80.04	14.34	24.8	180.	176.9	187.1	180.5	133.7
2701	120.45	21.57	32	179.6	170.8	—	172.2	120.0
2704	120.00	21.49	32.4	180.1	171.9	181.3	177.5	122.4
2707	120.00	21.49	29.5	176.3	171.3	177.5	174.6	127.6
Averages	120.15	21.52	31.3	178.7	171.3	179.4	174.8	123.6
2705	120.05	21.50	45.9	177.9	166.9	178.4	172.5	139.3
2708	119.59	21.42	46.5	176.4	166.6	—	171.6	133.7
2714	120.01	21.49	47.4	176.5	164.9	176.6	173.6	134.6
Averages	119.88	21.47	46.6	176.9	166.1	177.5	172.6	135.9
2710	179.94	32.23	47.8	179	161.7	175.7	161.3	114.8
2712	180.04	32.25	48	176	160.9	174.3	161	113.6
2713	180.19	32.27	48.3	176.5	161.1	175.0	161.4	113.6
Averages	180.06	32.25	48	177.3	161.2	175	161.2	114

It is customary in calculations for determining tractive effort, etc., based on the working pressure of the boiler to assume the mean effective pressure on the pistons as 85 percent of the working pressure of the boiler.

A.S.M.E. Specifications for Fusion Welding

(Continued from page 167)

welds in boiler drums or shells, the joints of which are X-rayed, in order to be permitted to construct boiler drums or shells with a shell thickness over 3 in. without X-ray examination.

Note: The removal of the words "stress relieved" from this paragraph has been suggested in order to permit the X-ray examination of vessels before stress relieving.

It is contemplated that the manufacturer should demonstrate his ability to produce sound welds in boiler drums or shells, the joints of which are X-rayed, of a thickness approaching 3 in. before being permitted to construct drums or shells of a thickness of over 3 in. without X-ray examination. It has been proposed that the minimum thickness for demonstrating this ability be made 2½ in.

R. F. Mehl, superintendent of the division of physical metallurgy of the Naval Research Laboratory has been appointed assistant director of research of the American Rolling Mill Company, Middletown, O. He will be in charge of the physical science department of the Armco laboratories, and will take up his new responsibilities September 1.

Associations

Bureau of Locomotive Inspection of the Interstate Commerce Commission

Chief Inspector—A. G. Pack, Washington, D. C.
Assistant Chief Inspectors—J. M. Hall, Washington, D. C.; J. A. Shirley, Washington, D. C.

Steamboat Inspection Service of the Department of Commerce

Supervising Inspector General—D. N. Hoover, Jr., Washington, D. C.

American Uniform Boiler Law Society

Chairman of the Administrative Council—Charles E. Gorton, 253 Broadway, New York.

Boiler Code Committee of the American Society of Mechanical Engineers

Chairman—Fred R. Low.
Vice-Chairman—D. S. Jacobus, New York.
Secretary—C. W. Obert, 29 W. 39th Street, New York.

National Board of Boiler and Pressure Vessel Inspectors

Chairman—C. D. Thomas, Salem, Oregon.
Secretary-Treasurer—C. O. Myers, Commercial National Bank Building, Columbus, Ohio.
Vice-Chairman—William H. Furman, Albany, N. Y.
Statistician—L. C. Peal, Nashville, Tenn.

International Brotherhood of Boiler Makers, Iron Ship Builders and Helpers of America

International President—J. A. Franklin, suite 522, Brotherhood Block, Kansas City, Kansas.
Assistant International President—J. N. Davis, suite 522, Brotherhood Block, Kansas City, Kansas.
International Secretary-Treasurer—Chas. F. Scott, suite 506, Brotherhood Block, Kansas City, Kansas.
Editor-Manager of Journal—John J. Barry, suite 524, Brotherhood Block, Kansas City, Kansas.
International Vice-Presidents—Joseph Reed, 1123 E. Madison street, Portland, Ore.; W. A. Calvin, 1622, Glendale street, Jacksonville, Fla.; Harry Nicholas, 6215 S. Benton Blvd, Kansas City, Mo.; W. E. Walter, 637 N. 25th street, E. St. Louis, Ill., J. H. Gutridge, 910 N. 18th street, Milwaukee, Wis., W. G. Pendergast, 26 South street, New York, N. Y.; W. J. Coyle, 424 Third Avenue, Verdun, Montreal, Quebec, Can.; A. M. Milligan, 262 Trent Avenue, E. Kildonan, Man., Can.; J. F. Schmitt, 28 S. Roys street, Columbus, O.; William Williams, 502 Labor Temple, Portland, Ore.

Master Boiler Makers' Association

President—Kearn E. Fogerty, general boiler inspector, C. B. & Q. R. R., Aurora, Ill.
First Vice-President—Franklin T. Litz, general boiler foreman, Chicago, Milwaukee, St. Paul & Pacific Railroad, Milwaukee, Wis.
Second Vice-President—O. H. Kurlfinke, boiler engineer, Southern Pacific Railroad, San Francisco, Cal.
Third Vice-President—Ira J. Pool, division boiler inspector, Baltimore & Ohio Railroad, Baltimore, Md.
Fourth Vice-President—L. E. Hart, boiler foreman, Atlantic Coast Line, Rocky Mount, North Carolina.
Fifth Vice-President—William N. Moore, general boiler foreman, Pere Marquette R. R., Grand Rapids, Mich.
Secretary—Albert F. Stiglmeier, general foreman boiler maker, New York Central Railroad, Albany, N. Y.
Treasurer—W. H. Laughridge, general foreman boiler maker, Hocking Valley Railroad, Columbus, O.
Executive Board—Charles J. Longacre, chairman, foreman boiler maker, Meadow Shops, Pennsylvania Railroad, Elizabeth, N. J.

Boiler Makers' Supply Men's Association

President—Irving H. Jones, Pittsburgh Crucible Steel Company, Pittsburgh, Pa.
Vice-President—Reuben T. Peabody, Air Reduction Sales Company, New York.
Second Vice-President—E. S. FitzSimmons, Flannery Bolt Company, Pittsburgh, Pa.
Treasurer—George R. Boyce, A. M. Castle & Company, Chicago, Ill.
Secretary—Frank C. Hasse, Oxweld Railroad Service Company, 230 N. Michigan Ave., Chicago, Ill.

American Boiler Manufacturers' Association

President—H. H. Clemens, Erie City Iron Works, Erie, Pa.
Vice-President—S. G. Bradford, Edge Moor Iron Company, Edge Moor, Del.
Secretary-Treasurer—A. C. Baker, 801 Rockefeller Building, Cleveland, O.
Executive Committee (three years)—Homer Adams, Fitzgibbons Boiler Company, Inc., New York; George W. Bach, Union Iron Works, Erie, Pa.; G. S. Barnum, The Bigelow Company, New Haven, Conn. (Two years)—Owsley Brown, Springfield Boiler Company, Springfield, Ill.; F. W. Chipman, International Engineering Works, Framingham, Mass.; W. C. Connelly, Foster Wheeler Company, Cleveland, O. (One year)—J. G. Eury, Henry Vogt Machine Company, Louisville, Ky.; A. C. Weigel, Combustion Engineering Corporation, New York; E. G. Wein, E. Keeler Company, Williamsport, Pa.; *Ex-officio*, H. E. Aldrich, Wickes Boiler Company, Saginaw, Mich.

States and Cities That Have Adopted the A.S.M.E. Boiler Code

States

Arkansas	Missouri	Rhode Island
California	New Jersey	Utah
Delaware	New York	Washington
Indiana	Ohio	Wisconsin
Maryland	Oklahoma	District of Columbia
Michigan	Oregon	Panama Canal Zone
Minnesota	Pennsylvania	Territory of Hawaii

Cities

Chicago, Ill.	St. Joseph, Mo.	Memphis, Tenn.
Detroit, Mich.	St. Louis, Mo.	Nashville, Tenn.
Erie, Pa.	Scranton, Pa.	Omaha, Neb.
Kansas City, Mo.	Seattle, Wash.	Parkersburg, W. Va.
Los Angeles, Cal.	Tampa, Fla.	Philadelphia, Pa.
	Evanston, Ill.	

States and Cities Accepting Stamp of the National Board of Boiler and Pressure Vessel Inspectors

States

Arkansas	Missouri	Pennsylvania
California	New Jersey	Rhode Island
Delaware	New York	Utah
Indiana	Ohio	Washington
Maryland	Oklahoma	Wisconsin
Minnesota	Oregon	Michigan

Cities

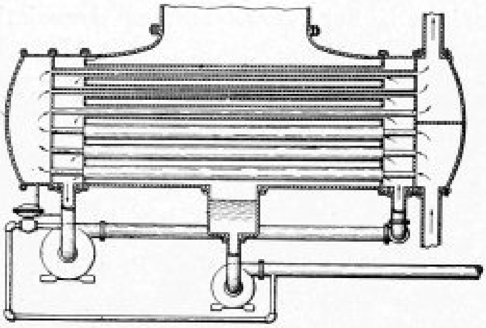
Chicago, Ill.	St. Louis, Mo.	Nashville, Tenn.
Kansas City, Mo.	Scranton, Pa.	Omaha, Neb.
Memphis, Tenn.	Seattle, Wash.	Parkersburg, W. Va.
Erie, Pa.	Tampa, Fla.	Philadelphia, Pa.
Detroit, Mich.		

Selected Boiler Patents

Compiled by Dwight B. Galt, Patent Attorney, Washington Loan and Trust Building, Washington, D. C. Readers wishing copies of patents or any further information regarding any patent described, should correspond directly with Mr. Galt.

1,738,455. STEAM CONDENSER. ARTHUR R. SMITH, OF SCHENECTADY, N. Y., ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

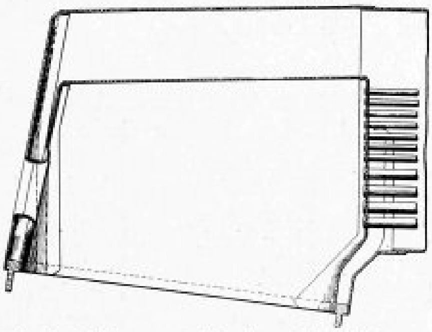
Claim.—The combination with a surface condenser comprising means forming passages for the flow of cooling water, of means whereby there is



maintained around said passage-forming means throughout their length a pressure higher than that within such passages whereby any leakage will be into the cooling water passages. Seven claims.

1,663,216. LOCOMOTIVE FIREBOX. WILLIAM L. REID, OF LIMA, OHIO.

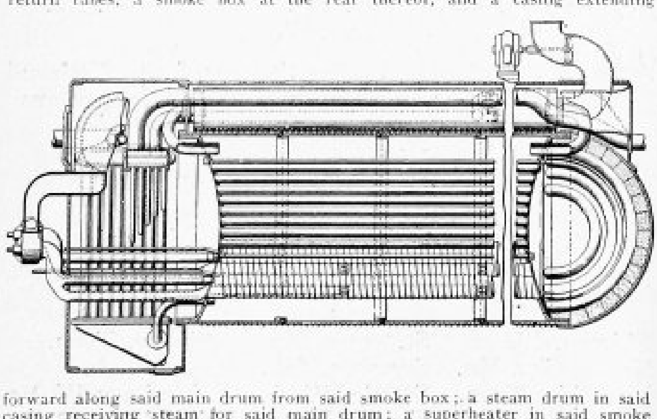
Claim.—A locomotive firebox comprising the usual inside and outside boxes, the corners of the boxes, however, being materially rounded and



formed on radii diminishing upwardly, the radius of the outside corners at the bottom being approximately equal to the radius of the inside corners at the bottom and both bottom radii being not less than the distance between side sheets. Four claims.

1,760,139. LOCOMOTIVE. HOWARD L. INGERSOLL, OF STAMFORD, CONN.

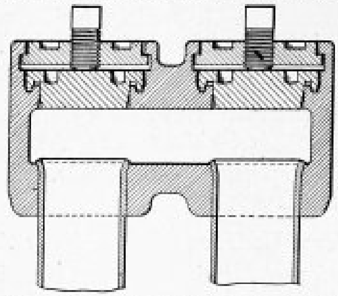
Claim.—A locomotive boiler comprising a main drum with fire flues and return tubes, a smoke box at the rear thereof, and a casing extending



forward along said main drum from said smoke box; a steam drum in said casing receiving steam for said main drum; a superheater in said smoke box receiving steam from said steam drum; a feedwater heater in said smoke box delivering into said main drum; and a supply conduit for air for combustion extending rearward through said casing. Eleven claims.

1,758,909. TUBE CLOSURE OR HEADER. HERBERT B. COFFIN, OF ROSELLE PARK, N. J., ASSIGNOR TO STANDARD OIL DEVELOPMENT COMPANY, A CORPORATION OF DELAWARE.

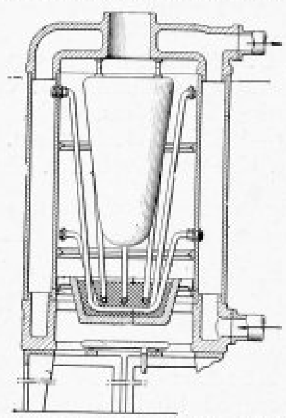
Claim.—A tube closure comprising a box receiving the end of a tube and having an opening therein, a seat in the box, a sealing plug adapted to fit tightly against the seat and close said opening, an exterior in-turned flange on said box and having recesses on its inner margin, a locking plate



having projections adapted to slip through said recesses, a compartment beneath said flange and adapted to receive said projections so that they lie under unrecessed portions of the flange, a removable locking block adapted to fit into one of the recessed portions of the flange and into the registering space therebelow between projections on the locking plate and means for forcing the sealing plug against the seat. Two claims.

1,741,657. STEAM GENERATOR. EUGENE J. ROWAN, OF ROCKVILLE CENTER, N. Y.

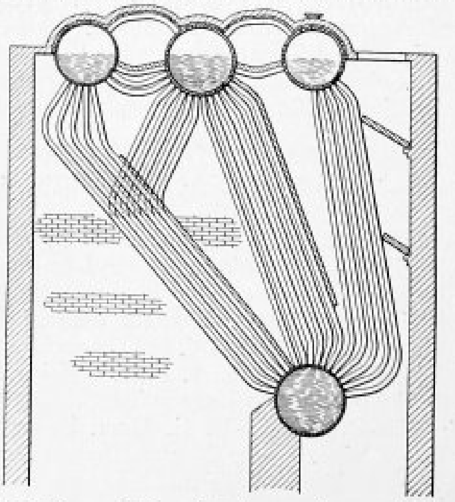
Claim.—A steam generator comprising a water-jacketed boiler including a shell outlining a combustion chamber, water heating means in said chamber including in superposed order, a gas burner, a basin containing a mass of lead spaced from the shell to provide an annular gas passageway



between the basin and shell, and a heating tube having opposite ends opening into the water space in the boiler and a midportion embedded in said lead and having end portions extending upwardly therefrom and positioned adjacent said shell and in the path of the burning gases from the burner. Eleven claims.

1,762,779. BOILER. LOUIS G. HALLER, OF CHATTANOOGA, TENN.

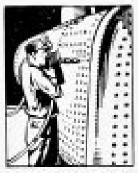
Claim.—In a boiler, the combination of a front, a middle, and a rear upper drum, a lower drum, all of said drums being parallel, a bank of tubes connecting the rear upper drum to the lower drum, a bank of tubes connecting the middle upper drum to the lower drum, and a bank of tubes arranged in rows lying in parallel planes at right angles to the drums, the



tubes of all of said rows having their lower ends connected to the lower drum, the upper ends of all of the tubes of a number of rows distributed through the bank from one end to the other being connected to the front upper drum, and the upper ends of all of the tubes of the remaining rows being connected to the middle upper drum. Ten claims.

The Boiler Maker

Reg. U. S. Pat. Off.



Baldwin Centennial

When a manufacturing organization passes through one hundred years of uninterrupted activity and grows from a one-man business to a corporation employing a maximum of 21,500 people, that organization may justly celebrate its exceptional progress. Such a company, The Baldwin Locomotive Works, was founded in 1831 by Matthias W. Baldwin and from the time of its inception has held a reputation for advancement. Not only in the building up of its own organization has The Baldwin Locomotive Works been progressive, but also in respect to the boilers it has produced. The equipment of the company together with the methods employed in the boiler shop are the most advanced in the boiler making industry today.

The boiler shop, the largest in the world, is capable of producing forty complete locomotive boilers per week. This is due to the excellent layout of the plant together with the modern selection of machinery. In general, it may be said that the mechanical facilities of the Baldwin boiler shop can accommodate practically every operation that might occur in the fabrication of any type of heavy or light plate work and would be equal to any demand of quantity boiler production. The plant is laid out to best advantage, being arranged to obtain a constant direction of material flow in order to reduce handling to a minimum. Manufacturing departments have been placed adjacent to the installing departments to bring about a co-ordination of effort. These factors —modern production control, modern equipment and modern material handling as well as effective layout— are instrumental in the success of the Baldwin Company.

An outline of the history of The Baldwin Locomotive Works, in this issue, mentions the ideals on which the company was founded. To have lived up to these ideals during a century of time and to be capable of further progress is an enviable record for any manufacturer.

Inspection Requirements

Fundamentally the quality of all locomotive maintenance and repair work depends upon the exact and careful determination of the condition of the machine by competent inspectors. After the parts requiring repair or replacement have been decided upon by examination, the actual work can be carried through according to more or less fixed specifications, which the mechanical engineer's staff has been able to develop. Such specifications, combined with quality workmanship by experienced men, make possible highly efficient motive power.

For many years the records of the Bureau of Locomotive Inspection have shown a marked improvement in the condition of power in this country as demonstrated by the continually decreasing number of accidents caused by failures of the locomotive and its appurtenances. Behind the record of improvement is the inspection staff, made up of Federal inspectors of the Bureau of Locomotive Inspection and the railroad inspectors. All railroads of the country are governed by the Federal inspection rules and regulations. A number of roads have amplified and adapted these fundamental requirements to their particular needs, to the end that the work not only of the inspectors but also of the men in the shop is greatly simplified.

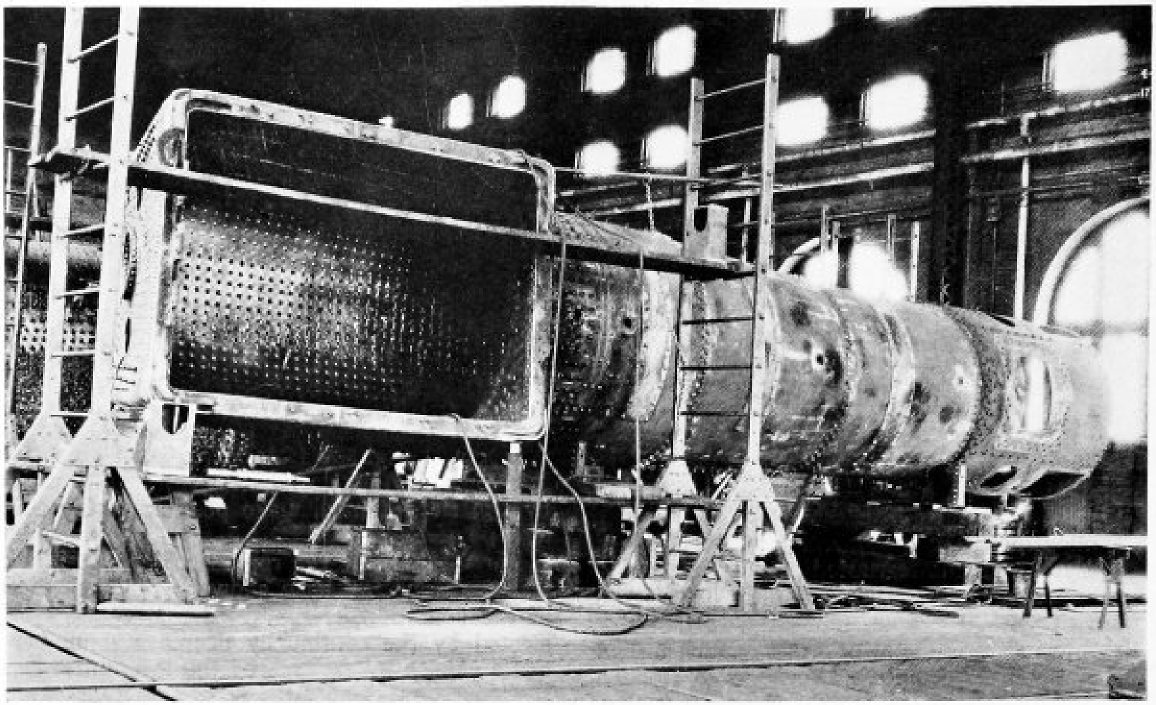
As an example of this, the Northern Pacific Railway Company's inspection and test requirements for locomotive boilers are outlined in this issue. The rules given are in addition to the regulations of the Bureau of Locomotive Inspection and as such demonstrate the possibilities in this direction. These rules are issued to all mechanical officers, supervisors, inspectors, foremen and others whose duty it is to maintain the locomotives for the railroad. With these rules in mind it is possible for every man to understand exactly the work he will be called upon to perform in any particular case. Individual interpretations are thus eliminated and errors in judgment or misunderstandings cannot occur.

Rules have also been prepared governing the actual operations to be performed, with explicit explanation for procedure. Further articles on welding practice, patch design, flue practice and general locomotive boiler repair work of this railroad will appear in later issues.

Welding Engineers

With welding rapidly becoming a vital factor in the construction of pressure vessels, a thorough and exact knowledge of its applications and limitations is necessary to all those—manufacturers, engineers, inspectors and men in the shops—who will have to apply it to the vessels which they collectively produce. Realizing the importance of this, the American Boiler Manufacturers' Association, at its recent annual meeting, invited an outstanding authority on the subject of fusion welding, Dr. Comfort A. Adams, to address them on practical phases of welding.

(Continued on page 190)



In the Brainerd boiler shop of the Northern Pacific

Northern Pacific Rules for Boiler Inspection and Test

The methods of inspecting and testing locomotive boilers, although basically the same, on railroads of the United States, being regulated by requirements of the Bureau of Locomotive Inspection, actually vary somewhat in method. The following outline of requirements of the Northern Pacific Railway Company, as issued to all those dealing with the phases of boiler work, offers an excellent example of proper control in this important work:

Where laws exist boilers must be inspected, tested and reports made in conformity with the requirements of those laws. Where no laws exist these rules will govern. Where laws do exist and the requirements are less rigid than those given, the latter rules will govern.

All boilers shall be given a general inspection once every twelve months.

The general inspection shall include a hydrostatic test with hot water, a steam pressure test, a staybolt test, and a thorough external and internal inspection.

Once every month the boilers of all locomotives in service shall be inspected and have the staybolts tested.

Boilers are to be washed out once every month, and oftener if the character of the water in the district makes it advisable.

Safety valves, steam gages, etc., shall be tested when boilers are washed, once every month, except as hereinafter provided.

The working steam pressure of all boilers in service and the hydrostatic and steam test pressure must conform to the schedule issued by the general mechanical superintendent.

Gage cocks and water glass gages must be cleaned and inspected and all spindles must be removed and cleaned of all scale or sediment at least once each month.

All staybolts shorter than 8 inches except flexible stays must have telltale holes $\frac{3}{16}$ inch in diameter and not less than $1\frac{1}{4}$ inches deep drilled in the outer end. These holes must be kept open at all times. All flexible staybolts having caps over the outer ends shall have the caps removed once every 24 months, and also must receive the hammer test each time a hydrostatic test is applied with a pressure not less than the allowed working pressure and proper notation of such test made. Flexible staybolts which do not have caps shall be tested once each month the same as rigid bolts.

A boiler found to have more than one broken staybolt in any one whole firebox sheet must be held out of service until new bolts are applied.

The use of flue plugs is prohibited at shops and roundhouses. Where used temporarily at outlying points, the plugs must be provided with a hole through center not less than $\frac{3}{4}$-inch diameter. Where one or more tubes are plugged at both ends of tube, they must be tied together by means of a rod not less than $\frac{5}{8}$-inch diameter. Such plugs must be removed and tubes repaired at next regular inspection.

If a defect or leak develops, which cannot be corrected by those immediately in charge, the master mechanic shall at once be notified; he will have the foreman boiler maker inspect and report his findings, the boiler to be held out of service until released by master mechanic.

The use of taper plugs to repair leaks is prohibited. Where plugs are necessary they must be turned parallel and made of wrought iron.

At every monthly inspection when boiler is washed or the steam gage is tested, the safety valve set or the gage cocks or water glass cocks cleaned, a special report form must be filled out in quadruplicate, the original and one copy to be sent to the general boiler inspector at St. Paul, one copy to be placed in card holder in the cab of locomotive provided for that purpose, and the remaining copy forwarded to the division master mechanic for his office record.

If any staybolts are found broken or partially broken, or are replaced for any cause, their locations shall be indicated on the back of the proper forms, furnished for that purpose; copies to be forwarded as provided for above.

When locomotives are working and stationary boilers are in regular service, the steam pressure should be kept as nearly uniform as possible. Water should be fed to the boiler steadily and a constant water level maintained.

Permitting the water level to become low and quickly filling the boiler with cold water, causes rapid variation in the pressure and temperature and produces undue stresses.

To prevent currents of cold air passing through the firebox and tubes, locomotives with fires drawn or with banked fires, must have the dampers closed and shall be moved by their own steam as little as possible.

The general boiler inspector, master mechanics and foreman boiler makers shall personally keep in touch with the work of inspecting and caring for boilers, and must know that the rules and instructions are complied with.

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

In addition to Federal requirements for locomotive boilers, the Northern Pacific Railway Company, Mechanical Department, has issued additional rules governing the inspection, test and care of steam boilers. The present article outlines the scope of these rules and regulations and constitutes the first of a series of articles which will cover the boiler repair and maintenance practice of this railroad. Specific examples of the methods and tools employed, as well as details of patching, welded design, and the like, will be given.

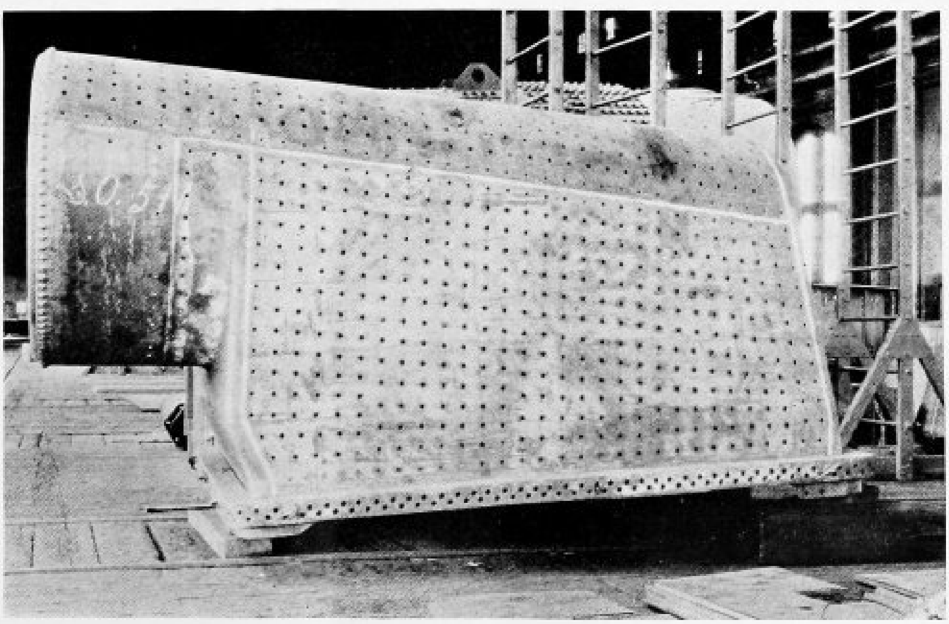
Whenever the flues are taken out, the inside of the boiler must have the scale removed and be thoroughly cleaned. The entire interior of the boiler must then be examined for cracks, pitting, grooving or indications of burning, and for damage where mud has collected or heavy scale formed. The edges of all plates, all laps, seams and points where cracks and defects are most likely to develop, or which the exterior examination may have indicated, must be given an especially minute examination.

If telltale holes in staybolts have become plugged or have pins properly secured in place, and that each is in condition to support its proportion of the stress.

If tell-tale holes in staybolts have become plugged or obstructed, they shall be cleaned out or, if necessary, redrilled.

After all required renewals and repairs have been

Firebox assembly ready for installation



made and flues put in place, the boiler will be subjected to a hydrostatic test pressure of 25 percent above the working pressure.

All cocks, valves and fittings must be tight under this pressure.

If leaks or defects are found to exist they must be remedied.

Then, with the water drawn off and the boiler under a pressure of from 75 to 100 pounds of air or steam, the staybolts must be tested by the hammer test, and all found broken or defective shall be replaced.

After this, the boiler will be filled with two gages of water, fired up, and steam raised to 15 percent above the allowed working pressure, attention being given to the proper operation of safety valves when the desired pressure is indicated by the steam gage.

These tests must be made under the personal supervision of the foreman and boiler inspector, who will examine the entire shell and firebox for defects while the test pressures are on. A record of these tests must be made.

Monthly Inspection—The firebox and all parts of the boiler which can be reached, of every locomotive in service, must be carefully examined once every month and the staybolts given the hammer test under steam or air pressure of 75 to 100 pounds. All telltale holes must be opened before test is made.

Defects will be remedied, new staybolts put in if required and a diagram filled out as previously explained.

Every boiler taken into a shop for repairs, whether work is required on the boiler or not, and regardless of the date of last inspection, shall not leave the shop until the boiler is as completely examined and tested as possible and a form filled out in quadruplicate, the original and one copy to be sent to the general boiler inspector at St. Paul, one copy to be placed in card holder in the cab of locomotive provided for that purpose, and the remaining copy forwarded to the division master mechanic for his office record.

Safety Valves and Steam Gages—The steam gages of all locomotive boilers must be tested and set at least once every month. Safety valves must be tested under steam at least once every three months, and also when any irregularity is reported.

If the safety valves fail to open at not to exceed three pounds above the working pressure as shown by the gage, an examination must be made at once, the gage tested and valves properly set.

For locomotives which do not reach a shop where a standard gage testing apparatus is located, the master mechanic at the required interval, will supply a tested gage to replace the one in use, and, if necessary, a competent man will be sent to examine the safety valves and exchange the gages.

The gage removed will at once be forwarded to the master mechanic, who will have it tested and put in first-class condition. This exchange of gages will require that the master mechanic keep on hand a few extra gages.

The pipe connection to the steam gage shall be formed as a siphon and must be filled with water.

Safety valves will be set by the gage employed upon the boiler, the gage in all cases to be tested before the valves are set or any change made in the setting.

When setting safety valves the water level should be at the middle gage cock.

For locomotive boilers equipped with both muffled and open pops, the muffled valve will be set to open at the working pressure; the pop valves at three to five pounds above the working pressure; not to exceed five pounds.

For all other boilers the safety valves should be set at the working pressure; an extreme variation of from two pounds below to three pounds above will be allowable.

The foreman in charge must personally direct the work and will furnish a report.

Washout Regulations—Preliminary to washing, a boiler must be gradually cooled. The crown sheet and tubes or fire sheets and flues of the boiler must be kept well covered with water during the process of cooling, so that mud cannot dry and bake upon the hot sheets.

Do not empty a boiler by blowing off while under pressure excepting at points where hot water is used for washing.

The procedure of washing should be such that the sediment and scale will be washed from the higher to the lower surfaces and deposited where it can be reached and removed through the plug holes or manholes provided for that purpose.

A plug hand-hole plate or manhole cover must be returned to the hole from which removed, and plugs are to be coated with a mixture of oil and graphite.

When plugs are removed, the screw threads in the boiler sheet must be protected from damage by the nozzle or otherwise during the process of washing, and if found defective or damaged, shall receive proper attention.

In the absence of special instructions all boilers will be washed out once every month, a report of each washout to be stencilled on left forward corner of running board, with white lead, showing month and date of washout.

To assist those having the work in hand a special washout record board has been provided at each roundhouse, showing engine number and date of washout.

When a locomotive boiler is to be washed, first see that there are at least three gages of water in the boiler. Then blow off steam until the gage shows the boiler to be entirely relieved of pressure, excepting at points where hot water boiler washing plants are installed.

The highest row of plugs in the back boiler head should now be removed and the crown sheet nozzle inserted. These nozzles, which are numbered *two* and *three*, are of special construction and are made long enough to reach over and wash the flue sheet and the flues where they unite with the sheet.

When cold water is to be used for washing out, turn on slowly at first and do not open the blow-off cock until water has been running out of the top plug holes for several minutes and the cold water has had time to properly circulate and gradually reduce the temperature of the whole.

If the boiler is washed with hot water, the supply may be turned on full and the blow-off cock opened at once.

Plugs to be Removed—When boilers are washed, all washout, arch and water-bar plugs must be removed. Boilers should be thoroughly washed through every washout opening.

First wash the crown sheet and flue sheet and the upper portion of the firebox door sheet with the long special nozzles Nos. 2 and 3, from the back head; then arch tubes with Liberty flue cleaner and nozzle No. 1; over and under fire door and in barrel of boiler over checks with nozzle No. 2; the bottom of the shell and lower flues and under combustion chamber with nozzle No. 4, specially designed for this purpose; then sides over mud ring with nozzle No. 2; finally with straight nozzle No. 1, from each corner the mud ring shall be thoroughly washed and all scale removed.

The interior of the boiler at every washing, by the use of torch and mirror, must be as completely examined as possible, and suitable rods and scrapers employed to detach scale which has not been dislodged by the washing.

In addition to the usual report, the foreman in charge will keep notes on the condition of each boiler under his charge.

The standard pressure for washing out is not less than 90 pounds at a ¾-inch nozzle.

At the roundhouses, flues will be expanded with grooved expander only and flue rollers are not to be used, except when new flues are being put in.

The lighting of a fire in the firebox is positively prohibited except on the personal authority of the roundhouse foreman, assistant roundhouse foreman, boiler foreman, night roundhouse foreman, or hostler. The above mentioned roundhouse men will be held personally responsible for injury to fireboxes due to firing up locomotives without sufficient water in the boiler.

(To be continued)

Combustion Steam Generator

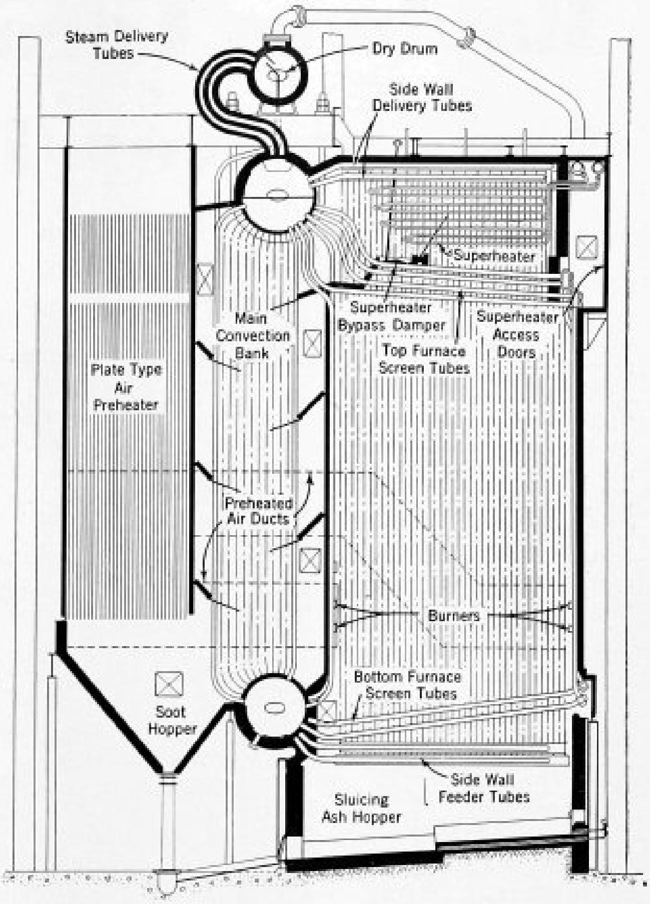
Combustion Engineering Corporation, 200 Madison Avenue, New York, is now offering the Combustion steam generator, a standard steam generating unit built in various sizes and providing a wide range of capacities at any desired conditions of steam temperature and pressure. Detail designs have been completed for eight sizes with capacities ranging from 70,000 to 400,000 pounds of steam per hour, from and at 212 degrees F.

As shown in the accompanying illustration, this design combines in one unit all the elements required for fuel burning, steam generation and superheating, heat recovery and ash disposal. Those familiar with the development of pulverized-fuel firing and the history of steam generating practice will note that there are no novel or radical departures from fundamentals, but rather that the design represents a highly compact and simple arrangement of long and well established elements. They will also note the apparent absence of the maze of pipes, headers, etc., exterior to the boiler casing, with which such construction has become associated in their minds. These pipes and headers essential for completing the circulating system of water walls are located entirely within the casing, where, in addition to performing their normal function as circulators, they also serve as highly effective heat-absorbing surface.

A point of particular interest is the entire absence of openings through the casing. Such openings are ordinarily required for the ingress and egress of wall tubes and headers. They are never perfectly sealed and consequently permit the discharge of dust during soot-blowing operations as well as the inflow of air during normal operation. The Combustion steam generator casing is air-tight and dust-tight throughout.

All four walls of the furnace are water-cooled, each wall being composed of a solid row of tubes with only sufficient space between them for construction requirements. The water-wall feeder and delivery tubes, at the bottom and top of the furnace respectively, complete the heating surface of the furnace proper nearly all of which is exposed to radiant as well as convection heat.

The result of this arrangement of wall tubes and circulators is a furnace built completely of watertubes



Sectional side elevation of Combustion steam generator showing the principal parts and arrangement of elements

to the exclusion of exposed refractories and having the maximum attainable quantity of contained water with provision for the highest possible freedom of circulation.

This type of furnace is perfectly adapted to the corner-tangential system of firing which produces intense turbulence with extreme rapidity of combustion and correspondingly high temperatures; these high temperatures being the result (not the cause) of the high rates of combustion.

Another feature of interest is the superheater by-pass damper which affords a unique and much needed means of controling superheat temperature. Adequate space is provided for the superheater which is so located in the assembly as to permit of simple supports and a degree of accessibility unusual in boiler construction.

The first unit of this new design to be installed in America has now been in operation for several months in the plant of a leading industrial company. In overall results and ease and dependableness of operation, its performance has set an exceptionally high standard.

R. I. Fretz has been transferred from the Reading district and will assume charge of the Pittsburgh district in place of Wyman Howells who will now direct the activities of the Reading district.

The Babcock & Wilcox Company, New York, has acquired non-exclusive licenses under the automatic arc-welding patents of the Automatic Arc Welding Company, New York. The initial payment for such licenses was $20,000.

Baldwin Locomotive Works Celebrates Its Centennial

It is a notable event when any industrial enterprise in America has survived the vicissitudes of a century and lived to celebrate its one-hundredth birthday. Founded by Matthias W. Baldwin, when he undertook to build a miniature steam locomotive for the Philadelphia Museum in 1831, The Baldwin Locomotive Works has shared the entire life of steam transportation, growing with the railroads, without a break in the continuity of the enterprise or its management. So marked has been this continuity that men in the service of the corporation today speak familiarly of the work of the founder and his associates.

Matthias Baldwin was an able craftsman, an ingenious inventor and a man who adhered to a chosen course with a fixity of purpose which sometimes amounted to stubbornness. His ingenuity and skill as a mechanic stood him in good stead during his early ventures in locomotive building. Machine tools were few and crude and few mechanics competent to enter this new field were available. It is said that few blacksmiths could be found who could weld a bar of iron larger than 1¼ inches thick and that cylinders had to be bored with a chisel fixed in a block of wood, turned by hand. For years, therefore, his endeavors were as much concerned with finding new shop methods and practices to keep ahead of the requirements of the new industry as in the development of the product itself.

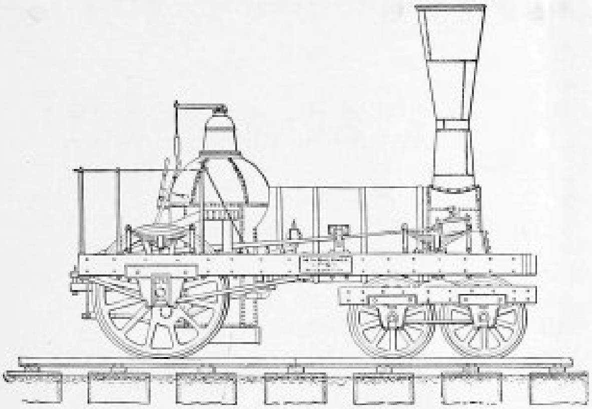
One of the outstanding facts in the history of The Baldwin Locomotive Works is that it was operated as a partnership until 1909, before it was incorporated. Not until 1911, however, did its stock become available to the public, when it was reorganized as a public joint stock company under the laws of Pennsylvania. For practically the entire period during which the railroad system of the United States was being laid out and developed, therefore, The Baldwin Locomotive Works was operated and expanded with the resources of its owner-managers. It is one of the few if not the only established major industrial organization in the United States which passed unchanged through the period of great financial reorganizations and mergers started during the early years of the present century.

Early in his career as a locomotive builder Mr. Baldwin sought the association of others in the management of the enterprise. In 1839 he took George Vail and George W. Hufty into the business and the partnership of Baldwin, Vail & Hufty was formed. In 1842 this partnership was dissolved and Asa Whitney joined Mr. Baldwin in the firm of Baldwin & Whitney. Mr. Whitney had been superintendent of the Mohawk & Hudson. He withdrew from the firm in 1846 to establish the firm of A. Whitney & Sons, which engaged in the manufacture of car wheels in Philadelphia.

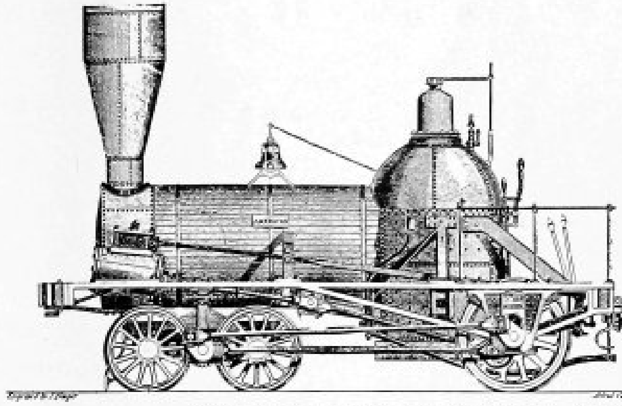
Aside from his railroad experience, Mr. Whitney brought to the firm a thorough business talent. He is said to have systematized many of the details of the management of the business which Mr. Baldwin in his preoccupation with mechanical problems had ignored. It was shortly after Mr. Whitney became a partner that the present method of designating locomotive types by letters and numbers, based on the wheel arrangement had its origin.

Mr. Baldwin continued his business alone until the firm of M. W. Baldwin & Company was formed in 1854, with Matthew Baird as the partner. Thus began the period of overlapping partnerships which continued in unbroken sequence until 1909.

Mr. Baird had been a foreman in the works since 1836, and it was he who carried on the business follow-



A Baldwin locomotive of 1834



From the Journal of the Franklin Institute, Vol III.

Baldwin's geared locomotive

ing Mr. Baldwin's death in September, 1866. The following year the firm of M. Baird & Company was formed with George Burnham and Charles T. Parry as partners. Both had been employees of Mr. Baldwin from his pioneer years as a locomotive builder. Mr. Burnham, whose connection with the works began in 1836, continued in the firm until the final partnership of Burnham, Williams & Company was dissolved in 1909 to make way for the corporation.

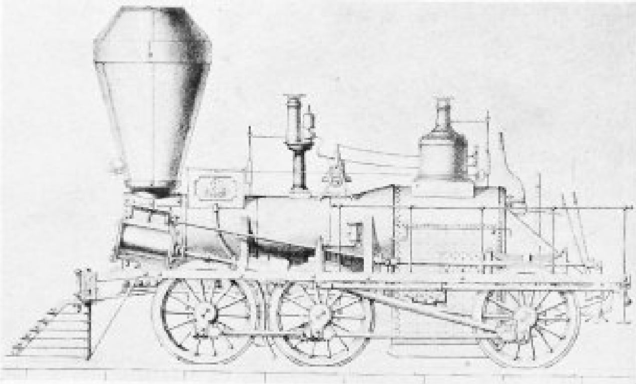
Space does not permit a complete record of the changes in the firm, but two of these are worthy of special comment. In 1873 the other partners bought out Matthew Baird (a transaction said to have involved over a million dollars) and organized the firm of Burnham, Parry, Williams & Company. In addition to Messrs. Burnham and Parry, the partners in the new firm were Edward H. Williams, William P. Henszey, Edward Longstreth and John H. Converse.

Mr. Burnham had for some time been in charge of the financial affairs of the business. Mr. Parry has been general superintendent, in charge of the operation of the works. Mr. Williams, who had been brought into the business as a partner in 1870, contributed a broad experience as a railroad officer and a wide acquaintance among railroad men, which fitted him to handle sales. Mr. Henszey, who was mechanical engineer and had been an employee since 1859, was largely responsible for the standardization of locomotive details, and had perfected a system for manufacturing interchangeable parts for locomotives of the same class. He had also designed many unusual types of locomotives to meet difficult service requirements. Mr. Longstreth had succeeded Mr. Parry as general superintendent. Mr. Converse, who became a partner in 1878, had been associated with Mr. Williams in a clerical capacity during the latter's railroad days and was brought in by Mr. Williams in 1870 to organize and improve the office work and accounting.

This brief survey of the partnership of 1873, suggests that, while men were brought into the management from outside to meet special conditions, most of the partners had served years of apprenticeship in the business before assuming responsibility for a part in its management.

It was during this partnership, in 1875, that the firm acquired a controlling interest in the Standard Steel

An early ten-wheel locomotive built for the Cleveland & Pittsburgh in 1856



A six-wheels-connected locomotive of 1842

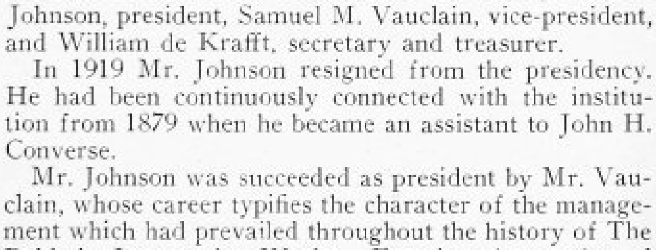
Works which had been incorporated in that year by the creditors of the former proprietor, William Butcher.

In 1896 three new members were admitted to the partnership. These were Samuel M. Vauclain, Alba B. Johnson and George Burnham, Jr. Messrs. Vauclain and Johnson, and William L. Austin, who became a member of the firm in 1886, are all widely known among the present generation of railroad men.

In 1899, prior to the death of Edward H. Williams, there were eight partners. During the next decade the number had been reduced by death or withdrawal to five, one of whom was past 90 years of age. The financial burden thus placed on the remaining active members led to the incorporation in 1909. The following year $10,000,000 of first mortgage bonds were issued, the first public financing in the history of the institution. In 1911 the present corporation was organized, with William L. Austin as chairman of the board, Alba B. Johnson, president, Samuel M. Vauclain, vice-president, and William de Krafft, secretary and treasurer.

In 1919 Mr. Johnson resigned from the presidency. He had been continuously connected with the institution from 1879 when he became an assistant to John H. Converse.

Mr. Johnson was succeeded as president by Mr. Vauclain, whose career typifies the character of the management which had prevailed throughout the history of The Baldwin Locomotive Works. Entering the service of the works in 1883 after having served there as an inspector for the Pennsylvania Railroad, Mr. Vauclain was made general superintendent early in 1886 in the reorganization following the retirement of Edward Longstreth as one of the partners. Ten years later he became a partner and served as a director of the first corporation. When the present corporation was organized in 1911, Mr. Vauclain was elected vice-president and a member of the board of directors, and he became senior vice-president later in that year. On March 28, 1929, he was elected chairman of the board of directors and was succeeded as president by George H. Houston.



Drawing of boiler for "Old Ironsides" made by Mr. Baldwin in 1882

The history of the growth and development of The Baldwin Locomotive Works parallels the history of the growth of steam railroad transportation in America. Beginning with the period when steam locomotives were a public curiosity and when the future place of the steam railroad in the economic life of America was still a matter of controversy, the facilities and output of the Works grew as the increase in railroad mileage and traffic density created a constantly increasing demand for locomotives.

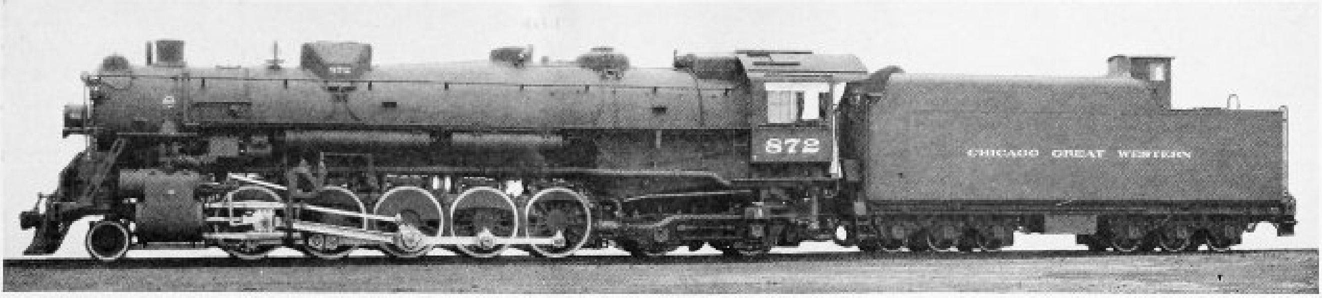
During the decades of growth and development of the railroad system in the United States The Baldwin Locomotive Works grew from a shop employing some 300 men in 1837 to an aggregation of shops employing a maximum of 21,500 men.

After having expanded steadily on land now within the heart of the City of Philadelphia, it ultimately became necessary to find more room for further expansions. Accordingly in 1906 a site of 184 acres was purchased at Eddystone, Pa., and the foundries and blacksmith shops were established on this property. At various times during the next twenty-two years additional departments were transferred to new quarters erected at Eddystone, some of them in buildings which were first used for the production of munitions during the war. Since the transfer of the last department in June, 1928, the Eddystone plant of The Baldwin Locomotive Works, now occupying sites aggregating 518 acres, presents a picture of well integrated and co-ordinated facilities that it falls to the lot of few industries developed over so long a period to possess.

It would be impossible in the scope of a single article to record all of the events in the early evolution and later developments of the steam locomotive boiler in America in which the men, connected with The Baldwin Locomotive Works, played a part. However, we are fortunate is being able to reproduce a drawing of a boiler made by Mr. Baldwin himself for his first locomotive, "Old Ironsides," in 1832. This boiler, 30 inches in diameter, had a rectangular firebox and smokebox and 72 copper tubes, each 7 feet long. In the early days of boiler building, nothing but an outline was made on the drawing and only the principal dimensions were shown. Two years later, Mr. Baldwin adopted the dome-shape firebox, as is shown in another illustration, and a short time afterwards, this firebox was modified in such a way that the dome and the boiler barrel were faired with a gradual curve. This development is evident in the boilers built by Mr. Baldwin in 1848.

In the early days, a number of watertube boilers were constructed in accordance with F. P. Dimpfel's patent of 1838. This type of boiler contained approximately 186 tubes, having 1¼ inches outside diameter. These tubes extended between the front tube sheet and the crown sheet of the firebox.

Among the interesting developments of the sixties may be mentioned the growing use of steel in various parts of locomotive construction. Steel fireboxes were first applied to locomotives built by The Baldwin Works



"Old Ironsides" weighed something less than 6 tons in working order—this locomotive weighs 232 tons in working order

in 1861. The first application, on some locomotives built for the Pennsylvania, was of an English steel of high temper which cracked while the sheets were being fitted and it became necessary to replace the steel firebox with copper. The so-called homogeneous "cast steel" of American manufacture was then tried out on two locomotives completed early in 1862 for the Pennsylvania Railroad. This material was found to work successfully and by 1866 its use had become general.

Between the early days of Mr. Baldwin's achievements and approximately 1870, the records of the boilers constructed and of the developments made in that time are quite incomplete. However, locomotives employing flat-sided wagon-top boilers with T-iron stays in the gussets were in evidence about 1872, while at the same time a boiler with two detachable domes and crown bar staying was built. In 1877, a number of unusual locomotive boilers were built for Anglomar's steam street cars. This type of boiler was constructed to reduce the height of the barrel, which was oval in shape, having a height of about 7½ inches and a width of approximately 24½ inches. This was later increased to a height of 12½ inches and a width of 26½ inches. In 1878, a number of boilers, similar to the Gray & Chanter boiler of 1837, were constructed. These employed the divided firebox and with this exception were similar to the prevailing boilers of that period.

About 1877, John E. Wootten developed the first broad firebox boiler which has since been modified in almost every conceivable shape and under fictitious names. In the first Wootten boilers, a long overhanging, but very shallow, firebox was incorporated, a combustion chamber being projected into the barrel or waist of the boiler. The water leg was provided next to the throat sheet which was extended above the bottom of the combustion chamber and on which the bridge wall was built. A mud ring or water space frame was made out of U-shape metal bent and ingeniously joined at the corner. This type of boiler served its purpose in the burning of refuse or unmarketable sizes of anthracite coal. By 1900, all of the fast trains on the Reading Railroad were operated with this type of boiler and by its employment was able to save approximately 68 percent in the cost of fuel over the old type of locomotive.

In 1895 a locomotive with the customary four-wheel leading truck, two pairs of coupled wheels, both placed in front of the firebox, and a pair of trailing wheels under the firebox was built by Baldwin for the Atlantic Coast Line, and this wheel arrangement became known as the Atlantic type. Although the firebox in this locomotive did not assume the characteristic form of modern trailer-borne fireboxes, advantage was taken of the opportunity offered by the trailer to place the mud ring above depressed frames and thus increase the firebox volume without unduly raising the center of gravity.

About 1900, the Vanderbilt boiler, employing a circular corrugated firebox, was introduced. Quite a number of these boilers were built and in a few cases were modified to employ three fireboxes with a single combustion chamber, similar in type to our present-day Scotch boiler used aboard ship. The years between 1900 and the present day show marked advance, not only in the perfection of the present type locomotive, but also in the increase in size and tractive force. The

A locomotive takes shape in the erecting shop

Belpaire firebox is quite popular among railroads today and has been used by the Pennsylvania Railroad for a number of years. Among the novelties of this design is the construction of boilers without seams at the front of the inside and outside throat sheets.

About 1915, approximately 280 locomotives were built employing the Pechot type boiler. These were double-end boilers, with a firebox in the middle.

In later years, a locomotive known as No. 60,000, the 60,000th locomotive built by The Baldwin Locomotive Works, stands out as another great step in the advancement of the locomotive builders' art. This engine, built during the early part of 1926, employs the Emerson watertube firebox and operates at a pressure of 350 pounds per square inch. Built with driving wheels, 63½ inches in diameter, and with cylinders each 27 inches in diameter by 32 inches stroke, the total weight of the locomotive was 457,500 pounds, of which 338,400 are on the driving wheels. Apart from the modifications necessary to the use of the watertube firebox and the high pressure, the boiler does not differ in principle from that of the conventional locomotive. The boiler barrel is of the usual firetube type having two hundred and six 2¼-inch tubes and a type-A superheater, carrying fifty 5½-inch flues. In the firebox, each side wall consists of forty-eight tubes, 4 inches in diameter, connecting a hollow steel mud ring at the bottom to one of the horizontal cylindrical drums at the top. This construction provides a boiler entirely free from staybolts and from flat surfaces requiring staybolts. This feature of design gives it an important advantage when high steam pressures are to be carried.

While the development of the locomotive boiler has followed along conventional lines, limitations in early construction were caused by the inability of rolling mills to produce large-sized plates. When it is considered that practically no machinery for handling heavy material was available during the first part of the 19th century, it may be realized that the development in design was limited by the ability of manufacturers and their machinery to fabricate boilers. At the present time, however, with the production of high-grade steel, modern machinery and welding methods, a number of the limitations imposed upon early designs have been removed. The use of the all-welded firebox has been proven in service, while other developments in boiler staying and construction render the modern boiler, as produced by the Baldwin Locomotive Works, quite different from the original boiler as produced by Matthias W. Baldwin.

Work of the Boiler Code Committee

The Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information as to the application of the code is requested to communicate with the secretary of the committee, 29 West 39th street, New York, N. Y.

The procedure of the committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the secretary of the committee to all of the members of the committee. The interpretation, in the form of a reply, is then prepared by the committee and passed upon at a regular meeting of the committee. This interpretation is later submitted to the council of the society for approval, after which it is issued to the inquirer and published.

Below are given records of the interpretations of the committee in cases Nos. 676, 680, 681, 682, 683, 684 and 685 as formulated at the meeting on March 27, 1931, all having been approved by the council. In accordance with established practice, names of inquirers have been omitted.

In addition, cases Nos. 661 and 674 formulated at the meeting on April 24, 1931, are included.

CASE No. 676. Inquiry: Is it considered that an outside-screw-and-yoke type of globe cross-valve will meet the requirements of the Code when used as a shut-off in a connection to a water column; the valve to be similar in construction to the angle type of valve which causes no stoppage of flow by deposits of sediment and has a hand wheel attached to the rising and falling stem?

Reply: It is the opinion of the committee that unless the valve stem of the type of valve described, is so arranged that it indicates clearly by its position whether the valve is open or closed, the construction will not meet the requirements of Par. P-293 of the Code. It is the further opinion that the opening provided between the seat and disk of the valve must be such that a full free opening is obtained. The construction of such a type of globe cross-valve interferes with proper cleaning of the water column connection and it is pointed out that erroneous installation of such a cross-type valve might create a hazardous condition.

CASE No. 680. *Inquiry:* Will a steam gage siphon which is formed to provide a water pocket between baffles in the body of the device, meet the requirements of the Code for Low-Pressure Heating Boilers if it is made of ferrous material, if its water capacity is not sufficient to insure that the gage tube will be kept full of water under all conditions of normal operation, if the connection between it and the steam gage is of ¼-inch diameter iron or steel pipe, and if it is installed so the water pocket is immersed in the steam space of the boiler?

Reply: The fact that the siphon is made from ferrous material does not, in the opinion of the committee, violate the requirements of Pars. H-55, H-56, H-108 and H-109, if the area through the siphon is at least the equivalent of ½-inch pipe size, and the distance between the gage and point of attachment of pipe is not over 5 feet. The siphon as described does not meet the requirements of Pars. H-55, H-56, H-108, and H-109 if the water capacity is not sufficient to keep the gage tube filled with water under all conditions of normal operation, nor unless all parts of the piping less than ½-inch pipe size are of brass, copper, or bronze composition. It was not the intent of the Code to sanction the installation of a siphon with the water pocket immersed in the steam space of the boiler. A revision which will prohibit such installation is under consideration.

CASE No. 681. *Inquiry:* With further reference to Case No. 672, are the plates into which the pressed steel diaphragm plates are inserted and welded to be classified as tube sheets or heads, under the meaning of Par. H-12, in which the minimum thickness requirement is $\frac{5}{16}$ inch?

Reply: It is the opinion of the committee that where cross boxes such as the pressed steel diaphragm plates described are inserted in the slots in plates and welded therein, neither the boxes are to be classified as tubes, nor the plates in which they are inserted to be classified as heads as contemplated in Par. H-12.

CASE No. 682. *Inquiry:* Is it the intent of Par. H-35, which requires that wet-bottom steel-plate boilers be so set that there will be a space of not less than 12 inches between the bottom of the boiler and the floor line, to cover a rectangular-shaped boiler of a width not to exceed 36 inches with water space below the furnace?

Reply: Par. H-35 was intended to apply to steel-plate heating boilers of the wet-bottom locomotive type. It is the opinion of the committee that it should not apply to rectangular-shaped heating boilers of the type described, provided sufficient space is allowed beneath the bottom of the boiler for inspection. It is the further opinion of the committee that if 6 inches clearance is provided for a boiler of the sort and the boiler is so set that all parts of the bottom can be thoroughly inspected, the intent of the paragraph will be met. A revision of the Code to embody this idea is contemplated.

Case No. 683. (In the hands of the committee).

Case No. 684. *Inquiry:* Will a jacketed kettle of riveted construction meet the requirements of the Code for Unfired Pressure Vessels if the inner shell is formed of a nickel-chromium steel known as Enduro KA2, which has the following analysis and physical properties:

Carbon, maximum, percent	0.07
Manganese, percent	0.40-0.65
Phosphorous and sulphur, maximum, percent	0.035
Silicon percent	0.30-0.75
Nickel, percent	8.00-9.50
Chromium, percent	17.50-19.50
Tensile strength, minimum, lb., per sq. in.	85,000
Yield point, lb. per sq. in.	40,000
Elongation in 2 inches, percent	55-60
Reduction in area, percent	70-75

All other details would be designed to conform to Code requirements, but it is noted that the Code calls specifically for flange or firebox-quality steel.

Reply: It is the opinion of the committee that an interrelation exists between the several Codes and although it is not specifically so stated in the Code for Unfired Pressure Vessels, Section VIII, the provisions in Par. P-1 of Section I of the Code, providing for the use of other materials than those for which specifications are given, is applicable to Section VIII. The committee is further of the opinion that the material as above described is suitable for the particular use proposed.

Case No. 685. *Inquiry:* In the recent 1930 revision of the Code for Unfired Pressure Vessels, Par. U-87 has been so modified that it now requires the entire vessel to be stress relieved as a unit and the provision for local annealing of the forge welded joints has been omitted. However, fusion-welded joints are permitted by revised Par. U-72 to be stress relieved either locally or the entire vessel as a unit, and it is respectfully requested that Par. U-87 be made at least as liberal in its requirements as Par. U-72.

Reply: It is the opinion of the committee that the provisions for stress relieving under Par. U-87 should be substantially in accordance with those provided for under Par. U-72. A revision is under consideration to make Par. U-87 substantially the same as Par. U-72.

Case No. 661 (Reopened). *Inquiry: a* Is it permissible to make the cylindrical portion of the furnace of an internally-fired boiler of lap-welded pipe which conforms to the Code specifications, or of firebox-steel plate with an autogenous-welded longitudinal joint? It is to be noted that in order to maintain uniform spacing of tubes, it will be necessary to locate one row of tube holes through or adjacent to the weld.

b Is it permissible to attach the dished head to the cylindrical portion of the furnace by autogenous welding?

c By what method may the strength of the cylindrical furnace, which is in compression, be computed in order to meet the Code requirements? Is it permissible to compute the allowable working pressure by Par. P-240 and decrease this in proportion to the efficiency of the plate along a longitudinal line of holes?

Reply: a The furnace in the boiler referred to may, in accordance with Par. P-9 of the Code, be formed of lap-welded pipe, or if it is cylindrical so that no cross-strains tending to induce tension stress develop in the longitudinal joint, it is the opinion of the committee that welding will not conflict with the requirements of Par. P-186.

b The Code does not prohibit this method of construction.

c The maximum allowable working pressure for a furnace of this particular type may be calculated by the Adamson ring formula as given in Par. P-242 and the allowable working pressure decreased in proportion to the efficiency of the plate along a longitudinal line of holes. As the tubes are rolled into holes in the furnace sheet, the inside diameter of the tubes may be used in the deductions for metal removed in computing the efficiency of the longitudinal joint.

Case No. 674. *Inquiry:* Will a steam gage for use on low-pressure steam heating boilers conform to Pars H-56 and H-109 of the Code, if the dial indicator movement is so designed that the movement of the pointer is over only a quadrant of a complete circle and it would be manifestly impossible to locate a stop pin at a minimum of 300 degrees of the circumference from the zero point?

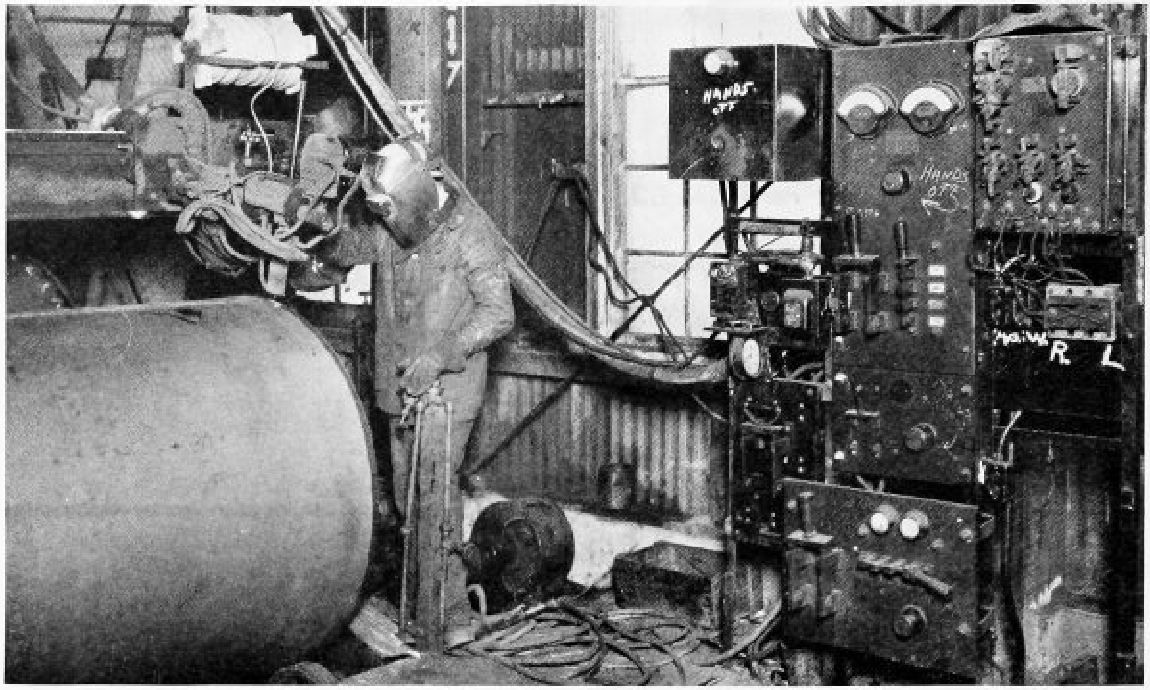
Reply: It is the opinion of the committee that the combination thermometer and pressure gage described does not conform to Pars. H-55, H-56, H-108, and H-109 of the Code, in that there is no stop pin at the zero point or at the maximum pressure point; because the pressure scale does not indicate 1½ times the maximum allowable working pressure for water heating systems; and because the travel of the pointer from the zero point to the maximum pressure point is less than 300 degrees of the dial circumference. A revision of the Code to cover the above is under consideration.

Twisting Angles and Straightening Twisted Angles

By George Gardner

It sometimes happens that angles which have been twisted have to be straightened and no means are at hand for furnacing them. If the twist is not too severe it can be taken out by holding the angle crosswise on a block and striking the flange just off the edge of the block. By looking along the bar it will be seen in which direction the twist occurs and the blows struck accordingly. An angle bar can also be twisted in this manner.

A general axiom of hot bending whether of angles or sheets is that steel will bend where it is hot and (especially in external corners of angles, bulb angles, tees, etc.) the length of the heat is of primary importance. If the heat is too long the material will bend where it is not required and involve extra work in removing or taking out the undesired bend. If the heat is too short the bend may break or the material will not be the right shape. Therefore a great amount of unnecessary work can be saved by heating, if possible, the material only where it is desired to bend it.



Welding head in end of large storage tank by electronic tornado process

Boiler Steels . . . and Other Soft Steels

By Henry Percival*

Of all the metals, steel is perhaps the most valuable because the service it performs is probably greater than that of any other material of which we have adequate knowledge. Our steam boilers, railroads, bridges, steamships and pipe lines for oil and natural gas are almost exclusively made of steel.

Iron in the form of wrought iron is also a good material, but it lacks the strength of steel; and yet, steel consists principally of iron. The carbon in 100 pounds of ordinary machine steel weighs only a trifle over 3 ounces. Disregarding tool steels, razor steels, etc., the soft and strong steels will never have more than, say 14 ounces of carbon to 100 pounds of steel.

In machine steel, boiler steel, and other soft steels, carbon is not present in all parts of the metal. In fact a large part of the total substance is pure iron and contains no carbon. However, adjacent to the particles of pure iron, there is another substance, containing all the carbon. This other material is cementite which is neither carbon nor iron, but a combination of the two. The most powerful microscope would not reveal in it a speck of carbon nor a speck of iron. The two things are in a partnership of such a character that neither is to be discerned.

Boiler steel is made up, in part, of particles of this cementite, while the remainder is pure iron. The microscope enables one to distinguish cementite from the iron.

In the foregoing, it has been assumed that steel consists only of iron and carbon. As a matter of fact, there are other kinds of impurities present. There is perhaps no piece of steel in commercial service that does not contain an assortment of substances other than carbon and iron. However, this is not necessarily a misfortune. Some of these impurities confer benefits while others do not.

In a modern treatise on steels, published in Germany and now available in English, the authors, Doctors Mueller-Hauff and Stein, place manganese as the most desirable constituent of steel after carbon. They list a series of substances which may be added intentionally for the purpose of securing special properties. Two of these are manganese and silicon. Consequently, we are not to regard these two substances as impurities, unless they are present in a considerable amount.

Let us note, first of all, that silicon is present in all steels. There may be only a trace. On the other hand, its proper amount may run up to 0.30 or 0.40 percent. Silicon is employed principally as a means of getting rid of gas. It may be added to high class steels for the purpose of removing the last traces of gas and thus supplying the metal without bubbles within it.

Let me now quote from "The Elements of Ferrous Metallurgy," by Dr. Rosenholtz. "Silicon in larger amounts [than 0.10 percent] improves the tensile properties of steel . . . It is especially valuable in making sound castings, since it decreases the tendency for the formation of blowholes."

The principal effect of manganese is to produce soundness by the formation of manganese sulphide and by freeing the steel from harmful oxides and gases. In

* New York Distributing Company, 1440 Broadway, New York.

manufacturing steel, aluminum is sometimes added for the purpose of getting rid of gas, especially if the steel itself is an alloy steel.

Naturally, manufacturers of welding equipment and developers of welding processes are, or should be, concerned as to the character of the steel which constitutes the weld. Porous metal—that is, metal containing bubbles of gas—is not wanted. In welding with the electric arc, the difficulties encountered in producing a proper steel in the weld have been attributed by some engineers to the electrodes or the process or the two combined. On the other hand, W. E. Stine, of the Research Laboratories of the Lincoln Electric Company, Cleveland, conceived the idea that the metal itself might be the cause of trouble. He attempted to overcome the difficulty along this line.

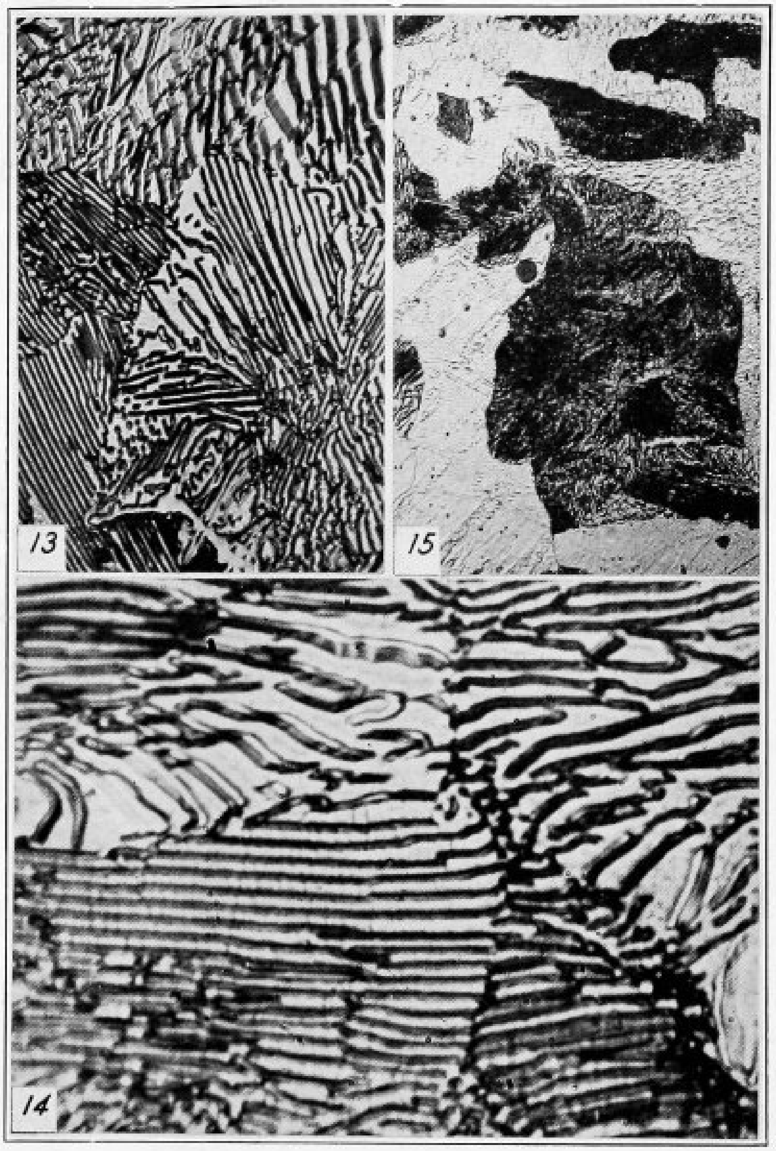
The solution finally secured was not attained without extensive efforts. In fact, thousands of steels were used in the experiments, actual welds, tests and analyses being made. Eventually, a graphic formula presented in the June, 1931, issue of The Boiler Maker, was produced. It is based on the principle that manganese and silicon, and sometimes aluminum, are competent when added in proper proportions to produce a steel for welding that will cause the final weld to be sound and free from porosity.

As the Lincoln system of welding with the shielded electric arc is widely used, we expect this new method of determining the proper steel to be used extensively in commercial practice. It is said that in any system of arc welding the graphic formula can be used to advantage.

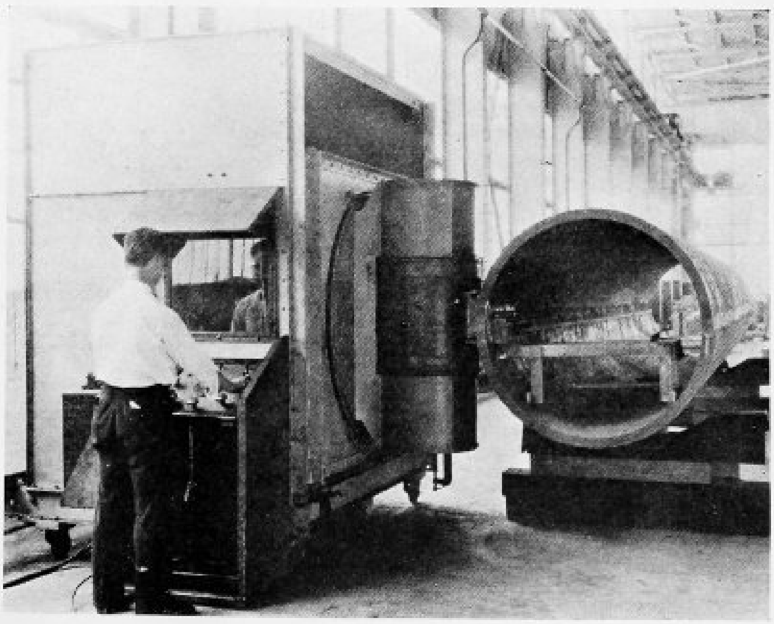
As the American Society for Steel Treating, 7016 Euclid Avenue, Cleveland, O., has been kind enough to lend the illustration showing Figs. 13, 14 and 15, it will be possible to set forth with some degree of clarity the structure of low carbon steel of the type ordinarily used in boiler manufacture. This illustration is taken from a recent book entitled "The Constitution of Steel and Cast Iron," by Frank T. Sisco.

Fig. 15 represents the appearance, in the observational field of a high powered microscope, of a small portion of a steel specimen surface. The steel is soft, having a carbon content of 0.25 percent. This means that in a lump of steel weighing 100 pounds, the carbon would weigh just 4 ounces.

Consider the matter of size. Fig. 15 represents a magnification of 1000 times. Consequently, the black and white regions in the figure were actually very minute. The white regions represent pure iron (ferrite) and the dark regions represent pearlite. It is perfectly clear that this sample is not a chemical compound. If it were such a compound, you would not be able to find different kinds of material, as is evident in Fig. 15. This prepares us to understand that steel is not a chemical compound but a kind of mixture. More than one kind of material can be discerned, if you are prepared to look closely



(Above) Fig. 13.—Pearlite magnified 1000 times. Fig. 14.—Pearlite magnified 3000 times. Fig. 15.—Structure of low carbon steel, 0.25 percent carbon, magnified 1000 times. (Below) X-ray installation in Babcock & Wilcox boiler shop at Barberton, O.



and detecting regions that differ from one another.

Perhaps the reader can detect differences in the dark spots. As a matter of fact, there are differences. This may be seen more clearly in Fig. 13. Here the magnification of 1000 times is the same. However, most of this steel is of the same material as that shown in the dark regions in Fig. 15. In fact, this steel is practically all pearlite. It contains more than three times as much carbon. Indeed, the sample shown in Fig. 13 is a steel containing 0.80 percent carbon. In 100 pounds of the steel, the carbon would weigh nearly 13 ounces.

The reader will, perhaps, have already suspected that Fig. 13 exhibits two different materials, since there are rather sharply defined regions of white and black. This is a fact. Pearlite itself is a kind of mixture. The white is pure iron and the dark is cementite, a chemical compound. It consists of carbon and iron, but they are so combined that a new material exists, neither iron nor carbon, just as water is neither hydrogen nor oxygen.

If the reader will look closely at Fig. 13, he may be able to discern some small dark spots, like grains of granulated sugar. But, for the most part the steel appears as strips of iron and cementite lying side by side. In fact, there are two kinds of pearlite, granular and laminated. Laminated pearlite consists of layers of cementite interleaved with layers of pure iron.

In Fig. 14, we have a splendid view of pearlite. The carbon content of this steel is 0.90 percent, so that it may be considered as all pearlite in structure. The reader may consider himself fortunate in having Fig. 14 set before him. The magnification is 3000 times. Measure one of the stripes. Divide the amount by 3000 and you have the actual width. This, however, is not really correct, since in preparing the steel for microscopic examination, there will be ridges and valleys (the black and the white), and the ridges have probably been somewhat eaten away by acid.

Return to Fig. 15 where you can see plenty of pure iron. This is because of the low carbon content. The large white patches and the white portions in the dark patches are iron, since these dark patches are really pearlite as shown in Figs. 13 and 14. There is more iron than is shown by the white; but it is undiscernible, being involved with carbon in the cementite constituting part of the pearlite.

In Fig. 15, the pearlite appears as islands in a sea of pure iron. It is easy to perceive that this iron which surrounds the pearlite islands is a large part of the whole. In 0.25 percent steel, there is more iron than could be crowded into pearlite.

It is naturally desirable to examine a finished weld in some way to ascertain, as easily as possible, its interior condition. Manganese and silicon, we will suppose, have duly taken care of the matter of porosity, by the chemical action of these two substances. After the weld is done, we can make an examination with X-ray apparatus to determine the actual condition. In the accompanying view, a boiler drum is set up so that the longitudinal weld may be examined. This view shows an X-ray installation in the boiler shop of the Babcock & Wilcox Company, Barberton, O. Equipment was supplied by St. John X-Ray Service Corporation, New York.

Locomotive Boiler ▲ ▲ ▲ Strength Formulas*

By C. J. Zusy and G. M. Davies

We bring to a conclusion the subject of locomotive boiler strength formulas with a discussion of the strength of stayed surfaces. The maximum allowable working pressure for stayed surfaces and the calculation of stay stresses are dealt with in the following paragraphs.

P=33.—(a) The maximum allowable working pressure for any curved stayed surface subject to internal pressure shall be obtained by the two following methods, and the minimum value obtained shall be used:

First: The maximum allowable working pressure shall be computed without allowing for the holding power of the stays, due allowance being made for the weakening effect of the holes for the stays. To this pressure there shall be added the pressure secured by the formula for braced and stayed surfaces given in Par. 28, using 80 for the value of *C*.

Second: The maximum allowable working pressure shall be computed without allowing for the holding power of the stays, due allowance being made for the weakening effect of the holes for the stays. To this pressure there shall be added the pressure corresponding to the strength of the stays for the stresses given in Table 7, each stay being assumed to resist the steam pressure acting on the full area of the external surface supported by the stay.

* This is the fifth and last of a series of articles entitled "Locomotive Boiler Strength Formulas." The first appeared in the March issue.

TABLE 7—MAXIMUM ALLOWABLE STRESSES FOR STAYS AND STAYBOLTS

Description of stays	Stresses, pounds per square inch: For lengths between supports not exceeding 120 diameters	Stresses, pounds per square inch: For lengths between supports exceeding 120 diameters
(a) Unwelded or flexible stays less than twenty diameters long, screwed through plates with ends riveted over	7500	....
(b) Hollow style less than 20 diameters long, screwed through plates with ends riveted over	8000	....
(c) Unwelded stays and unwelded portions of welded stays, except as specified in line a and line b	9500	8500
(d) Welded portions of stays	6600	6600

(b) The maximum allowable working pressure for a stayed wrapper sheet of a locomotive boiler shall be determined by the two methods given above and by the two methods which follow, and the minimum value obtained shall be used:

First, $$P = \frac{55{,}000}{F.S.} \times \frac{t \times E}{R - D}$$

Second, $$P = \frac{55{,}000}{F.S.} \times \frac{t \times E}{R - s \, \Sigma \sin a}$$

in which

a = angle any crown stay makes with vertical axis of boiler.

$\Sigma \sin a$ = summated value of sin a for all crown stays considered in one transverse plane and on one side of vertical axis of boiler.

s = transverse spacing of crown stays in crown sheet, inches.

E = minimum efficiency of wrapper sheet through joints or stay holes.

t = thickness of wrapper sheet, inches.

R = inside radius of wrapper sheet, inches.

D = distance from center of radius of wrapper sheet to top of crown sheet, inches.

P = maximum allowable working pressure, pounds per square inch.

FS = factor of safety, or ratio of the ultimate strength of the material to the allowable stress.

The above formula applies to the longitudinal center section of the wrapper sheet, and in cases where E is reduced at another section, the maximum allowable pressure based on the strength at that section may be increased in the proportion that the distance from the wrapper sheet to the top of the crown sheet at the center bears to the distance, measured on a radial line through the other section, from the wrapper sheet to a line tangent to the crown sheet and at right angles to the radial line. See Fig. 11.

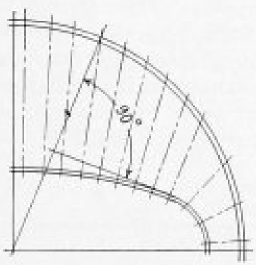


Fig. 11.—Staying for wrapper sheet of locomotive boiler

P = 34.—The area of a segment of a head to be stayed shall be the area enclosed by lines drawn 2 inches from the outside of tubes or the center of a row of stays and at a distance d from the shell or wrapper sheet as shown in Figs. 12 and 13.

The area of the dry pipe hole in the tube sheet should be omitted from the area as obtained above as it is assumed this area is supported by the dry pipe fastenings and superheater header.

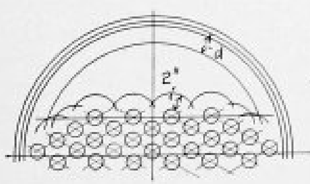


Fig. 12.—Tube Sheet

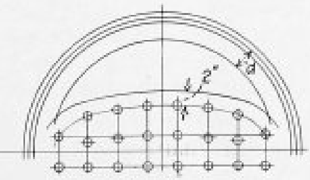


Fig. 13.—Backhead

Gusset braces are calculated separately from the rod braces when both types are used to brace the same surface.

The angle of each stay must be ascertained and if in excess of 15 degrees, the area of the stay must be reduced by multiplying the area of the stay by the cosine of the angle the stay makes with a line drawn at right angles to the area supported as shown in Figs. 14 and 15.

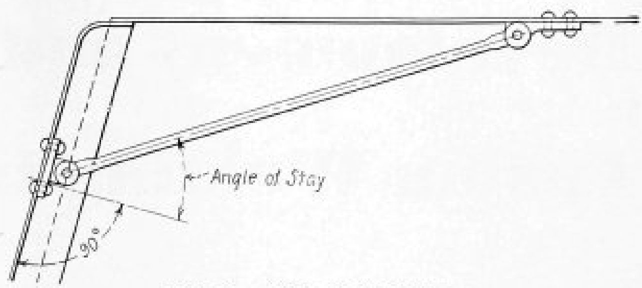


Fig. 14.—Angle of Rod Braces

In addition to calculating the stress on the body of the stay the stresses on rivets and fastenings must also be obtained.

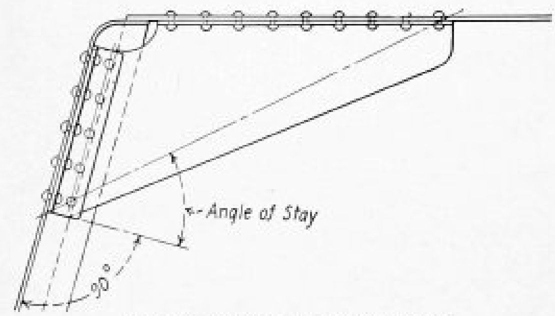


Fig. 15.—Angle of Gusset Braces

The value of d used may be the larger of the following values:

(1) d = the outer radius of the flange, not exceeding 8 times the thickness of the head.

(2) $$d = \frac{5 \times T}{\sqrt{P}}$$

where, d = unstayed distance from shell in inches.
T = thickness of head in sixteenths of an inch.
P = maximum allowable working pressure in pounds per square inch.

Table 8—Value of d Given in Above Formula

Value						
(1)	Thickness of head, inches		1/2	9/16	5/8	11/16
	Outer radius of flange not exceeding this diameter, inches		4	4.5	5	5.5
		P	Value of d in inches			
(2)	$d = \frac{5 \times T}{\sqrt{P}}$	160	3 1/8	3 1/2	3 15/16	4 5/16
		170	3 1/16	3 7/16	3 13/16	4 3/16
		180	2 15/16	3 3/8	3 11/16	4 1/16
		190	2 7/8	3 1/4	3 5/8	3 15/16
		200	2 13/16	3 3/16	3 1/2	3 7/8
		210	2 3/4	3 1/8	3 7/16	3 3/4
		220	2 11/16	3	3 3/8	3 11/16

P = 35.—In calculating stresses for stays and their attachments the angularity of the stays, if in excess of 15 degrees, must be taken into account. The practice in calculating stresses on braces is to take the entire area support by the stays, multiplied by the boiler pressure and divided by the sum of the least sectional areas of all the braces.

This method is satisfactory providing the braces are uniformly spaced. If one or more of the braces are so segregated as to receive more than their portion of the load they must be calculated separately from the rest.

In taking into account the angularity of the braces, the angle of each brace must be found and its sectional area must be reduced in proportion to the angle that the stays make with a line drawn at right angles to the surface supported. This is to be done in preference to increasing the load in proportion to the angularity of the brace as this would necessitate calculating the area supported by each individual brace, which could not be accomplished with any degree of accuracy.

Development and Application of Fusion Welding in Pressure Vessels

By Dr. Comfort A. Adams*

For the information of members of the American Boiler Manufacturers' Association, a special session of the annual convention in May was devoted to an outline of the development of the various fusion welding processes and their application. This abstract of the address presented at that time discusses not only the use of the various welding processes in pressure vessel construction, but also the methods being considered for non-destructive tests of welded joints. The author is an outstanding authority on the subject. The practical suggestions for proper procedure given herein should be valuable to all, having to deal with various phases of boiler and pressure vessel welding, in the future.

My memory goes back to the days when the only welding process was what is commonly called forge welding or hammer welding. Resistance welding was invented by Elihu Thompson back in the middle 80's and consists in the welding of two pieces of metal together, the surfaces of which have been heated by an electric current. For example, if I take two pieces of wire, two rods or two tubes of metal and butt them together with their contact surfaces well fitted to each other, then pass a current through them, heat is developed throughout the metal. As the resistance at the surfaces of contact is tremendously higher than that in the remainder of the electrical circuit the greatest heat is developed at their surfaces.

Therefore, when a heavy enough current is passed through the parts, the contact surfaces will be raised quickly to the welding temperature. If pressure now is applied, the metals can be joined. This process of welding is exactly analogous to the forge welding process, the only difference being that the applied pressure is static instead of dynamic. Therefore both the forge and resistance welding processes can be classified as pressure welding processes.

The process of resistance welding was employed first in the welding of copper wires together by electrical manufacturing concerns where, in the windings of electrical machinery of various sorts it was desirable to obtain continuous conductors.

When a butt joint is used and the joint surfaces are only heated to a temperature within the plastic range of the metals joined, the process is known as upset butt welding. However, as it is almost impossible to get large abutting surfaces accurately alined and thus secure uniform heating and upsetting, there has been developed what is called flash welding and flash-upset welding. In flash welding, the pieces are brought together lightly, without being fitted accurately. The light contact starts an arc, and the metal oxidizes, throwing off a shower of sparks in all directions. This flashing, as it is called, is continued until the two surfaces are brought to absolute parallelism, at which time the electrical circuit is opened and pressure applied to complete the weld. The flash-upset weld is a combination of the two processes from which it derives its name.

The flash and flash-upset welding processes are adaptable to all sorts of shapes and sizes. In the early days, conservatism and lack of money to build and try out machines kept the sizes of parts down and most of the parts welded were very small. In my opinion, it is wholly feasible to flash weld two tubular sections of a drum 4, 6, 8 or 10 feet in diameter, and 2, 3 or 4 inches in thickness, inside of a minute or two and do the job perfectly.

There are varieties of resistance welding other than those I have mentioned, however I will only mention two of the commonest, without going into their subdivisions. These two varieties are spot welding and seam welding. In spot welding two sheets are overlapped and gripped at the overlap between two electrodes, a current passed through and a weld effected when the pressure is applied. In seam welding, the weld is made linearly between two contact rollers or a contact roller and a contact bar. The spot welding process is used to a tremendous extent in industry for thin plate fabrication. For thick plates it becomes very difficult and as far as I know it is not used in any commercial way for plates thicker than ⅜ to ½ inch. Seam welding is principally used in the manufacture of tubing and light-walled containers.

At about the same time that the resistance welding process was first invented, the carbon-arc process was invented. In this process an arc is struck between the joint to be welded and a carbon electrode. When required, a welding rod is fed in to fill up the joint. It is exactly like the metal arc process except that the heat is developed by an arc between a carbon electrode and the plate or joint, rather than between a metal electrode which serves at the same time as filler metal.

Then came the gas and metal-arc welding processes.

In the gas welding process, the heat is generally developed by an oxy-acetylene flame and the filler metal melted in the flame when necessary. In the gas welding process the heat is not so intense, consequently it is necessary if the plates are of any considerable thickness, and in general, to apply the torch flame to the joint surfaces until they are up to the welding temperature before you melt the filler metal. With the arc process

* Professor, Harvard University and president of the Welding Engineering and Research Corporation, New York.

the intensity of the heat of the arc is such that even though the plates be very heavy, it is sufficient to fuse the surface where the terminal of the arc strikes. Therefore no preparatory heating of those surfaces is necessary.

Just a word in regard to the properties of the electric arc. If it is a direct-current arc, and most arc welding is done with direct-current, the heat is developed at three points, the anode drop, the cathode drop and the arc-stream drop. At the anode or positive terminal from which the current comes, the heat developed is, roughly 50 percent more than at the cathode or negative end of the arc. The arc-stream drop varies with the length of the arc. The drop of potential at the anode and cathode is practically a constant quantity.

If you are welding plates of any considerable thickness and are using a bare metal electrode to fuse the joint, it is obvious that the thermal conductivity of these massive plates is such that it will take a larger amount of heat to raise their joint surfaces to a fusing temperature than it does merely to melt a relatively small wire. It is for this reason that in bare electrode welding the positive terminal of the machine is connected to the plate, and the negative terminal to the electrode.

With alternating current, the cathode and anode are interchanging all the time and it is obvious you would get the same amount of heat developed at the two terminals.

The physical properties of steel depend upon two things, its chemical composition and its thermal history. When metal cools, it crystallizes, and under such thermal conditions as prevail in arc welding a crystalline structure is obtained which is coarse and commonly called columnar. An examination of the cross section of any arc weld made with bare electrodes and wherein only one layer is used, discloses that the direction of crystallization is always perpendicular to the surface, that is, it is in the direction of the heat flow or temperature gradient in the weld. A coarse columnar structure may be quite high in tensile strength in certain directions, but it is universally brittle. In bare electrode welding the metal also passes across the arc for the most part in globules or drops, perhaps 5 or 10 a second, depending somewhat upon the size electrode. In passing across the arc, it is at a temperature when it absorbs oxygen and nitrogen readily, both of which are highly undesirable in the weld. Beyond a certain point these elements cause an actual weakness, but in any case they create brittleness.

If in arc welding a deposited layer of metal is thin and another layer is placed on top if it, the underlying layer and the fusion zone of the joint goes through a process of heat treatment such as has never been developed by any other process. In other words, a grain refinement results such as the metallurgist has hardly ever been able to produce. Regardless of this, the ill effects of oxygen and nitrogen in the weld are not entirely overcome, consequently welds made with the bare electrodes now available are not satisfactory for such structures as boilers and pressure vessels of the critical type.

In gas welding, we have rather a different situation, because there the products of combustion serve as a protective envelope surrounding the weld metal which is being deposited, and there is not the same likelihood of oxide and nitride inclusions which are the bane of fusion welding of the arc type.

In order to prevent these oxide and nitride inclusions in arc welding, there have been used in one form or another for many years what we commonly know as coated and covered electrodes.

In gas welding it is difficult to employ the layer method for the reason that you have to reheat the metal every time you pass over a layer so that, as a rule, gas welding is done through the full depth of the groove in a sort of diagonal or sloping plane, and built up back and forth throughout the length of the joint. Although it is impossible in gas welding, to get the grain refining action that I referred to, nevertheless as compared with a bare electrode weld, the gas weld has a very distinct advantage of cleaner metal and, as a rule, more ductile metal. If a gas weld can be heat treated so as to produce grain refinement, which means heating it up to a temperature above the critical point, then you get exactly the same result as you do with the best covered electrode arc welds.

This brings us to a very important question which is a moot question among authorities: Is the higher brittleness or lower ductility of welds without grain refinement any serious handicap to most structures, if the tensile strength of the joint is, as in most cases, higher than that of the bare metal?

I am not going to answer that question for you. It is a question which depends upon a great many factors. I am going to say, however, as my personal opinion, that there are very few structures in which the slightly higher brittleness or lower ductility of the unrefined metal, referring to grain size, is a disadvantage if the metal is clean and free from porosity, and the structure designed and welded under the supervision of competent welding engineers. It is, however, desirable that the metal in the joint and the joint itself have properties as nearly as possible equal to, if not superior to the plates in which the joint is made.

As it is very difficult even with the greatest possible care, the most perfect development of procedure in the shop, with automatic machines or with manual welders, to produce continuously day in and day out joints that are free from slag pockets or gas pockets or porosity of considerable extent, therefore I will briefly comment on porosity and its influence. If the pores are fine they probably will not affect any of the qualities determined by test any appreciable amount. The point at which a gas pocket, we will say, becomes of such size as to be dangerous depends upon the service to which the vessel is to be subjected and its size with respect to the thickness of the plates.

You probably all have followed the engineering developments in this field and know something of the breathing tests that have been made on welded pressure vessels. Perhaps you do not know, however, that when slag pockets were present the failures occurred at a comparatively low number of applications (approximately 200,000) of a pressure only 50 percent above the working pressure or 30 percent of the ultimate strength of the material. When these slag pockets or gas pockets were not present, the same drums went up to 2,000,000 without failure.

In other words, when a stress is applied to a piece of metal with a hole in it, the concentration of stress around the hole is very considerable. If this stress is 30 percent of the ultimate strength of material, it would be in the fatigue limit range.

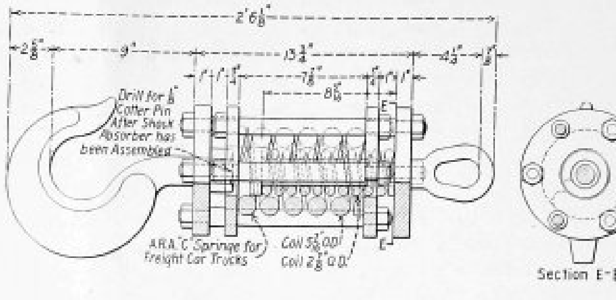
I do not suppose even boiler makers know how many times a boiler drum has had its pressure raised up and down again during its life. It certainly has not had, as in the tests I mentioned, a pressure of one and one-half times the working value applied 200,000 times. But there must be a factor of safety in properly designed structures, and the reason I bring this up is that it affects the standard of perfection of the welds in pressure vessels, the failure of which involves danger to life and serious danger to property.

A great deal of good welding has been done for many years, but mostly in places or in structures which are not of the critical variety. I will add to that statement; namely, I doubt very much if it is possible for any manufacturer to develop the very best technique for the welding of heavy pressure vessels in his own shop without the aid of the X-ray.

In referring to the relative utility of X-ray and gamma rays, I will say that I have not had as wide experience with gamma rays as I have had with the X-ray. I have seen a number of radiographs of sample welds and have examined the welds after fracture. The definition of a radiograph with gamma rays is not as clear as with the X-ray. Whether or not the proper technique was employed with the gamma ray, I do not know. On the other hand, even though the gamma ray takes a longer time, it does not require equipment in the ordinary sense, for all that is necessary is small capsules or tubes of radium emanating salts which can be obtained from hospitals and elsewhere. As the emanations from these salts are short lived, they are not as powerful as those from radium itself and the time required to obtain a proper radiograph is longer. I should think, frankly, that if this examination is necessary in a large number of boilers over a period of years it would be almost cheaper to pay $50,000 or $75,000 for a gram of radium which would last a lifetime, even though used rather continuously. As a matter of fact, on the basis of buying a gram of radium, the overall cost of the radiographs would probably be less than those obtained by the X-ray.

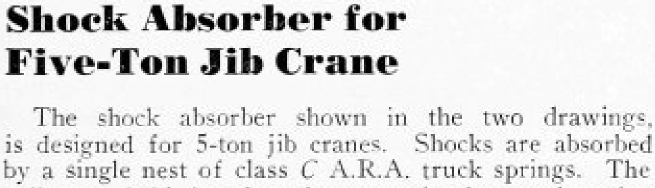
(To be continued)

Shock Absorber for Five-Ton Jib Crane



The shock absorber for five-ton capacity jib cranes

The shock absorber shown in the two drawings, is designed for 5-ton jib cranes. Shocks are absorbed by a single nest of class *C* A.R.A. truck springs. The coils are held in place by two circular steel spring seats. The shock absorber is assembled by securing the hook plate to the top of the hook by means of a 1½-inch nut, which is held in place by a ⅛-inch cotter pin. The top spring seat, which holds the inner coil in compression against the bottom seat, is secured to the center rod by the hook eye. The top seat for the outer spring coil and the outer spring are applied and the seat is secured to the hook plate by three plate rods. Three 1 1/32-inch holes are drilled in the top spring seat for the outer coil for the 1-inch plate rods connecting the hook plate to the seat. The outer spring coil carries the load, and the inner spring serves to cushion any upward movement.



Details of the five-ton shock absorber

Welding Engineers

(Continued from page 173)

After reviewing the history of fusion welding and the development of the various methods, Dr. Adams visualized for the group the more technical phases on which the quality of welded construction depend. An abstract of his address is published in this issue.

Reducing the points brought out to their fundamentals, it is evident that fusion welding is not the simple process that the average individual, unfamiliar with its characteristics, has assumed it to be. While many of the effects of welding on various metals are known, what actually occurs, and how to control the action are matters still under controversy. The engineer attempting to enter the field of welded design, especially of pressure vessels, must be well grounded in the metallurgy, chemistry and physics which enter the problem, in order to provide adequately for the variable factors which determine the quality of the finished work. His must be the responsibility for making the design a practical one for which a definite procedure may be developed in order to bring about the desired result. It is his duty also to determine the value of the various testing methods available, and which of them will actually check the quality of the welds in the particular vessels under consideration.

The entire matter of fusion welding as a major process of fabrication resolves itself into the need for specially trained and qualified welding engineers capable not only of practical designs to be executed by means of welding, but also having the ability to control the process throughout production. When the American Society of Mechanical Engineers Boiler Code provisions for welding have been adopted and the requirements incorporated in state regulations in many parts of the country, the need for such technicians will be very great. This would seem to be an excellent field in which young mechanical engineers can specialize to advantage; also the actual production side of fusion welding offers a broad field for the younger men in boiler, tank and plate fabrication work to follow.

In a move designed to improve the service to users of its product on the Pacific Coast, The Union Chain & Manufacturing Company, Sandusky, O., has recently announced the appointment of the Industrial Gear & Machine Works, 225 Sixth avenue, Oakland, Cal., as exclusive distributors for its line of products.

Revisions and Addenda to the Boiler Construction Code ▲ ▲ ▲

It is the policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the Rules and its Codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the Code, to be included later on in the proper place in the Code.

The following proposed revisions have been approved for publication as addenda to the Code. These are published below with the corresponding paragraph numbers to identify their locations in the various sections of the Code and are submitted for criticisms and approval from any one interested therein. Communications should reach the Secretary of the Boiler Code Committee, 29 West 39th Street, New York, N. Y., not later than June 15, 1931, in order that they may be presented to the Committee for consideration.

For the convenience of the reader in studying the revisions, all added matter appears in small capitals and all deleted matter in smaller type.

PAR. P-184. REVISE SECTIONS *a* AND *b* AS FOLLOW:

P-184. *Circumferential Joints. a* The strength of A RIVETED circumferential joint[s] of A boiler[s], the heads of which are not stayed by tubes or through braces, shall be SUFFICIENT, CONSIDERING ALL METHODS OF FAILURE, TO RESIST THE TOTAL LONGITUDINAL FORCE ACTING ON THE JOINT WITH A FACTOR OF SAFETY OF FIVE. THE TOTAL LONGITUDINAL FORCE IS DETERMINED BY THE FOLLOWING FORMULA:

$$F = 3.14R^2P$$

WHERE F = TOTAL LONGITUDINAL FORCE IN LB.

R = RADIUS OF THE CIRCULAR AREA ACTED ON BY THE PRESSURE IN PRODUCING THE TOTAL LONGITUDINAL FORCE ON THE JOINT IN LB. PER SQ. IN.

P = PRESSURE IN LB. PER SQ. IN.

[at least 50 percent of that required for the longitudinal joints of the same structure.]

b When 50 percent or more of the TOTAL FORCE AS DESCRIBED IN (A) [load which would act on an unstayed solid head of the same diameter as the shell] is relieved by the effect of tubes or through stays, in consequence of the reduction of the area acted on by the pressure and the holding power of the tubes and stays, the strength of the circumferential joint [s in the shell] shall be at least 70 [35] percent of that required BY (A) [for the longitudinal joints.]

PARS. H-40 AND H-93. MODIFY PROPOSED REVISION OF THIRD SECTION OF THIS PARAGRAPH AS PUBLISHED IN APRIL ISSUE:

It is recommended that the return pipe connection of each boiler SUPPLYING A GRAVITY RETURN HEATING SYSTEM shall be so arranged as to form a loop substantially as shown in Fig. H-3 so that the water in each boiler cannot be forced out below the safe water level.

PARS. H-55 AND H-108 REVISED:

Steam Gages. Each steam boiler shall have a steam gage connected to ITS [the] steam space or to ITS [the] water column, or its steam connection, by means of a siphon or equivalent device EXTERIOR TO THE BOILER AND of sufficient capacity to keep the gage tube filled with water and so arranged that the gage cannot be shut off from the boiler except by a cock WITH TEE OR LEVER HANDLE, placed IN THE PIPE near the gage. THE HANDLE OF THE COCK SHALL [and provided with a tee or lever handle arranged to] be parallel TO [with] the pipe in which it is located when the cock is open. [Pipe connections to steam gages smaller than 1 in. pipe size, shall be of brass, copper, or bronze composition when the distance between the gage and point of attachment of pipe is over 5 ft. If less than 5 ft., the pipe connections shall be of brass, copper, or bronze composition if smaller than ½ in. pipe size.]

THE SCALE ON the dial of a steam BOILER gage [for a steam heating boiler] shall be graduated to not less than 30 lb. THE GAGE [and] shall be provided with EFFECTIVE STOPS FOR THE INDICATING POINTER [a stop pin] at the zero point and [a stop pin] at THE [a] maximum PRESSURE point [not less than 300 deg., nor more than 325 deg. of the dial circumference from the zero point, unless the gage be so constructed that the pointer cannot travel over 325 deg. of the dial circumference from the zero point.] THE TRAVEL OF THE POINTER FROM ZERO TO 30 LB. PRESSURE SHALL BE AT LEAST 3 IN.

STEAM-GAGE CONNECTIONS SHALL BE OF NON-FERROUS COMPOSITION WHEN SMALLER THAN 1-IN PIPE AND LONGER THAN 5 FT. BETWEEN THE GAGE AND POINT OF CONNECTION OF PIPE TO BOILER, AND ALSO WHEN SMALLER THAN ½-IN. PIPE AND SHORTER THAN 5 FT. BETWEEN THE GAGE AND POINT OF CONNECTION OF PIPE TO BOILER.

On a compound gage, AN EFFECTIVE [the] stop pins [or limit stops] shall be set at the limits of the gage readings on both the pressure and vacuum sides.

PARS. H-56 AND H-109 REVISED:

Pressure or Altitude Gages. Each hot-water boiler shall have a PRESSURE OR ALTITUDE gage connected TO IT OR TO ITS FLOW CONNECTION in such a manner that it cannot be shut off from the boiler except by a cock with tee or lever handle, placed on the pipe near the gage. The handle of the cock shall be parallel to the pipe in which it is located when the cock is open. [Pipe connections to gages smaller than 1 in. pipe size shall be made of brass, copper, or bronze composition when the distance between the gage and point of attachment of pipe is over 5 ft. If less than 5 ft., the pipe connections shall be of brass, copper, or bronze composition of smaller than ½ in. pipe size.]

THE SCALE ON the dial of the pressure or altitude gage shall be graduated to not less than 1½ times the maximum allowable working pressure. THE GAGE [and] shall be provided with EFFECTIVE STOPS FOR THE INDICATING POINTER [with a stop pin] at the zero point and [a stop pin] at the maximum PRESSURE point [not less than 300 deg. nor more than 325 deg. of the dial circumference from the zero point unless the gage be so constructed that the pointer cannot travel over 325 deg. of the dial circumference from the zero point.]

PRESSURE- OR ALTITUDE-GAGE CONNECTIONS SHALL BE OF NON-FERROUS COMPOSITION WHEN SMALLER THAN 1-IN. PIPE SIZE AND LONGER THAN 5 FT. BETWEEN THE GAGE AND POINT OF CONNECTION OF PIPE TO BOILER, AND ALSO WHEN SMALLER THAN ½-IN. PIPE SIZE AND

SHORTER THAN 5 FT. BETWEEN THE GAGE AND POINT OF CONNECTION OF PIPE TO BOILER.

PAR. H-120. REVISE FIRST SENTENCE TO READ:

H-120. All boilers shall be plainly and permanently marked with the manufacturer's NAME OR THE MANUFACTURER'S AND distributor's name and the maximum allowable working pressure.

PAR. U-17. MODIFY REVISION OF TABLE REFERRED TO IN APRIL ISSUE TO READ:

When the Diameter of Shell is	In.
16 in. and under	1/8*
Over 16 in. to 24 in.	3/16
Over 24 in. to 42 [36] in.	1/4
Over 42 [36] in. to 60 [54] in.	5/16
Over 60 [54] in. [to 72 in.]	3/8
[Over 72 in.	1/2]

* For riveted construction the minimum thickness shall be 3/16 in.

PAR. U-53. ADD THE FOLLOWING SENTENCE TO THE SECOND SECTION:

VESSELS 16 IN. IN DIAMETER OR LESS HAVING PIPE CONNECTIONS PROPERLY LOCATED FOR INSPECTION PURPOSES, NEED NOT BE PROVIDED WITH SEPARATE OPENINGS IF THE TAPPING FOR THE PIPE CONNECTIONS IS NOT LESS THAN 1½ IN. PIPE SIZE.

PAR. U-20. REVISED:

U-20. *For Internal Pressure.* The maximum allowable working pressure on the shell of a pressure vessel shall be determined by the strength of the weakest course computed from the thickness of the plate, the efficiency of the longitudinal joint, the inside diameter of the course, and the maximum allowable unit working stress.

$$\frac{S \times t \times E}{R} = \text{maximum allowable working pressure, lb. per sq. in.}$$

where S = maximum allowable unit working stress in lb. per sq. in.

TAKEN FROM TABLE U-2½

[11,000 lb. per sq. in. for steel plate stamped 55,000 lb. per sq. in., 10,000 lb. per sq. in. for steel plate stamped less than 55,000 lb. per sq. in., and for material used on seamless shells, one-fifth of the minimum of the specified range of the tensile strength of the material.]

t = minimum thickness of shell plates in weakest course, in.

E = efficiency of [riveted] longitudinal joint OR OF LIGAMENTS BETWEEN OPENINGS

FOR RIVETED JOINTS = CALCULATED RIVETED EFFICIENCY

FOR FUSION WELDED JOINTS = EFFICIENCY SPECIFIED IN PAR. U-67

FOR SEAMLESS SHELLS = 100 PERCENT

FOR LIGAMENTS BETWEEN OPENINGS, THE EFFICIENCY SHALL BE CALCULATED BY THE RULES GIVEN IN PARS. P-192 AND P-193 OF SECTION I OF THE CODE

R = inside radius of the weakest course of the shell, in., provided the thickness of the shell does not exceed 10 percent of the radius. If the thickness is over 10 percent of the radius, the outer radius shall be used.

NOTE: When the ALLOWABLE EFFICIENCY OF THE JOINTS IS NOT GIVEN, THE VALUES FOR $S \times E$ GIVEN [safe working pressure for welded or brazed vessels is to be determined, E will be omitted from the formula and the values for S] in Pars. U-67, [U-68], U-82, or U-94 SHALL BE USED [will be substituted for the values given above. For seamless shells, E equals 100 percent.]

TABLE U-2½ VALUES FOR S AT VARIOUS TEMPERATURES

Temp. degrees F.	Minimum of specified range of the tensile strength of the material, lb. per sq. in.				
	45,000	50,000	55,000	60,000	75,000
60–730	9,000	10,000	11,000	12,000	15,000
750	8,220	9,110	10,000	11,200	13,000
800	6,550	7,330	8,000	9,000	10,200
850	5,440	6,050	6,750	7,400	8,300
900	4,330	4,830	5,500	5,600	6,000
950	3,200	3,600	4,000	4,000	4,000

This table applies to all plain carbon steels for which specifications are given in the Code. Where the minimum tensile strength of the specified range or the temperature differs from those for which values are given in the table, the values for S for such materials may be determined by interpolation.

PAR. U-66. INSERT AFTER END OF FIRST SENTENCE:

IF THE VESSEL IS OF FUSION-WELDED CONSTRUCTION IT SHALL ALSO BE STAMPED TO SHOW THE CLASS OF VESSEL AND GRADE OF WELDING.

FIG. U-5. INSERT THE FOLLOWING UNDER THE CLOVER-LEAF SYMBOL:

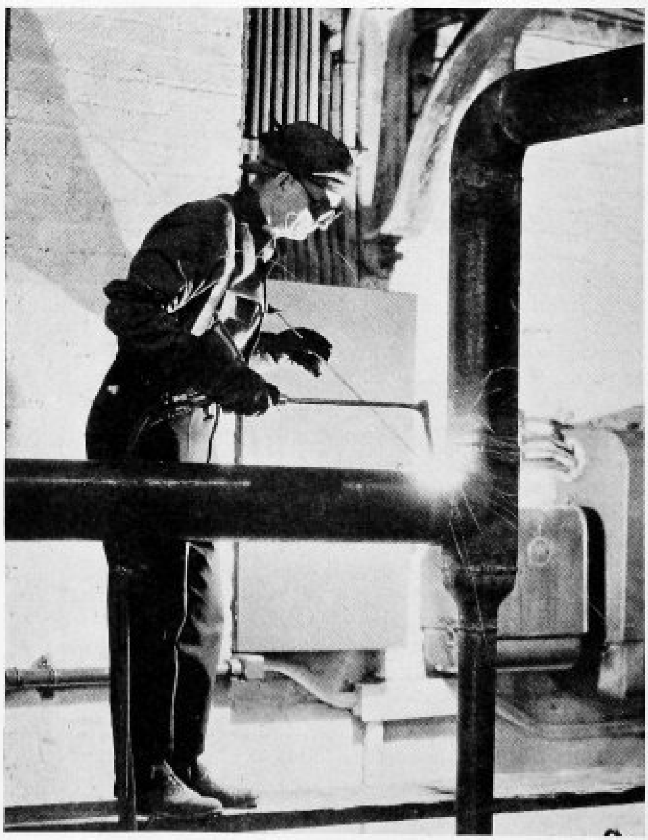
CLASS OF VESSEL..........

GRADE OF WELDING..........

Pipe Fittings For Welding

The Taylor Forge & Pipe Works, Chicago, Ill., has developed a complete line of seamless steel pipe fittings for welding, consisting of elbows, tees, reducing tees, bull plugs, and reducing nipples, as well as Taylor forged steel butt-welding flanges which have already been on the market for over three years. All sizes to 24 inches inclusive will be ready for distribution in the near future, but at present only sizes 12 inches and smaller are available. The tees are made in sizes 2 inches to 8 inches.

This line of seamless pipe fittings for welding is unique in many respects. It permits entire pipe systems fabricated by welding to be installed with only the use of true circumferential welds acknowledged to be the easiest to make, resulting in increased efficiency of the welder, and full strength welds. Erection is considerably simplified. Taylor fittings are lighter in weight than cast-steel fittings, and therefore require fewer and lighter supports. They require less space in erection



Application of fittings for welded pipe

and permit easy and economical insulation. The manufacturing methods are on a mass production basis employing patented processes to a great extent. The elbows are made without thinning or buckling of the walls, and further have the advantageous feature of short tangents to facilitate welding and accurate lining up. Elbows are made of the standard center-to-end measurement of American standard extra heavy screwed fittings, and with end-to-center-to-end dimension equal to one and one-half times the nominal pipe diameter. The ends are machine tool beveled to provide a smooth, clean surface for welding, and assure maximum accuracy as well as installation ease.

Taylor Forge tees are a forged tubular product made to pipe thickness at the ends, with the body thickened up especially around the outlet to give required reinforcement. The basis of design for the tee, as well as the other welding products, has been to make the fittings of an installation of welded fabricated pipe the strongest parts of the line. Flow or friction has also been carefully considered in design. The tees have sweep outlets, a feature especially important for lines of high velocity.

Favorable features descriptive of other Taylor Forge fittings may be briefly stated as follows: The reducing nipples are designed especially for welding, with the length sufficiently long to aid installation, yet shorter in dimension than that of the screwed reducing nipple. The smooth, well balanced shape of the reducing section assists materially in fostering easy and unimpaired flow. The bull plugs are forged under the most approved forging conditions; formed to an ellipsoidal shape to withstand end pressure; and made with a surplus of straight section to enable easy and simple attachment to pipe. The Taylor butt-welding flanges, providing for the insertion of valves in welded pipe installations, have a long fillet at the hub to prevent distortion, and are made to satisfy full American standard strength, requirements. By employing Taylor Forge fittings, three major results follow: Uniform strength, unimpaired flow and lower installation cost.

Obsolete Shop Equipment

Shop equipment, whether it be machine tools, material-handling equipment or small tools that can no longer be classed as modern, is a distinct liability in any shop. In times when earnings are high, shop facilities that have passed their period of greatest economic usefulness are tolerated because the service that they can render, unsuited as it is to modern production demands, is needed. When railroad business conditions are as they have been for the past year, the up-to-date shop supervisor should be checking up pretty carefully on the operating costs of individual units in his shop in order to determine the actual savings that could be effected by their replacement.

An American business man, writing recently on industrial conditions, mentioned the fact that there are many industrial plants in this country and many individual units of equipment in some modern plants that can never be economically operated again because competition and the readjustment of prices will force production costs in the future to be reduced to such an extent that obsolete equipment cannot meet the output demand at a cost which will permit a profit. Many railroad shop men have felt that the need for shop equipment of the most modern design was not justified in a railroad shop because the shop is not engaged in the manufacture of a product which is sold in keen competition and, therefore, the production costs need not be watched as closely as would be necessary in a manufacturing plant. This is not true today. The product of a railroad is transportation and today rail transportation seems to be the object of the keenest competition in our recent industrial history. It seems fairly certain that even the return of better business conditions will not restore to the railroads the increasing annual revenue that has come their way for many years in the past.

The maintenance of equipment—locomotives and rolling stock—requires approximately one-third of all the money spent by the average railroad for operation and it is in the constant reduction of unit costs of operation that the railroads should have the greatest hope for increasing profits from rail-line operations. Mechanical-department officers have demonstrated that it is possible to haul longer trains with modern locomotives at substantial savings in operating costs and it is up to the mechanical-department supervisor to demonstrate that this modern power can be maintained in such a manner that no part of the savings made in operation will be absorbed by higher maintenance costs. Modern trains are not being hauled by 30-year old locomotives and it is not reasonable to expect that modern locomotives can be efficiently and economically maintained by obsolete shop equipment.—*Railway Mechanical Engineer.*

New Ball Transfer

A new type of handling equipment, known as the Mathews ball transfer, is designed to accommodate the movement of any object, having smooth hard surfaces, in any direction on a horizontal plane. Its application is not confined to any particular type of work or to any one industry.

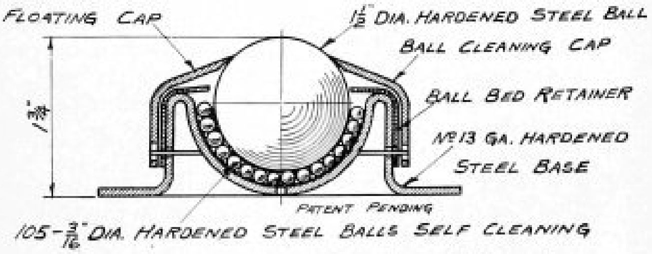
This conveying device is made up with a large hardened steel ball which rotates on a series of smaller balls held in a cupped base. A dust and dirt cap rests on the ball, being held in position by a spring retainer. Its knife edge contact with the large ball deflects foreign substances which might clog the supporting balls if admitted to the base.

Two models are available, one for mounting in series on a table or flat surface support, and one for mounting on pipe supports. When mounted in groups on a heavy structural support, Mathews ball transfers provide a very effective means of moving heavy shapes to and from shears, and for handling heavy cores or molds when these loads are placed on smooth bottom plates. The ball table, as it might be termed when a group of the ball transfers are used, also serves as an efficient turntable for rotating heavy work in machining operations. When mounted on pipe supports fixed in the floor in any desired arrangement, these transfers provide an ideal bed on which large plates and other materials of this sort can be moved.

The type-200 ball transfer is constructed with a 4-inch diameter round base, with four holes for mounting. Type-201 has a 3-inch square base with four holes for mounting. Type-202 has a threaded coupling base for 2-inch standard pipe. These three types have a load rating of 200 pounds each, and are equipped with a 1½-inch diameter hardened steel ball supported on one hundred and five $\frac{3}{16}$-inch diameter balls.

The balls in all three types of transfers are of hardened steel carried in hardened-steel bases.

The type-500 ball transfer is similar to the type-202, but of heavier proportions throughout, and has a load rating of 500 pounds each. The base is of drop forged steel, threaded for 2-inch standard pipe. A 2-inch



Sectional view of No. 200 Mathews ball transfer

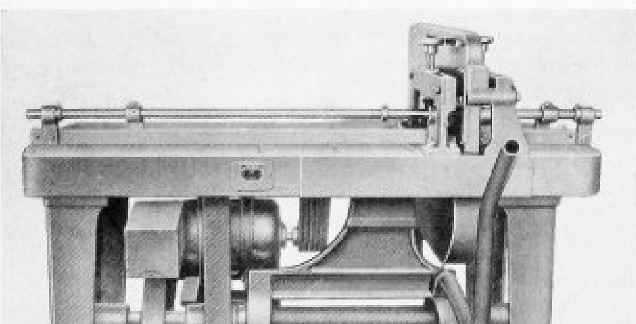
diameter hardened-steel ball is supported on sixty five 5/16-inch diameter hardened-steel balls.

The Mathews ball transfer was designed and is constructed by Mathews Conveyor Company, Ellwood City, Pa.

Campbell Cut-Off Machine

The Campbell, model 30, cut-off machine, manufactured by Andrew C. Campbell, Inc., Bridgeport, Conn., is a new contribution to industry being the only machine using an abrasive disk for cutting extra wide stock. The machine will cut materials of certain characteristics up to 1 inch thick and 16 inches wide at the rate of 2 to 12 seconds per cut. Nickel silver, soft iron, hardened high-speed steel and similar materials can be cut up to ¾-inch thick and 6 inches wide.

The success of the machine for cutting such wide stock is due to a unique arrangement for moving the disk through the material. The traveling arm is arranged in such a manner that the spindle travels parallel to the top of the table without the use of slides. Dirt and grit cannot enter the moving parts to effect the movement of the disk.



Campbell Model-30 cut-off machine

The motor is started and stopped by a pushbutton control conveniently located and a straight edge on the machine is provided for locating the work so that the proper angle cut can be made. Other features of the machine include quick-acting, adjustable clamps, to hold firmly the work to the table; welded steel guards to protect the operator; and six V-belts to insure a positive drive of the spindle. The machine is correctly counterbalanced so that the feed of the disk is under perfect control of the operator throughout the cut, whether the cuts be regular or irregular in shape.

Portable Rotary Air Grinder

The Cleveland Pneumatic Tool Company, Cleveland, O., has announced the production of a new type portable rotary air grinder to that company's line of air-operated tools. The new Cleco rotary grinder has a single rotor which is concentric with the arbor, insuring a perfect balance at all speeds. This type of motor has great power in compact form and operates without vibration or recoil. The rotor is provided with four longitudinal slots to accommodate four separate blades

New Cleveland rotary air-grinder

which are in turn forced outward to the wall of a stationary cylinder which is set eccentric to the axis of the rotor. As one blade of the set is always exposed to the air current a constant rotation is established. The arbor to which the rotor unit is attached is very rigid and made of selected steel, hardened and ground, and has a combination annular and thrust ball bearing at the rear end, and a double-row annular ball bearing at the forward end. These ball bearing units permit of high speed in operation and reduce friction and wear in service.

The governor is a detachable unit and when in operation controls and governs the amount of compressed air used. When the machine is running light, and not grinding, the air consumption is cut to one third. When grinding, the governor opens gradually as pressure is applied until the maximum load on the emery wheel is reached, thus an economical control of air is obtained, and ample power provided for each size wheel.

There is an oil reservoir provided in the rear end of the grinder body, which is filled with oil and is automatically delivered to the rotor, the flow of lubrication being controlled by the governor in the same manner as the air. This oil control system eliminates all lubrication trouble as the oil passes through large unrestricted ports insuring steady and free lubrication without danger of any foreign matter clogging the oil supply. This grinder is made in several sizes and styles for general grinding.

The Boiler Maker

VOLUME XXXI NUMBER 7

PUBLISHED Monthly by the Simmons-Boardman Publishing Company, 34 North Crystal Street, East Stroudsburg, Pa., with Executive Offices at 30 Church Street, New York City.

Edward A. Simmons, President. Henry Lee, Vice-President. C. R. Mills, Vice-President. L. B. Sherman, Vice-President. Samuel O. Dunn, Vice-President. F. H. Thompson, Vice-President. Roy V. Wright, Secretary. John T. De Mott, Treasurer. George Slate, Business Manager.

Chicago: 105 W. Adams Street. Washington, D. C.: 17th and H Streets, N. W. Cleveland: Terminal Tower. San Francisco, Cal.: 215 Market Street.

Subscription Price: United States, Canada and Mexico, $2.00. Foreign Countries, $3.00 a Year. Single Copies, 35 Cents.

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THE BOILER MAKER is a member of the Associated Business Papers, Inc. (A. B. P.), and the Audit Bureau of Circulations, (A. B. C.)

EDITORIAL STAFF: H. H. Brown, Editor. L. S. Blodgett, Managing Editor. W. Lumbard, Associate Editor.

Contents

Communications

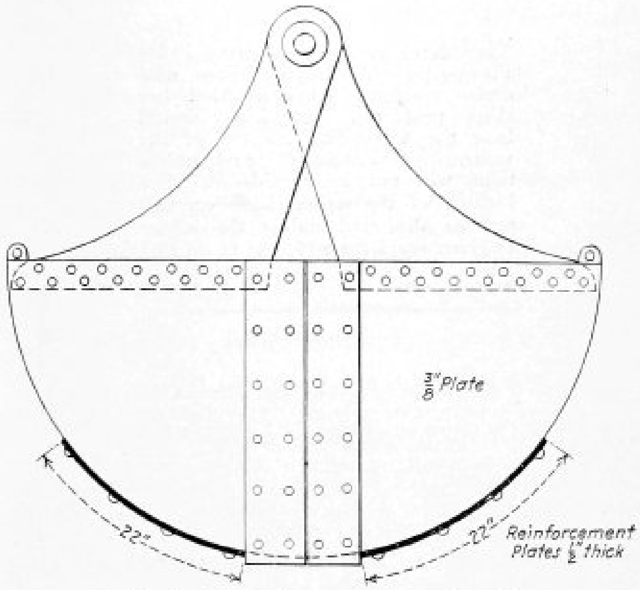
Crane Bucket Repairs

TO THE EDITOR:

At one of the locomotive shops in Florida, we have a locomotive crane equipped with a bucket used to handle coal and other material around the shops. For many years we had experienced difficulty with this bucket due to the fact that it was frequently damaged when dropped on the rails. The bottom of the bucket would be bent out of shape, necessitating its removal from the crane. It then would be taken to the shop, taken apart and straightened.

The accompanying sketch shows the application of re-inforcement plates which were applied to the crane bucket about three years ago and since that time the bucket has not been brought into the shop for repairs. In re-inforcing the bucket, ½-inch metal was used, this being rolled into the shape of the bucket and applied as indicated in the sketch. It was so placed that the end of each re-inforcement plate would come to the rear of each lip and the outer edge of the plate would butt against the edge of the flange at the sides of the bucket. A suitable number of rivets were then inserted to hold the plates together.

This method of re-inforcement, while it may be con-



Reinforcement plates on a crane bucket

sidered as expensive at the time of application, has, in this case at least, saved both time and money in the long run.

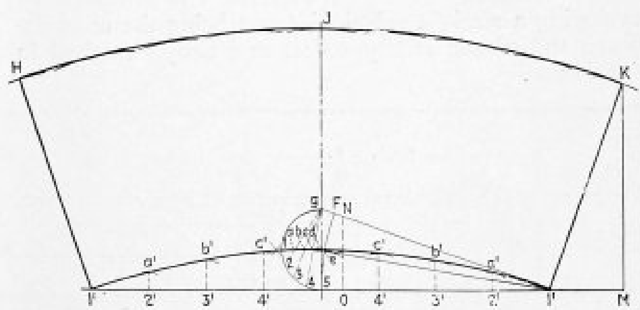
Jacksonville, Fla. CHRIS HANDLEE, JR.

Layout of Camber Line

TO THE EDITOR:

There are many different methods of laying out the camber line on a plate and I am sending one which I hope will be a help to layerouts. This method I have found to be accurate and not very difficult to remember.

First of all, draw a horizontal line *1'-1'* equal in length to the circumference of the small end of the frustum of the cone which you are going to make. Erect line *5-J* perpendicular to it at center. Extend line *5-1'* to *M* to equal half the circumference of the large end. At *M* erect a line at right angles to *5-M*.



Method of laying out a camber line

Next, with *1'* as a center and radius equal to the height of the plate which will be the slope height of the frustum of the cone, draw an arc to intersect the line drawn through *M* at the point *K*. Transfer the angle *M-1'-K* to *1'-N-O* and extend line *1'-H* to line *5-J*. With *1'* as

(Continued on page 198)

Questions and Answers Pertaining to Boilers

This department is maintained for the purpose of helping those who desire assistance on practical boiler shop problems. Inquiries should bear the name and address of the writer. Anonymous communications will not be considered. The identity of the writer, however, will not be disclosed unless the editor is given special permission to do so.

Limit of Hydrostatic Test

Q.—What is the reason for limiting the hydrostatic test to not over 6 percent of 1½ times the safe working pressure?

A.—The reason for limiting the hydrostatic test to not over 6 percent of 1½ times the safe working pressure is to keep the stress in the plate, well within the yield point of the metal so that no permanent set will take place in the metal during the test.

The limit of 6 percent is no doubt a working tolerance as it is difficult to maintain a steady pressure at a set figure, especially where the water is being pumped mechanically, that is by steam or air pressure in lieu of a hand pump.

Layout of Tapered Spiral

Q.—In the fourth edition of your book "Laying Out for Boiler Makers" in the 13th chapter on pages 338 and 339, you show a method for laying out a tapering spiral.

We have a similar problem, which does not seem to solve itself in the manner shown. We are attempting to place a straight spiral inside a 5⅜-inch diameter cylinder, the spiral to have a ½-inch round hole in the center. The pitch or rise with each complete turn of the spiral should be 1 inch. The total height inside the cylinder is 12 inches. Material for the spiral is specified as No. 22 gage galvanized sheet steel.

Any suggestions or advice that you can furnish will be greatly appreciated. We have laid out this problem according to the instructions in your book but find that the pattern which we develop is a perfect circle and when formed makes a very irregular spiral. Probably we have misunderstood the instructions; at any rate we would like to have your advice in the matter.—R. W. S.

A.—The principle of laying out a straight spiral is embodied in the layout of the tapered spiral shown on pages 338 and 339 in "Laying Out for Boiler Makers," the tapered spiral being a more complex layout.

The following developments show two methods of developing a straight spiral, the first being the most accurate, the second is a practical and simple method in general use.

By George M. Davies

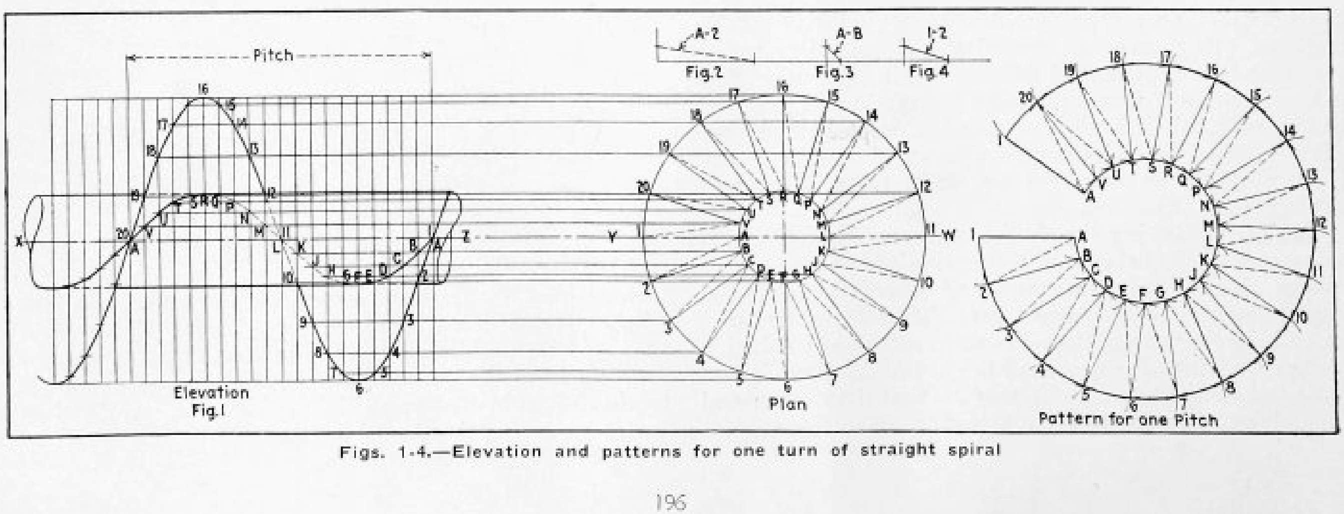
First Method.—The layout of the straight spiral shown in Fig. 1 may appear to be a very difficult problem, but if the method described is followed closely it will be found to be comparatively simple, as it merely involves a few principles that are not usually found in the average problems encountered in laying out sheet metal.

First, lay out the plan of the spiral. Divide the large and small circles in the plan into the same number of equal parts, and mark the points with letters and figures as shown.

Then, on the line *W-X*, space off a distance equal to the pitch as shown in Fig. 1. Divide the distance representing the pitch, in the elevation, into the same number of equal parts as the large and small circles of the plan were divided, and at these points erect perpendiculars to and cutting the line *W-X*. Parallel to the line *W-X* and through the points *1* to *20* of the plan view, draw lines cutting the lines just made in the elevation, locating the points *1* to *20* in the elevation, as shown. Connect these points with a curve, thus forming the outside contour of one pitch of the straight spiral. Repeat this process with the points *A*, *B*, *C*, to *V* of the plan view, locating these points in the elevation as shown. Connect these points with a curve, thus forming the inside contour of one pitch of the spiral.

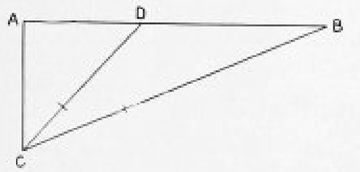
The construction triangles must now be formed as shown in Figs. 2, 3, and 4. As all the triangles are found in the same manner it is only necessary to show the three cases where the true length of the surface lines are found by right-angle triangles. The true lengths found by these triangles are used for laying out the entire pattern.

With a pair of dividers take the length of the line *A-2* of the plan, and place it on the horizontal line in Fig. 2. The height of the triangle will be equal to one division of the pitch in the elevation. Place this on the perpendicular line in Fig. 2. Scribe a line through the two points just found, forming the first construction triangle or the true length of the line *A-2*. Next,



Figs. 1-4.—Elevation and patterns for one turn of straight spiral

take the distance between the points *1* and *2* in the plan and place it on the horizontal line in Fig. 4. Then take the distance equal to one division of the pitch in the elevation and place this on the perpendicular line. A line across the two points will be the true length of the metal between the points *1* and *2*. Next, take the distance between points *A* and *B* in the plan and place it on the base line in Fig. 3, then take the distance equal to one division of the pitch in the elevation and place it on the perpendicular line in Fig. 3. A line across the two points will be the true length of the metal between the points *A* and *B*.



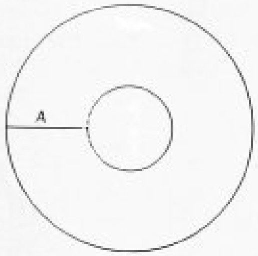


Fig. 5.—Lengths of helixes. Fig. 6.—Pattern for straight spiral sections

The last operation will be the formation of the pattern. Scribe a straight line at any convenient place on the sheet and lay off the distance between points *1* and *A* in the plan. This will be the true length of the line, as it does not rise, as will be seen in the side elevation, this also holds true for the lines *2-B, 3-C, 4-D, 5-E,* etc. With the point *1* as a center and the distance *1-2* in Fig. 4 as a radius, scribe an arc. Then with the point *A* as a center and the distance equal to *A-2* in Fig. 2 as a radius scribe an arc cutting the arc just made locating the point *2*. Then with *2* as a center, and the distance *2-B* in the plan as a radius, scribe an arc, and then with *A* as a center and the distance *A-B* in Fig. 3 as a radius, scribe an arc cutting the arc just made. Continue in this manner, completing the pattern. The distances *3-C, 4-D, 5-E,* to *20-V* are taken equal to their corresponding lengths in the plan view. The distances *B-3, C-4, D-5, E-6* to *20-A* are taken equal to the distance *A-2* in Fig. 2. The distances *B-C, C-D, D-E,* to *V-A* are taken equal to the distance *A-B* in Fig. 3. The distances *2-3, 3-4, 4-5, 5-6,* to *20-1* are taken equal to the distance *1-2* in Fig. 4.

The pattern thus completed is for one pitch of the straight spiral and additional patterns may be cut from the same layout for the number of turns required.

Second Method.—To lay out the pattern for a spiral proceed as follows: Make a diagram like that shown in Fig. 5 where the base *A-B* is equal to the outside circumference of the spiral, and the height *A-C* is equal to the distance advanced in one turn. Also lay out a similar diagram, using the base *A-D* equal to the circumference of the shaft and the height *A-C* equal to the distance advanced in one turn. Complete the diagrams by drawing the hypotenuse or third side of each. Measure the length of this line carefully and divide the length by 3.1416. The quotient will be the diameter of a circle having this length for its circumference. Use one-half of this diameter as the radius for describing a circle on the sheet metal stock. Likewise describe a central circle equal in length to the shorter hypotenuse. The pattern for a single turn of the spiral will appear like Fig. 6. Cut through the pattern with a radial line *A*. Place the pattern around the shaft and separate the two ends lengthwise of the shaft a distance equal to the required advance in one turn.

If heavy metal is used the blades should be made of short pieces riveted together. Where many spirals are built of heavy stock, a cast iron die is used to shape the sections after they have been cut from the sheet. The sections are heated and then placed between the spiral dies and pressed into the finished shape. It should be noted that the blade of a spiral is a warped surface, and a surface of this kind cannot be formed from a flat surface without distorting the metal.

Therefore, a pattern laid out on a flat surface is not strictly accurate, but the method given above is generally used and the metal can be forged into shape so as to be accurate enough for practice.

Development of Firebox Cracks

Q.—Is it a proven fact that firebox cracks first develop on the water side of the plate? If so, just what conditions occasion this? J. A. M.

A.—The four causes of firebox failures including the back head, flue sheet and crown sheet and side sheets in order of their importance are as follows:

(1)—Expansion due to rise in temperature.

(2)—Scale and mud which raise the temperature of the sheets and greatly increase the thermal expansion.

(3)—Corrosion.

(4)—Vibration.

One of the most common failures is cracking in the knuckle of the back flue sheet. The flue sheets fail on the water side of the flange.

This is due *first:* To the difference in the expansion of the boiler shell and wrapper sheet on one hand and the

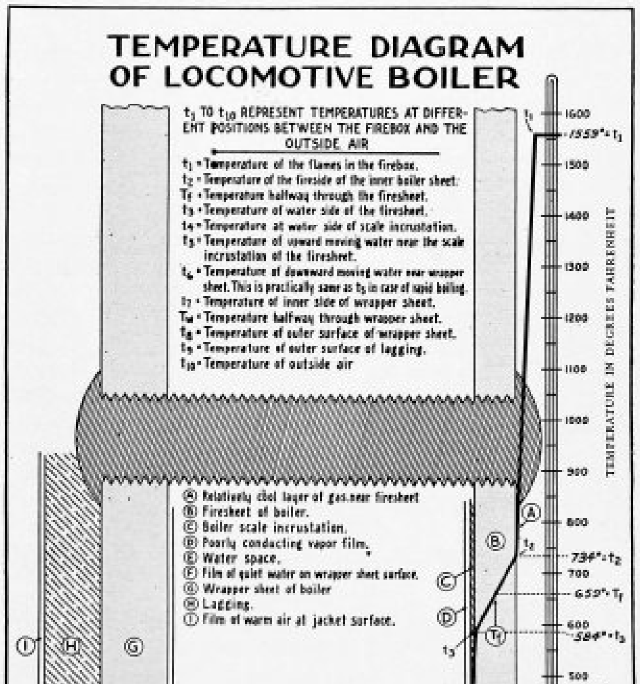


Fig. 1.—Temperature diagram of water leg in locomotive boiler

flues and firebox on the other hand, caused by the difference in temperature between the barrel and wrapper sheet against the flues and firebox sheets. The difference is piled up in the form of stress on the flange in the flue sheet and is the reason for the cracking in the knuckle.

Second: The expansion in the vertical direction of the flue sheet from the mud ring to the top and the sagging of the crown sheet due to the stretch in the crown staybolts, also bends the flue sheet knuckle.

The stresses in the side plates and the staybolts is due to the difference in the temperature between the firebox plates and the outside sheets under service conditions. Thermocouples for measuring temperatures have been placed in the water leg of an engine about half way between the fire zone and the brick arch. The temperatures were measured while the engine was in operation. The temperatures that were recorded were noted on the diagram, Fig. 1.

You will notice that on this chart the mean or middle temperature of the fire sheet at this point is 659 degrees F., and that of the outside wrapper sheet 380 degrees F., a difference of 279 degrees F. Now, if the length of the firebox was 12 feet from the front row of staybolts to the back row of staybolts, the firebox plate would expand 0.622 inch in coming up to 659 degrees F. and the wrapper sheet would expand 0.310 inch in coming up to 380 degrees F. from 70 degrees F. The difference would be 0.312 or 3/10 inch. This expansion causes the bending stress on the staybolts and cracks the fire sheet around the staybolt holes.

There are also inequalities in the temperature in the plates themselves with resultant strains set up in the plates. In the average firebox using a brick arch there is a hot spot under the arch, with cooler metal above and below it. The hot spot is generally 3 to 5 times as long horizontally as it is vertically.

Consequently this section of the plate wants to expand more in a horizontal direction than it does in the vertical direction. But it is surrounded and confined by a cooler plate and it cannot relieve itself by bulging in towards the fire because the staybolts hold it to a flat plane so it just upsets or squeezes itself together when hot. Then, when it cools down, it is under strain in the opposite direction and here is the result—cracks running vertically from the staybolt holes. A failure in a part is always at right angles to the load. The plate tries to pull away from the staybolts when cold and the water leaks out on the hydrostatic test. The boiler maker pounds on the staybolt expanding the bolt in a hole which is already under stress and thus he adds insult to injury and the plate gives up the unequal battle. The cracks are always up and down because the pull is in the horizontal direction due to the shape of the hot spot. They always start on the side of the plate next the fire.

Now in referring back to Fig. 1, you will remember that the firebox plate was at 734 degrees F. next the fire and 584 degrees F. on the water side with a drop of 150 degrees F. through the plate. The plates are always flat when put in the boiler but when cut loose after being in service they always curl or dish as if backing away from the fire.

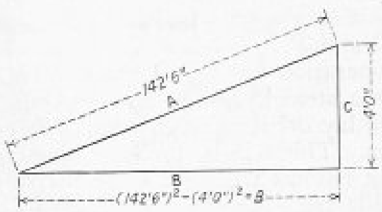
If we have a piece of plate 12 inches long and heat it to 725 degrees F. it would expand 0.067 inch and if heated to 575 degrees F., it would expand 0.046 inch. The difference is 0.021 inch. Suppose the side next the fire did expand 0.067 inch and the side next the water only 0.046 inch, it would cause the plate to bow out towards the fire with a curvature 1/8 inch per foot. However, the plate cannot do this on account of the staybolts holding it flat. So the hot side gets compressed when hot enough and then when it is cooled down it pulls the sheet into a reverse buckle. As long as the staybolts are holding it flat it will be under strain on the fire side of the plate and the greatest strain is in the line of greatest expansion and compression which causes the cracks to start on the fire side of the plate and to run vertically. The hotter the hot spot, the greater the compression of the metal and the quicker the failure of the plate.

Use of Logarithm Tables

Q.—I would appreciate it very much, if you would send me through your magazine, THE BOILER MAKER, the solution to the following questions:

In the book entitled, "Smolley's Parallel Tables of Logarithms and Squares," the table of logarithms and squares gives values from 1/32-inch to 99 feet 11 31/32 inches, and in the table of circumferences, areas, squares, cubes, and square roots, values of 0 to 999 are given. I would like to know by means of an explanation and example, how can one work with higher numbers than these. To make myself clearer, I am enclosing a sketch with its problem. R. G.

A.—In order to solve the problem submitted in the question, by the use of parallel tables of logarithms and



Sketch of right triangle for use of tables

squares, it would be necessary to extend the tables sufficiently to include the dimensions shown in the problem.

The procedure would then be the same as Problem 1, illustrated on page 342 of "Smolley's Parallel Tables of Logarithms and Squares." Subtract log *c* from log *a*, the difference is log Sine $A = \log S$, etc.

Layout of Camber Line

(Continued from page 195)

a center and *1'-5* as a radius, strike an arc to *F*. Bisect this arc at *e*; draw a line from *1'* through *e* to intersect *5-J* at *d*; *d* will be the height of the camber. With *d* as a center and *d-5* as a radius, draw a half circle. Bisect this half circle at *1* and divide the lower quadrant in any number of equal spaces, four being preferred. Number these points *1, 2, 3, 4* and *5*. Next divide *5-1'* into the same number of equal parts and number the *1', 2', 3', 4'* and *5*. From points *2', 3'* and *4'* draw perpendicular lines. Next with *g* as a center, draw lines to *2, 3* and *4*; mark the intersections of these lines with the line *d-1* as *a, b* and *c*; transfer the distance *a-2* to *a'-2', b-3* to *b'-3'* and *c-4* to *c'-4'*. Connect up the points *1', a', b', c', d* with a curved line and you have the required camber for one half of the pattern. The other half is then easily drawn. The top camber line of the pattern is found by drawing a number of arcs from points *1', a', b', c', d* using *1'-K* as a radius. Then draw a curved line through these arcs. It is necessary to measure the correct circumferences of the bottom and top of the pattern along the curved lines with a graduated measuring wheel to complete the pattern.

Sarnia, Ont. J. Ross.

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States and Cities That Have Adopted the A.S.M.E. Boiler Code

	States	
Arkansas	Missouri	Rhode Island
California	New Jersey	Utah
Delaware	New York	Washington
Indiana	Ohio	Wisconsin
Maryland	Oklahoma	District of Columbia
Michigan	Oregon	Panama Canal Zone
Minnesota	Pennsylvania	Territory of Hawaii
	Cities	
Chicago, Ill.	St. Joseph, Mo.	Memphis, Tenn.
Detroit, Mich.	St. Louis, Mo.	Nashville, Tenn.
Erie, Pa.	Scranton, Pa.	Omaha, Neb.
Kansas City, Mo.	Seattle, Wash.	Parkersburg, W. Va.
Los Angeles, Cal.	Tampa, Fla.	Philadelphia, Pa.
	Evanston, Ill.	

States and Cities Accepting Stamp of the National Board of Boiler and Pressure Vessel Inspectors

	States	
Arkansas	Missouri	Pennsylvania
California	New Jersey	Rhode Island
Delaware	New York	Utah
Indiana	Ohio	Washington
Maryland	Oklahoma	Wisconsin
Minnesota	Oregon	Michigan
	Cities	
Chicago, Ill.	St. Louis, Mo.	Nashville, Tenn.
Kansas City, Mo.	Scranton, Pa.	Omaha, Neb.
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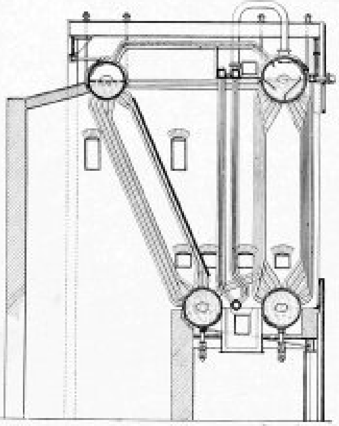
Erie, Pa.	Tampa, Fla.	Philadelphia, Pa.
Detroit, Mich.		

Selected Boiler Patents

Compiled by Dwight B. Galt, Patent Attorney, Washington Loan and Trust Building, Washington, D. C. Readers wishing copies of patents or any further information regarding any patent described, should correspond directly with Mr. Galt.

1,762,180. BOILER CONSTRUCTION. PHILIP MARQUAND, OF NEWBURYPORT, MASS., ASSIGNOR TO EDGE MOOR IRON COMPANY, OF EDGE MOOR, DEL., A CORPORATION OF DELAWARE.

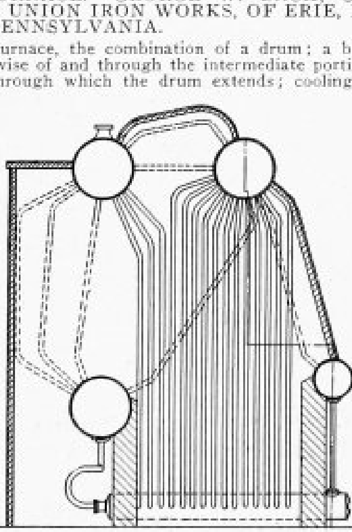
Claim.—A watertube boiler element adapted for use with a one direction transverse flow of fire gases through its tube banks comprising in combination two drums provided with tube holes spaced to leave substantial ligaments of sheet metal between them and one or more banks of tubes



the intermediate and greater part of the length of which are in each bank disposed parallel to each other in spaced relation which leaves between them narrow gas passes substantially narrower than the spaces between the tube holes, said tubes having their ends spread apart and secured in the tube holes of the drums all of the tubes in each boiler element in the rear of the tube rows between which contracted gas passages are first formed being disposed as described to form contracted gas passages throughout the entire depth of the tube banks. Four claims.

1,763,210. FURNACE. GEORGE W. BACH, OF ERIE, PA., ASSIGNOR TO UNION IRON WORKS, OF ERIE, PA., A CORPORATION OF PENNSYLVANIA.

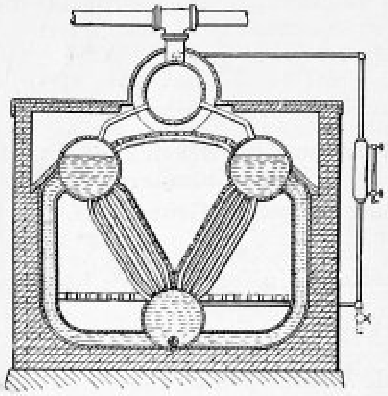
Claim.—In a furnace, the combination of a drum; a boiler tube system connected lengthwise of and through the intermediate portions of the drum; a furnace wall through which the drum extends; cooling tubes extending



radially and fan-wise from the drum, said cooling tubes being bent to distribute the tubes at intervals in parallel relation with their axes in a plane within the wall; and a manifold arranged without the wall and connected to the ends of the tube opposite their connection with the drum, said manifold having its axis in a plane extending transversely of the axis of the drum. Four claims.

1,762,136. WATERTUBE STEAM BOILER. JOHN C. HANRAHAN, OF LOS ANGELES, CAL.

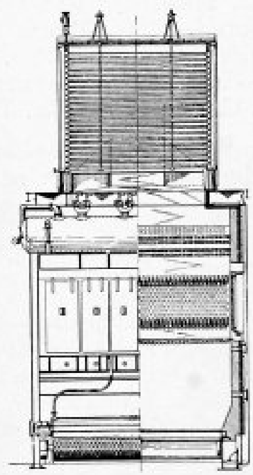
Claim.—A watertube steam boiler comprising a mud drum, two banks of tubes connected to the mud drum and divergently extending upward therefrom, two steam and water drums arranged above the mud drum, one steam and water drum being connected to one bank of tubes and the other steam and water drum being connected to the other bank, means providing walls connecting each steam and water drum to the mud drum, said banks of tubes serving to divide the space between the drums and walls into three chambers, the chambers between the banks of tubes and the adjacent walls constituting initial combustion chambers and the chambers between the banks of tubes constituting a secondary combustion chamber, there being passages between the tubes of each bank permitting fuel and the products of combustion to pass therethrough from the initial combustion



chambers into the secondary combustion chamber and to meet therein in opposition and revive or complete the combustion before passing upwardly between the steam and water drums, and a steam or super-heating drum arranged above the secondary combustion chamber in the path of the products of combustion issuing therefrom and connected to the steam and water drums. Ten claims.

1,762,134. ECONOMIZER. WILLIAM A. JONES, OF WEST NEW BRIGHTON, N. Y., ASSIGNOR TO THE BABCOCK & WILCOX COMPANY, OF BAYONNE, N. J., A CORPORATION OF NEW JERSEY.

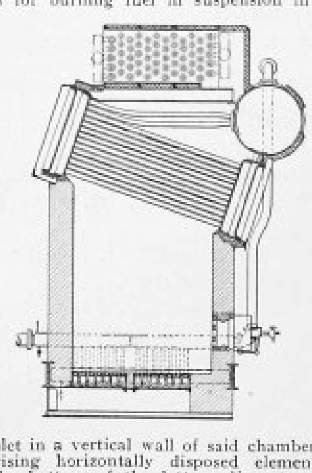
Claim.—In combination, a boiler, an economizer placed above the boiler,



an unobstructed flue admitting gases from the boiler directly to the top of the economizer, and an exit for the gases at the bottom of the economizer. Seven claims.

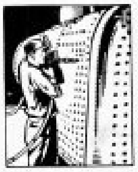
1,764,050. SUPERHEATER BOILER. JOSEPH JOHN NELIS, OF BROOKLYN, N. Y., ASSIGNOR TO FOSTER WHEELER CORPORATION, NEW YORK, A CORPORATION OF NEW YORK.

Claim.—The combination with a boiler furnace comprising a combustion chamber, of means for burning fuel in suspension in said chamber comprising a burner inlet in a vertical wall of said chamber, and a radiant heat superheater comprising horizontally disposed elements extending across said chamber at the bottom of the latter adjacent said vertical wall and adapted to absorb radiant heat at their upper sides from said chamber. Six claims.



The Boiler Maker

Reg. U. S. Pat. Off.



Water Treatment

With its experimental locomotive, known as No. 3800, the Canadian National is attempting to determine whether or not economy in water treatment can be accomplished by installing suitable arrangements on the locomotive itself rather than by the customary treating plant. On the western region of this railroad or on territory of any road where bad water exists and water treating plants are uneconomical because of a comparatively limited number of locomotives using them, it may be that the results obtained from this locomotive will offer a reasonable solution to the problem.

Since it commenced operation in fast freight service last Fall, this locomotive has demonstrated its ability to correct the bad water of the region that must be used. Its operation has indicated the necessity of altering the design slightly in future locomotives of this type and some changes have been made on the present unit. It will be some time before the ultimate value of the method can be learned but, without doubt, in the near future other locomotives of the same type will be built by this railroad. Details of the water treating system, as installed, appear in an article in this issue.

The New Welding Code

The first complete welding code developed in any country has been adopted by the American Society of Mechanical Engineers after ten years of almost constant effort on the part of the Boiler Code Committee. In that the code covers the fusion welding of pressure vessels and the drums or shells of power boilers, the work of the committee is of vital importance to the boiler manufacturing industry of the United States. Members of this industry, the American Welding Society, the Boiler Code Committee, and all others who have contributed to the preparation and final adoption of the code are to be commended on their efforts.

It remains now for the American Uniform Boiler Law Society to further the early adoption of the code in those states and cities now accepting the A.S.M.E. Boiler Code as a standard of construction. Many already have provided for the application of the code. In fact, action for some time has been necessary in supplying such a code, since a number of states have badly needed it to control properly the rapidly growing demand for welding in boiler and pressure vessel construction.

From time to time, as the art progresses, changes will be made in this as in other A.S.M.E. codes, but as it stands, the present provisions are the result of the best efforts and brains in the industry. As such, the code should have the firmest support from every manufacturer of welded pressure vessels, to the end that standards of construction may be made better and safer.

Staybolt Tests

In the development of the modern steam locomotive, metallurgy has played an extremely important part. Advances in this art have, without question, made possible the high pressures, longer runs, and lower maintenance costs of motive power of the railroads.

In approaching the problem of developing better materials, the steel manufacturer has utilized the research laboratory to the utmost. A very practical application of this procedure to boiler materials is explained in an article by H. L. Miller on the subject of "Corrosion Fatigue Tests of Staybolts" in this issue. The methods of testing adopted accomplish in a brief time what long months or years of actual staybolt installation service would be required to determine. The tests definitely indicate the most suitable material for staybolts and, for this reason, are well worth the careful study and consideration of the mechanical department.

The conclusion reached by the tests is that staybolts, in order to improve resistance to corrosion and toughen the metal, should contain copper, molybdenum or nickel. The slightly greater cost of the original bolts is more than compensated by their longer life.

Chain Maintenance

In any metal fabricating industry, the problem of chain maintenance is a not inconsiderable item. In the interests of shop safety, it is essential that worn or corroded links be replaced. Practical suggestions on this subject are given in an article in this issue. Every boiler shop, large or small, has available welding facilities with which to make rapid and inexpensive repairs to chain, as well as to other mechanical equipment. Time and expense may be saved and possibly serious injuries may be avoided if proper consideration is given to this item which, after all, is an extremely important one in any shop.

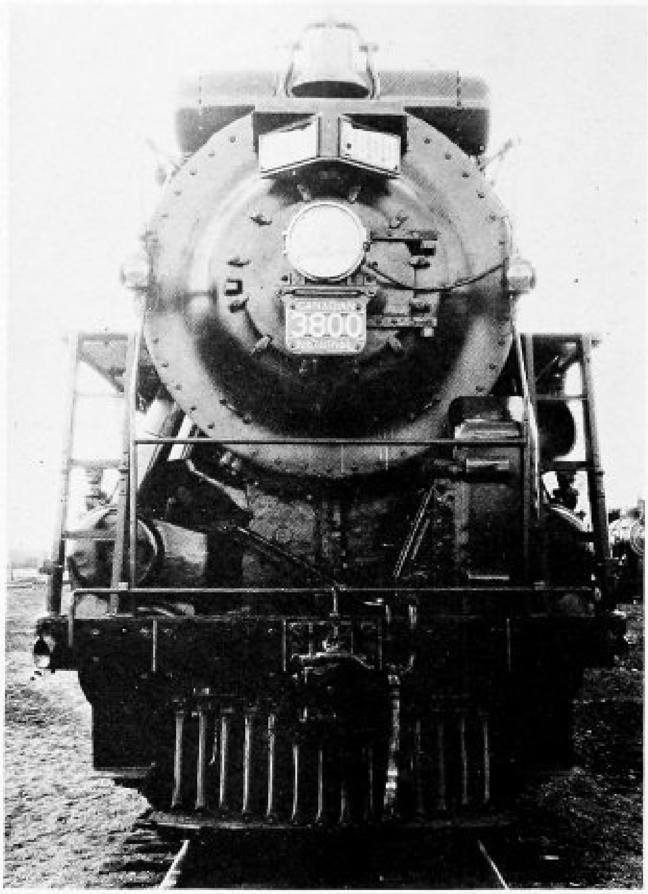
New Canadian National 2-8-2 Type Locomotive for Prairie Service

Experimental locomotive designed with boiler having self-contained water treating system

On the Western Region of the Canadian National in the prairie provinces, operating conditions are encountered which render locomotive maintenance costly, due primarily to the poor quality of feedwater available. When new freight power was being considered for this region, it was decided to build a sample locomotive in which features were embodied that would tend to relieve these conditions.

Most of the difficulties experienced have been due to sludge and boiler sediment being carried over by the steam flow into the superheater units and cylinders, and by the burning out of firebox sheets.

A locomotive, to meet the above conditions, must provide some method of collecting and conveying steam to the cylinders different from that usually employed, must have a relatively slow rate of combustion, high boiler capacity and steam distribution of a nature such that full capacity can be developed without unduly forcing the machine as a whole.



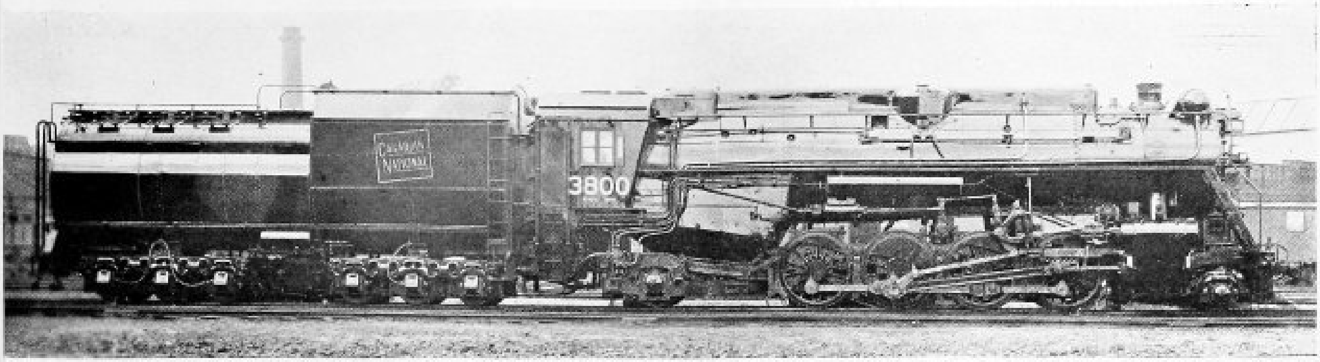
Front view of the Canadian National 2-8-2 type locomotive

With these conditions in view, the company designed and built at its Point St. Charles shops, Montreal, Que., locomotive No. 3800, Class S-4-a, and, on completion in the early fall of 1930, placed it in service on the Central Region for observation and test between Danforth, Ont., and Sarnia, Ont., in fast-freight service and, later, between Danforth and Fort Erie, Ont., in heavy coal service. Under both classes of operation the locomotive has demonstrated its ability to perform in a satisfactory manner and considerable valuable experience is being gained for incorporation in further designs at a future date. Several minor alterations have been made to the original design as the result of the preliminary test runs.

The No. 3800 exerts a tractive force of 56,200 lb. It has 24-in. by 30-in. cylinders and operates at a boiler pressure of 265 lb. The driving wheels are 63 in. in diameter. The locomotive weighs 337,200 lb., of which 237,000 lb. is carried on the drivers.

In accordance with the requirements referred to in the preceding paragraphs, the dome and inside dry pipe have been omitted from the boiler and an outside dry pipe of somewhat novel design introduced in their stead. On the top center line of the boiler at suitable intervals three 5½-in. holes are cut to provide an outlet for the steam. Over these openings are riveted cast-steel saddles, consisting of a base and a cylindrical body portion, the forward two of which are open at both ends, while the rear is open on one end only. The other end is cored and faced for a ball joint. The collector pipe, a 10¾-in. seamless steel tube, is passed through the cylindrical saddles and bottomed on a faced joint on the inside of the solid head of the rear saddle. These saddles are of such shape that an annular passage is formed between the collector pipe and the cylindrical shell, terminating at the bottom or base portion in a hole which registers with one of the 5½-in. holes in the boiler shell. The open ends are faced and bored to a sliding fit for the pipe and made steam tight by means of electric welding around the outside faces of the saddles and the collector pipe.

Around the periphery of the collector pipe at the portion covered by each of the saddles are drilled five rows of ⅝-in. holes, 20 in each row, making a total of 100 ⅝-in. holes, to conduct the steam from the 5½-in. boiler outlets to the interior of the collector pipe. The forward end of this pipe is swedged down to receive an 8-in. outside diameter seamless steel dry pipe which is securely welded at its rear end to the swedged portion of the collector. The dry pipe terminates at the smokebox end in a steel flange which is welded to the pipe and faced for a ball-joint connection to the shut-off valve. A cast-steel L-shaped shut-off valve body, provided with ball-joint flanges, passes through an opening in the smokebox immediately in front of the cir-



Canadian National 2-8-2 type locomotive built for freight service on the western region

cumferential seam, the vertical leg of which connects with a horizontal flange on the superheater header, while the horizontal leg is fitted to the dry-pipe flange. The shut-off valve, a flat disk of plate bored in the center to form a seat for the balancing valve and actuated by an Acme threaded screw, the initial movement of which unseats the balancing valve, has its seat on a forged-steel ring pressed into a suitable recess at the top of the vertical leg of the shut-off valve body. Faced lugs on the sides of the valve body are fastened by suitable anchor plates secured to the smokebox shell to relieve the body casting and dry pipe of any end thrust due to steam pressure.

Inside the boiler, immediately under the outlet openings, a shallow box of ¼-in. plate is tightly fitted to the shell and held in place by studs. The bottom face of this box or pan is perforated over the greater portion of its length with 468 ⅝-in. holes of an extruded form, through which the steam must pass before having access to the outlet holes.

It was anticipated that, by spreading the steam-outlet area over a large extent of water surface in this way and baffling any sludge or entrained water by means of the extruded form of the perforations, some of the difficulties experienced could be overcome.

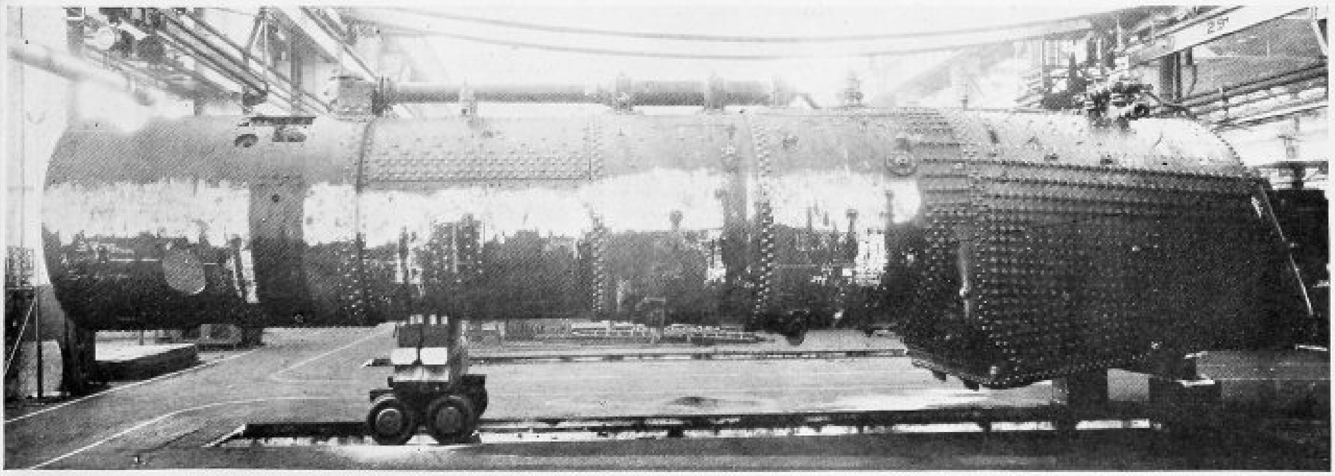
However, these expectations have not been entirely realized in service and the box or pan has since been altered.

In addition to the alteration made to the pan under the dry pipe and changing the feed pump, the front outlet hole in the boiler has been blanked off and the remaining two holes have been found of sufficient area to meet the steam requirements of the cylinders and auxiliaries in a satisfactory manner. While using the three openings, the locomotive showed a tendency to carry water and sediment into the dry pipe, especially during periods of surge such as follows a heavy brake application. Since the front opening was blanked, no further difficulty has been experienced and dry steam with a high degree of superheat is consistently maintained.

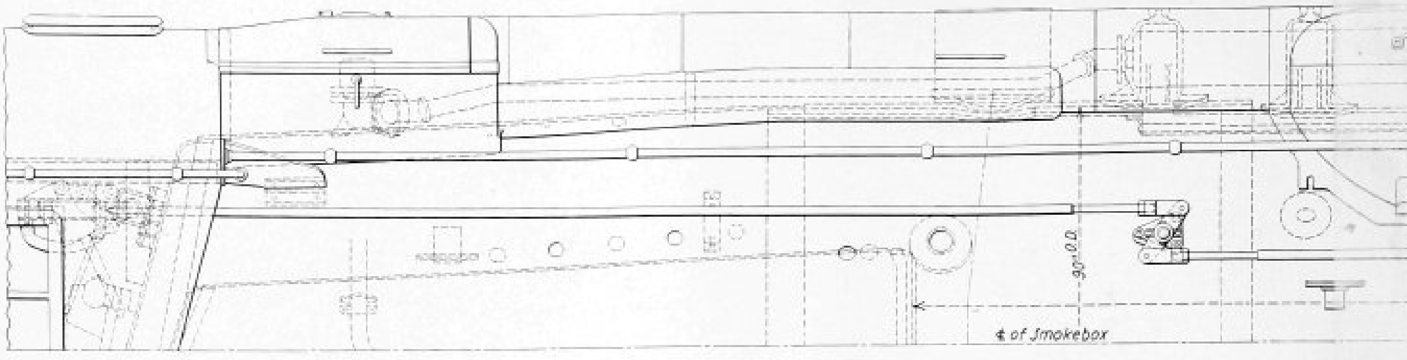
A 2½-in. iron pipe with flanged connections runs from the back end of the rear collector saddle to the cab turret on the right side. This pipe supplies saturated steam to a number of auxiliaries. The superheated-steam turret connects to a 2½-in. pipe which is carried along the top of the running board on the left side to a cast-steel auxiliary steam-pipe elbow passing through the smokebox near the top and connected directly to the superheater header.

A 13-in. by 15-in. manhole provides access to the interior of the boiler. This manhole is located on the top center line at the rear of the collector saddles and is closed by a cast-steel cover into which the safety valves are screwed. The dry pipe, collector pipe and saddles are lagged and jacketed and an external inverted U-shaped casing is fitted from the stop valve at the smokebox over the entire length of the boiler to the cab-turret casing. The sand box is made in two halves straddling the collector saddles, and the U-shaped casing is fitted into it at the front and back faces, and into the cab turret casing, forming an unbroken outline from the front to the rear of the boiler.

Feedwater enters the boiler on the top center line of first course directly beneath the dry pipe. A small steel casting, with inlets at an angle of approximately 30 deg. on each side and tapped to receive 2-in. iron pipe, is riveted to the boiler. Short lengths of double-extra-heavy pipe, screwed and welded, join these inlets



Boiler of the Canadian National 2-8-2 type locomotive designed for service in bad-water territory



Arrangement of outside dry pipe as fitt

with cast-steel flanged elbows which extend beyond the U-shaped casing and serve to attach the right- and left-hand boiler-check valves.

Silicon steel is used throughout in the construction of the boiler shell, with the exception of the welt strap of the third course, from which the manhole is flanged and where ordinary open-hearth boiler steel is used.

A Type E superheater with multiple throttle header is applied. The firebox, of liberal grate area, is fitted with two Nicholson Thermic syphons and two 3-in. outside diameter arch tubes and a 23½-in. combustion chamber. The somewhat limited tube length imposed restrictions at this point. The net firebox volume, after deducting the arch, syphons and arch tubes, is 361.25 cu. ft. Canadian National standard round-hole grate bars are used, which provide a free air opening of 11.8 per cent. An ashpan of moderate slope and ample capacity, fitted with Canadian National standard cast-steel hoppers and swinging doors, a type BK stoker, Franklin single-cylinder grate shaker and Franklin fire door, an Elesco feedwater heater and Superior automatic soot blowers complete the boiler and auxiliaries.

Originally an Elesco centrifugal pump was fitted, but since going into service this pump has been replaced by a type CF-1 Elesco pump, which is supported on the same bracket cast on the left side of the cradle, below the ashpan, which was for the centrifugal pump. An H.N.L. injector is located on the right side.

The cut-off is limited to 64.8 per cent on the main ports, while on the auxiliary ports it is 83 per cent. An additional five per cent compensating cut-off is provided on the head end of each cylinder by a slight enlargement of three ports, still further improving the starting torque, and, with a factor of adhesion of 4.21, the locomotive showing little tendency to slip. The 14-in. piston valves are actuated by a Baker long-travel, long-lap type of valve gear.

The main frames are nickel cast steel and the cylinders and steam pipes are nickel cast iron. The main and side rods are nickel steel. The main crank pins and axles are of Steel, Peech & Tozer quenched steel. The single guide bar is of nitrided alloy steel and forced lubrication is supplied to this detail, as well as to the valves and cylinders, by a Nathan D.V.S. lubricator on the right side.

The engine truck has outside bearings and provides 40 per cent constant resistance, while the trailing truck is the Delta outside bearing with 20 per cent constant resistance, both of General Steel Castings Corporation manufacture. The engine and trailing truck and the main driving journals are fitted with Canadian National standard revolving-bushing boxes.

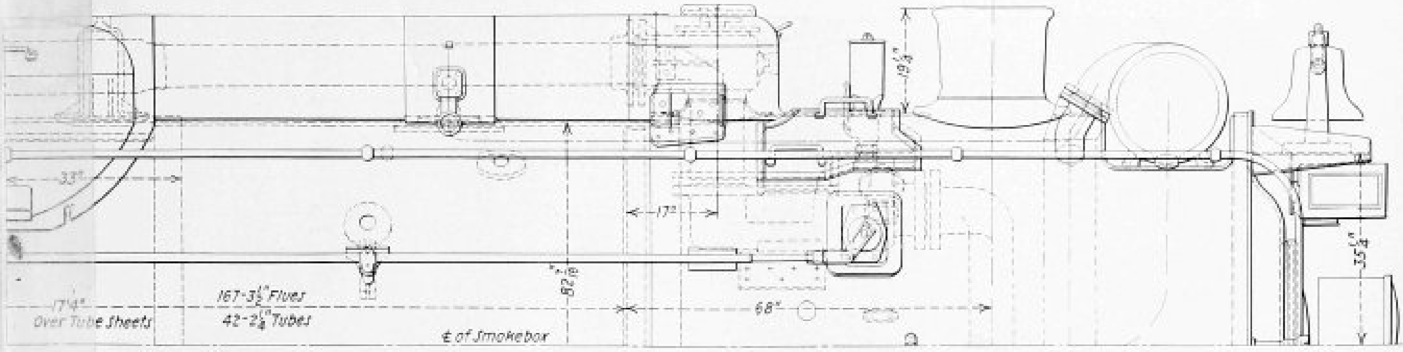
The tender of this locomotive is of interest, being an improved design of the Canadian National standard frameless Vanderbilt tank, first introduced on a number of 4-8-4 locomotives built in 1929. The later design used on the No. 3800 was also applied behind 4-8-2 engines built during 1930.

The Canadian National now has in service, or in the course of construction, more than 50 tenders of this same general arrangement. No underframe is employed. The bottom tank plate of 1-in. thickness forms the backbone to which the draw and center castings are riveted and welded. The internal bracing is of such a nature as to add substantially to the rigidity of the bottom structure. Tenders of this general design in service over a period of practically 2½ years have rendered satisfactory service. They have proved their ability to withstand the shock of collision and, although the body plates were ruptured, the under structure was found to be intact.

In the latter design, as used on the No. 3800, considerable lightening in weight, mainly in the castings, was effected and the compartment for housing the stoker engine was relocated. This compartment is now placed directly in the rear of the conveyor. The engine is carried on a cast-steel base plate and is connected to the conveyor gear shaft without using the customary shaft and universal joints. Only one joint is required for alinement purposes, making a more compact con-

Principal Dimensions and Weights of the Canadian National Sample 2-8-2 Locomotive

Railroad	Canadian National
Builder	Canadian National (Pt. St. Charles shops)
Road class	S-4-a
Service	Freight
Rated maximum tractive force	56,200 lb.
Weight on drivers ÷ max. tractive force	4.21
Cylinders, diameter and stroke	24 in. by 30 in.
Valve gear, type	Baker
Weights in working order:	
On drivers	237,000 lb.
On front truck	39,000 lb.
On trailing truck	61,200 lb.
Total engine	337,200 lb.
Tender	272,300 lb.
Total engine and tender	609,500 lb.
Wheel bases:	
Driving	16 ft. 9 in.
Total engine	37 ft. 8 in.
Total engine and tender	76 ft. 3¾ in.
Wheels, diameter outside tires:	
Driving	63 in.
Front truck	31¼ in.
Trailing truck	43 in.
Boiler:	
Steam pressure	265 lb.
Fuel, kind	Bituminous
Diameter, first ring, inside	80⅞ in.
Firebox, length and width	120⅛ in. by 84¼ in.
Tubes, number and diameter	42—2¼ in.
Flues, number and diameter	167—3½ in.
Length over tube sheets	17 ft. 4 in.
Grate area	70.28 sq. ft.
Heating surfaces:	
Firebox and combustion chamber	339 sq. ft.
Tubes and flues	3,065 sq. ft.
Total evaporative	3,404 sq. ft.
Superheating surface	1,591 sq. ft.
Combined evap and superheat	4,995 sq. ft.
Tender:	
Water capacity	11,000 Imp. gal. (13,200 U. S. gal.)
Fuel capacity	20 tons.



…on new Canadian National locomotive

nection. Access is had to the compartment by means of a casing which passes out through the side of the tank and is fitted with a hinged door. The design of the vestibule diaphragm spring equipment has been modified and the diaphragm is now of all-welded plate construction. The rear bumper beam of cast steel has been eliminated and a structural steel platform of a design suitable for jacking has been substituted. The locomotive cab is also of welded construction.

A new style of coal gate has been fitted to the bunker of the No. 3800 and is giving satisfactory service. The customary construction using four or more leaves has been replaced by a single flat-hinged door. This door provides access to the coal space, and a small door of semi-cylindrical shape revolving on trunnions furnishes the necessary opening for hand-firing or adjusting stoker slides. Peep holes covered by small pivoted slides are provided so that a bar may be inserted to break down any arching of the coal before it is off the entrance gate. The front tank plate is not cut away to the same extent as before and can be substantially braced. Six-wheel General Steel Castings Corporation trucks with clasp brakes are applied.

One 8½-in. Westinghouse cross-compound air compressor is applied at the front end on the left side of the locomotive and is supported on a cast-steel bracket, carried from the frame and engine truck center-pin guide. A plate shield is fitted in front, as shown in one of the illustrations. The pump throttle is located on the auxiliary steam-pipe elbow at the left side of the smokebox. It uses superheated steam and is opened and closed by enginehouse forces. The whistle is attached at the same point and is operated by a cable through the left handrail.

The tender brake equipment is somewhat modified, an 18-in. brake cylinder with Type L triple and double check valve being employed. The by-pass feature is inoperative and the triple functions in lieu of a brake-pipe vent valve. This arrangement is standard on most of the Canadian National heavy power.

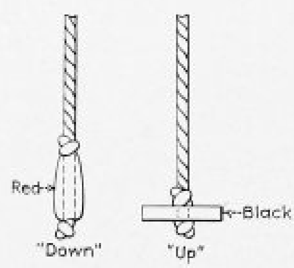
Precision power reverse gear, Franklin safety bar and side-spring radial buffer of a special design to suit Canadian National clearance requirements are applied. An Elesco trap is fitted in the tender tank, the condensate and stoker exhaust being piped into it. Practically all iron piping on the engine and tender is welded, thus eliminating as many sources of leakage as possible.

Standard frameless Vanderbilt tank

Designated Controls For Hoists

To designate the "Up" and "Down" movement of the hook on hoists having the pendant control, special handles were applied to the pendants on all hoists on an eastern railroad.

As shown in the illustration, a file handle, painted red, is attached to the pendant controlling the downward movement of the hook, while a handle placed in a horizontal position and painted black controls the upward movement. The horizontal handle can be made from a discarded hammer or maul handle. In some states the designation of pendant controls is mandatory in the interest of accident prevention.



The red and black handles, in different positions, make it easy to assure the right move on a hoist

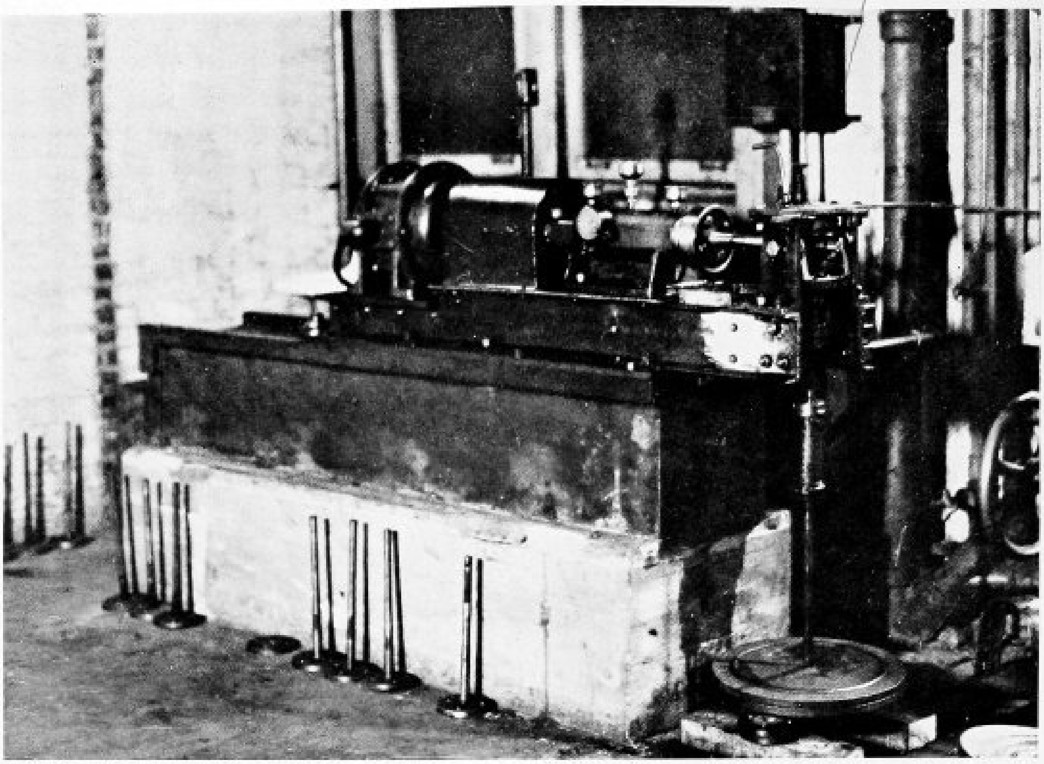


Fig. 1.—Staybolt under test in fatigue testing machine

Corrosion Fatigue Tests On Various Staybolt Materials

By H. L. Miller*

Corrosion fatigue testing of staybolts has been carried on for over two years at the Metallurgical Laboratories of the Republic Steel Corporation, Central Alloy Division, Massillon, O. A staybolt in service is subjected to water corrosion and to reversed bending stresses. The nearest approach to service conditions on a testing machine is found in the method of testing developed at the laboratories of this company. The tests are as follows:

A section of the bar material to be tested is threaded and screwed into a plate of standard 5/8-inch thick wrapper sheet stock. The bolt is headed up as if it were being applied in a boiler and the regular tell-tale hole is drilled in the center. This method tests not only the staybolt but also the plate and the joint between the bolt and plate.

In Fig. 2 is shown the assembled test specimen, consisting of the staybolt and wrapper sheet. The threaded end is fastened in the plate and headed up and drilled. The plate is then faced off on back and fastened on a special head in the lathe. The bolt is then centered on the other end and turned to its true center. Bolt is standard 1-inch × No. 12 thread—7/8 inch round at the outer end, tapered from the end of thread for 6 inches on the length; taper 1/4 inch per foot.

* Metallurgical department, Republic Steel Corporation, Massillon, O.

Fig. 1 shows a staybolt test in the fatigue testing machine. The assembled test piece is bolted into the head stock of the testing machine with the outer end passing through a bushing which runs in ball bearings. This bearing is in a yoke which is free to move in a vertical direction and has about 1/8 inch clearance on the sides. The weight is supported on a coil spring in the pipe section and this acts as a vibration dampener. The indicator shows the number of revolutions, and failure

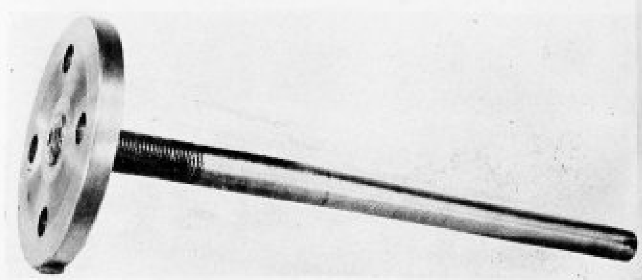


Fig. 2.—Staybolt and wrapper sheet test specimen

of the bolt lets the yoke down and stops the machine automatically.

When running corrosion fatigue tests the bent pipe on the machine shown above the test is pulled down, so that a stream of water at 150 degrees F. is flowing over the threaded section of the bolt. A hood is placed over the spindle to catch the water and it drains off below the machine.

The fiber stress on the critical section of the staybolt which is at the junction of the bolt and the plate, can be adjusted to any desired stress by the proper amount of weights on the rod.

The rotating beam formula used in this test is:

$$\text{Fiber stress} = \frac{\text{Load (lbs.)} \times \text{length (in.)} \times \text{radius}}{0.049 \times \text{diameter}}$$

The length from the face of the plate to the center of the bushing where load is applied is 11½ inches.

A load was applied to produce a fiber stress of 18,000 pounds at the junction of the bolt and the plate. The water was held around 150 degrees F. The speed was 1150 revolutions per minute. This gives about 1,650,000 reversals of stress in a 24-hour day. The life of the tests is given in days to failure. There is a wider spread in results on threaded sections than on polished smooth sections as are used in the other type fatigue machines.

Six brands of staybolt iron bought in the open market and samples of Toncan and Agathon nickel iron taken from warehouse stock were used in these tests. Heat-treated Toncan and Agathon nickel iron were also run. The range of life as shown by several tests from each bar is as follows:

The physical properties and fatigue life are shown in the following tables:

Material	Y. P.	Tensile	Elong. 8" per cent	Reduction per cent	Izod Ft. Lbs.	Corr. Fatigue life, Av. 5 tests
Wrought Iron						
A	34,000	50,200	29.0	57.0	48	8 days 3 hours
B	39,300	49,700	29.0	52.1	42	8 days 15 hours
C	31,700	49,800	31.0	51.3	43	13 days 18 hours
D	36,000	51,700	29.0	46.0	51	13 days 12 hours
E	34,300	48,900	32.0	50.7	53	14 days 18 hours
F	32,900	49,300	30.5	51.3	46	9 days 21 hours
Toncan	41,900	53,000	28.2	70.1	81	22 days 18 hours
Nickel	36,700	51,000	30.3	71.2	86	18 days 23 hours
Toncan Treated	49,600	62,400	21.5	72.4	91	53 days 9 hours
Nickel Treated	48,300	60,900	22.3	70.6	102	47 days 12 hours

As might be expected, when using a threaded section under reversed stresses, there is quite a wide spread in the results from some of the bars. Highly polished sections under these conditions of testing would give more uniform results, but staybolts in service are threaded and the results in service are not uniform either, some bolts breaking long before others in the same row. It is believed that more testing of each type might show truer average values but there is such a wide difference shown in the above tests in favor of the Toncan and nickel iron analyses, both in hot-rolled but especially in the heat-treated conditions, that it is doubtful if any number of tests would change the relationships shown in the above results to any great extent.

We found it very difficult to get the wrought iron bolts to break off unless they were machined to fit very tight in the threads.

When fitted in the ordinary manner the wrought iron bolts all tended to strip threads and pull out of the plate in a short time. This is due no doubt to the weakness of threads on account of slag inclusions. This bears out the data given to the writer by several boiler makers, that wrought iron bolts are more often replaced on account of stripped threads, rather than by breaking.

We also found that the wrought iron bolts did not last as long after a crack had started as did the steel bolts. The surfaces of the fractured ends of wrought iron bolts show rough and not much evidence of flattening or smoothing of surface and final rupture showed around 40 percent on the wrought iron tests. The Toncan and nickel iron seem to hold on until the surface of fractures was smoothed down and final rupture rarely shows over 20 percent of the area.

The heat treated bolts showed more than double the life under the same conditions than the "as rolled" Toncan or nickel iron, and 3 to 10 times the life of the wrought iron bolts.

Bolts with Brinell much over 130 tended to cause failure in the plate rather than the bolt. The Brinell on standard wrapper sheet stock runs around 116 to 134 according to carbon content and finishing temperatures. Some tests on a steel staybolt stock from an outside source were run. These bolts had around 45,000 to 50,000 pounds per square inch yield point but Izod values were low (15-20 foot pounds). They showed crystalline breaks on fracture tests and only lasted 2 to 3 days on the testing machine. One broke in less than ten hours. This shows that a high yield point should be accompanied by good impact values to give satisfactory service.

In conclusion, Toncan and Agathon nickel iron in hot-rolled condition with yield point around 40,000 pounds per square inch showed much better life than wrought-iron bolts. Heat treated bolts showed best of all. High yield point but low shock resistance showed to be poorest of all.

Elongation of the best life bolts was fully 10 percent below the A.S.M.E. or A.R.A. requirements, yet three locomotives in hard switching service in a hard water district have been equipped with a full set of heat-treated Toncan bolts. They have all made nearly 100,000 miles apiece in service to date, April 1931, and only one bolt has been removed from these engines in that period.

A low yield point will show good elongation, a high yield point will show less elongation. Neither of these

Life in days of 6 brands of Staybolt Wrought Iron, Agathon Toncan and Agathon Nickel Iron

Corrosion fatigue test, rotating beam. 1-inch round bars threaded No. 12 U. S. S. Standard thread. Running under water at 150 degrees F., speed 1150 R.P.M., 1,650,000 reversals of stress per 24-hour day. Life of tests given in days and hours. Wrought Iron tests marked A-B-C-D-E-F. Toncan and Nickel in "As Rolled" and "Treated" conditions marked T-N TT NT:

	Days	Hrs.	Days	Hrs.	Days	Hrs.	Days	Hrs.	Days	Hrs.	Days	Hrs.	Days	Hrs.	Days	Hrs.	Days	Hrs.	Days	Hrs.
Test No.	A		B		C		D		E		F		T		N		TT		NT	
1	4	6x	5	13x	19	3	13	3	15	9	7	3x	21	19	18	3	47	9	43	7
2	7	12	18	2	14	7	9	4	8	6	2	15x	32	7	15	7	36	11	49	1
3	6	14x	3	7x	9	6	17	21	21	4	19	21	26	14	29	4	59	3*	60	2*
4	14	3	9	4	17	18	16	7	16	19	12	4	19	7	19	3	72	10*	38	12
5	8	7	6	1	8	6	11	3	12	6	7	18	13	22	12	9	..	..	..	..
Total	40	16	43	3	68	16	67	14	73	20	49	12	113	21	94	2	215	9	190	22
Average	8	3	8	15	13	18	13	12	14	18	9	21	22	18	18	23	53	9	47	12

x—Tests marked "x" stripped threads and pulled out of plate.
—Tests marked "" removed—not broken.

(Continued on page 208)

New A. S. M. E. Rules for Welding Pressure Vessels

After more than ten years of active effort, the Boiler Code Committee of the American Society of Mechanical Engineers has completed its work of formulating a comprehensive code for fusion welding of pressure vessels and drums or shells of power boilers. The June meeting of the Boiler Code Committee marked the completion of its deliberations on the proposed drafts of the new welding rules, a copy of which was published in the June issue of THE BOILER MAKER.

The publication of the preliminary drafts provoked much criticism which was both constructive and otherwise, and as a result the committee has experienced much difficulty in arriving at a satisfactory solution of many of the problems that have arisen in this connection. At the June meeting of the committee, final hearings were held where those protesting against any details of the new code could be heard. By intensive effort satisfactory adjustments of the remaining questions were fortunately arrived at, and after all of the criticisms and comments had been thoroughly reviewed, the meeting concluded with unanimous approval of the new rules for fusion welding of boilers and pressure vessels. The proposed new code was ordered submitted to the Council of the A.S.M.E., and on July 7, the council adopted the new rules as standards of the Society.

With the above approval and adoption of the new welding rules, they became effective so far as any action of the Boiler Code Committee or the Society is concerned. Corresponding action in the various states and municipalities where the A.S.M.E. code is operative usually follows within six months of adoption by the Society.

Probably no section of the A.S.M.E. Boiler Code has ever been subjected to as much criticism and discussion as the proposed rules for welded construction. The governmental authorities, the insurance companies, and the users in general have been wary of agreement to so radical a departure unless the new rules could be surrounded by ample safeguards to insure sound and dependable construction. Some of the restrictions that were first proposed were considered onerous by the manufacturers, who suggested modifications. There was, however, too much influence from the users of welded construction to allow questionable requirements to be admitted, and the result is a code that is slightly more restrictive than some of the fabricators would like to see it, but yet which is undoubtedly practical and operative. It is the obvious opinion of the Boiler Code Committee that it is more desirable to have a code that is restrictive at the outset and which may be loosened up from time to time as the results may seem to warrant.

Many of the criticisms and suggestions received by the committee were of great value, and it is needless to state that the committee considered these and acted upon them with the greatest of care. The criticisms of the method originally proposed for grading of welds proved to be very helpful to the committee, and resulted in an important modification of the code which groups the welding rules under the headings of three different classes of tanks. All the requirements for each class, including allowable stresses, tests of welders, etc., are self-contained and complete in each class group. This will greatly simplify the matter of references to the rules, and will undoubtedly make them much more practical and workable.

There was much discussion of the questions of stress relieving of welded vessels, and of non-destructive testing of the welded joints. Both of these have been retained for Class 1 vessels and power boiler drums, but the stress relieving requirements for Class 2 vessels have been modified so that this treatment is called for only under certain conditions involving thick-walled tanks. Suggestions were advanced for a mechanical method of stress relieving, involving hydrostatic pressure test under certain conditions; on account of lack of definite data as to results with this method, no provisions therefor were incorporated in the new rules, but arrangements were made for inclusion of such rules whenever the method may be shown to be efficacious.

The A.S.M.E. Boiler Code Committee is entitled to a great deal of credit for devoting so many years of unstinted labor to this important work. There has been obvious need for a code of welding rules for many years, but for a long time there seemed to be insurmountable obstacles. By virtue of the co-operative effort with the American Welding Society and other interested organizations, this new code has been evolved. It is the first comprehensive welding code to be developed anywhere. It is the hope that the new rules will succeed in meeting the requirements of public safety, and that they will prove practical in actual operation.

Corrosion Fatigue Tests

(Continued from page 207)

factors is directly related to the Izod test or shock resistance. Furthermore, a bolt with a low elastic limit becomes very quickly over stressed and ages and becomes very brittle, showing crystallization when fractured.

To obtain the maximum service in a locomotive firebox the following physicals, obtained by heat treating, are recommended for staybolts:

Yield Point	Ultimate	Elongation	Reduction
45-50,000	58-63,000	18-23 percent	55-75 percent

Izod	Brinell
75-100 foot pounds	116-134

The bolts should contain copper, molybdenum or nickel to improve corrosion resistance and toughen the metal.

During March, 1931, the Missouri-Kansas-Texas, for the first time in its history, operated an entire month without an engine failure. The total mileage of all locomotives in service in that month was 930,610.

Chain storage at The Baldwin Locomotive Works

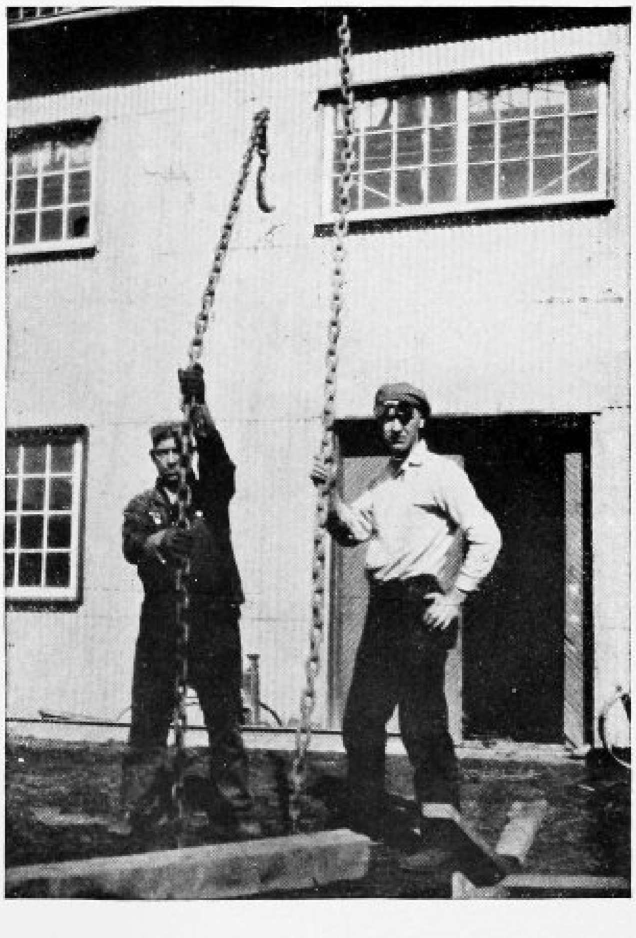
Maintenance of Chains . . .

In many industries the maintenance of chains has been a serious problem, due mainly to the cost of replacing worn out or broken links. This maintenance cost, however, has in many cases been materially reduced through the application of the oxy-acetylene welding and cutting process.

A Northwestern lumber company has had considerable success in rebuilding worn heavy bull chain links with manganese bronze welding rod. This was a case where new links in service 24 hours a day wore down in the eye ¾ inch in two years. Replacement links cost almost $5.00 each and underwent the same wear. The company tried rebuilding their old links by welding with manganese bronze and found that the rebuilt links wore only ⅜ inch in two years of service. As the cost of reclamation was only about 10 percent of the replacement cost, the rebuilding of old chains by oxwelding in now standard practice with this company.

In another instance a contract welding shop received 2800 sets of hooks and chains from a Government department. Each hook had a foot or two of chain already attached, and the welder's job was to fabricate a link to bind the sections together. This was accomplished by cutting mild steel bar into the required lengths with the cutting blowpipe. The bar was then heated with the welding flame and bent to shape. The necessary parts were then assembled and the fabricated link welded with high-test steel welding rod.

A natural gas producer in the East recently moved its gasoline plant equipment from the old site to a new location. This required the removal of a great deal of heavy machinery as well as several pieces of large size process equipment. The company has been using some extra heavy chains for this work, but was continually troubled by breakage due to the tremendous loads applied.



Steel chain with eight oxwelded links after undergoing stress

The removal of a 35-ton absorber was giving particular difficulty at the time. It was partially buried in the earth, and the combined power of two heavy-duty tractors succeeded in barely budging the absorber before the ⅞-inch steel chain that was being used would break. This occurred eight times. Each time it happened the fractured link was repair welded with high-test steel welding rod. Every welded link remained in perfect condition throughout the entire operation.

When the absorber was finally removed, it was found that the chain had been subjected to such a great stress that it had become permanently distorted. In fact, it was possible to stand it on end, or pick it up in the middle as one would a length of pipe. This shows the tremendous load that had been placed on the links and on the welds.

The gas company felt that this was an exceptional test of oxy-acetylene welds because the links were subjected not only to a severe tensile test, but also to a heavy shock test due to the suddenness with which the tractors put the load on the chain.—*Oxy-Acetylene Tips.*

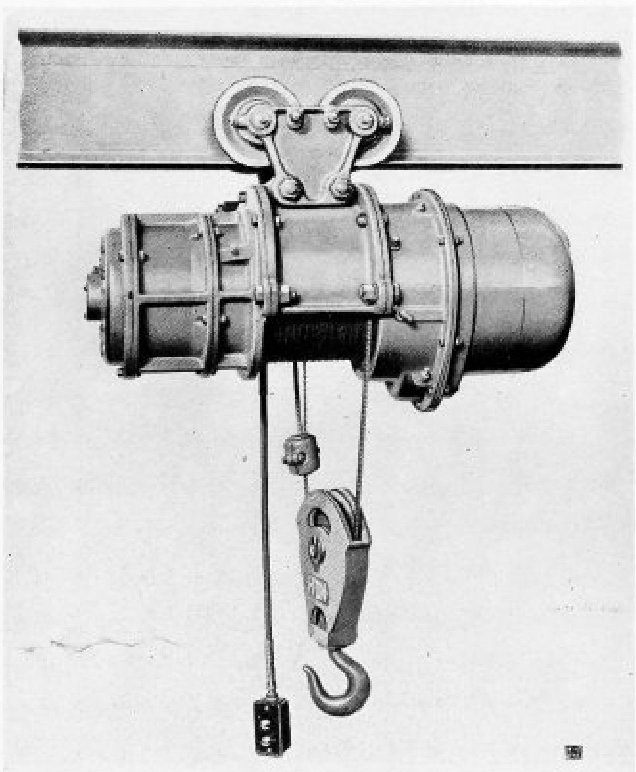
Wright Electric Trolley Hoists

The Wright Manufacturing Company, Bridgeport, Conn., has developed a new line of electric trolley hoists which are said to be complete in every respect. This line consists of the plain, geared, and motor driven trolley types. The bearings of the trolley wheels are designed to absorb both radial and thrust loads, thus reducing the effort to move the trolley along the I-beam to a minimum.

In the motor-driven trolleys, the wheels are driven on each side of the I-beam, insuring smooth operation, and are equipped with a safety stop. Controllers for single speed, two speed, or variable speed can be furnished.

The hoists can be mounted either parallel or at right angles to the runway beam. While the standard lift is 18 feet, lifts of 9 and 36 feet can be furnished.

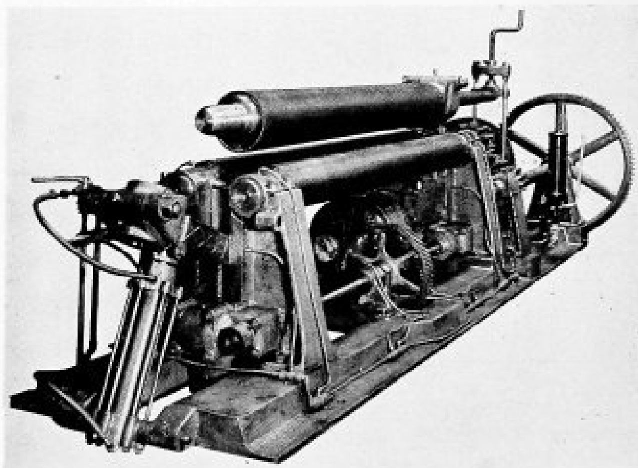
Features of the hoist include full size drums for long cable life, push button or pendant rope control, tru-lay pre-formed cable, safety-type limit switch, positive braking, and weather proof motors.



Motor-driven trolley hoist

Pyramid-Type Bending Roll

The Cleveland pyramid-type bending roll shown in the illustration was developed by The Cleveland Punch & Shear Works Company, Cleveland, O., to meet the demand for rolling small diameter cylinders of heavy material. The illustration shows a shell rolled to an 8-inch diameter, using a slightly smaller diameter top roll. The rolling of the shell so close to the diameter of the top roll was obtained only by the correct relation of the center distance to the diameters of the rolls. After the cylinder was formed, a test was made by laying a straight edge along the cylinder and this showed but a fractional deflection which was less than 1/32 inch at any point along the entire length of the cylinder.



Cleveland pyramid-type bending roll

Some of the additional features incorporated in this roll include an air-operated drop hinge to allow the cylinder to be removed from the roll, individual motor drive for operating the rolls and for raising and lowering the top roll.

The machine is bronze bushed throughout, has cut gears and all bearings are lubricated by a single shot system.

The roll is entirely self-contained and none of the parts extend below the floor level. This feature eliminates the necessity of building an expensive pit, as the machine can be installed on the floor.

The Fusion Welding Corporation, Chicago, Ill., has appointed the Puritan Compressed Gas Corporation of Kansas City, Mo., as distributors for the Weldite line of welding rods. The territory served by the Puritan Compressed Gas Corporation will include the State of Kansas and the western portion of Missouri.

Boiler Patch Formulas ▲ ▲ ▲

By Thomas C. Lewis*

Locomotive boiler patches on unstayed surfaces must have a factor of Safety (F.S.) of four or over, as required by rules of the Interstate Commerce Commission. These patches are round, rectangular or diamond-shaped. They may or may not have an inside welt plate. If, however, they have this plate, its thickness is added to that of the patch on the outside when using the formula, and all rivets through both inside and outside plates are figured in double shear.

If the original plate, or the material from which the patch is to be cut, is not stamped with the tensile strength (T.S.), generally 55,000 pounds, then a tensile strength of 50,000 pounds may be used in the calculations. The shearing strength allowed for iron rivets is 38,000 pounds, and for steel rivets is 44,000 pounds per square inch. The unit length or section of a seam used in calculating the strength of that seam is generally the smallest distance covering a symmetrical arrangement of rivets.

To find the factor of safety (F.S) use the following formula:

$$\frac{\text{T.S.} \times \text{thickness} \times \text{percent efficiency}}{\text{boiler radius} \times \text{pressure}} = \text{F.S.}$$

As we know, before we start our calculations, what each of these items, except the efficiency, should be, it will sometimes save much work to find, at first, the *necessary* efficiency. Let us twist the above formula around as follows:

$$\frac{\text{boiler radius} \times \text{pressure}}{\text{T.S.} \times \text{thickness}} = \text{Efficiency (necessary)}$$

It will be noted that if an inside welt plate is used the thickness will be more and the necessary efficiency less. The percent efficiency is the ratio of the strength of the plate with the rivet holes in it, or of the shear strength of the rivets, to the strength of the same section of plate without any holes in it. For the plate efficiency the formula is:

$$\frac{\text{net section (or pitch — diameter of rivet hole)}}{\text{solid plate of same length}} = \text{percent efficiency of plate.}$$

For the percent efficiency of the shearing strength of rivets the formula is:

$$\frac{N \times \text{area of rivet section} \times \text{shear (38,000 or 44,000)}}{\text{T.S. (of plate)} \times \text{thickness (of plate)} \times \text{unit length}} = \text{percent efficiency,}$$

where N = number of rivets in the row or the unit length taken.

Let us make the above formula simpler by using a gage point as follows:

$$\frac{N \times \text{area} \times .88 \text{ (if T.S. of plate is 50,000)}}{\text{thickness (of plate)} \times \text{unit length}} = \text{percent efficiency of rivets.}$$

All rivets in double shear in this length would count double. For instance if there were 10 rivets in single shear and 15 in double shear then N would be 40. If patch bolts have to be used then the area above is the net sectional area of the patch bolt at the bottom of thread.

Round patches are used where space is limited and cracks are small, such as around check-valve holes. The plate and rivet percent efficiency are figured differently for round patches. The formula for plate efficiency is:

$$\frac{S}{A} = \text{percent efficiency,}$$

where S is the net plate measured on an *arc* subtended by a chord A. A for circles of 12 inches or under is a chord equal in length to the radius of the rivet circle. For circles of over 12 inches, A is the chord subtending the arc included in six rivet pitches. Then A for circles of over 12 inches equals the radius times a constant. This constant varies with the number of rivet pitches in the circle according to following table:

Pitches	Constant	Pitches	Constant	Pitches	Constant
14	1.949	21	1.565	28	1.245
15	1.902	22	1.509	29	1.217
16	1.848	23	1.463	30	1.176
17	1.790	24	1.414	31	1.147
18	1.782	25	1.364	32	1.089
19	1.677	26	1.325	33	1.060
20	1.618	27	1.286	34	1.030
				35	1.000

Example—With a rivet circle of 14 inches diameter and 17 pitches, the pitch would be 14 × π divided by 17 or 2.58 inches pitch. 2.58 inches — ⅞ inch for rivet hole = 1.705 inches. 1.705 inches × 6 pitches = 10.23 inches = S.

From above table 1.79 × 7 inch radius — 12.53 inches = A.

$$\frac{S}{A} = \frac{10.23}{12.53} = 81\tfrac{1}{2} \text{ percent efficiency.}$$

In figuring the rivet percent efficiency for round patches, N is all rivets above or below the longitudinal center line and the unit length is the length from center to center of the outside rivets plus the diameter of one rivet.

Rectangular patches should have the circumferential and longitudinal seams similar to those used in making that particular course of the boiler. If several rows of rivets are used as where an inner welt plate is applied, the plate efficiency is figured from the row having the greatest pitch. Such seams have some rivets in double shear, so N equals the number of rivets in single shear plus twice the number of rivets in double shear above (or below) the center line of the patch.

It is sometimes necessary to place rivets in a longitudinal row with the pitch less than that which will give the necessary factor of safety of four, with the boiler pressure used. If this row includes more than two such adjacent pitches, the boiler pressure must be reduced to give the necessary factor of safety of four. To find this boiler pressure rewrite the first formula as follows:

$$\frac{\text{T.S.} \times \text{thickness} \times \text{percent efficiency}}{\text{boiler radius} \times 4} = \text{boiler pressure.}$$

Round or diamond patches should have no rivets on the longitudinal center line and the circumferential pitch

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at the center side should be large enough to calk well. The longitudinal width should be at least 3 inches more, from center to center of the outside rivets, than the length of the crack it is to cover, and this distance plus the diameter of one rivet is the unit length used in figuring for the rivet efficiency. The circumferential height of a diamond patch is determined by the necessary efficiency and the space available. The plate strength of a circumferential seam is double that of the same seam in a longitudinal direction. To find the plate strength of a seam of a diamond patch the efficiency as found above is multiplied by factors corresponding to the angle the seam makes with the longitudinal center line according to the following table:

Angle with longitudinal center line (degrees)	Factor
10	1.015
20	1.060
30	1.134
40	1.234
45	1.293
50	1.357
60	1.500

(Note.—These factors differ from those published on page 177 in THE BOILER MAKER of July, 1917, but they are those in use by Southern Pacific Railroad draftsmen.

The thickness used in figuring the rivet percent efficiency is the thickness of the original plate only.

In using the following table, use the area of rivet after upsetting.)

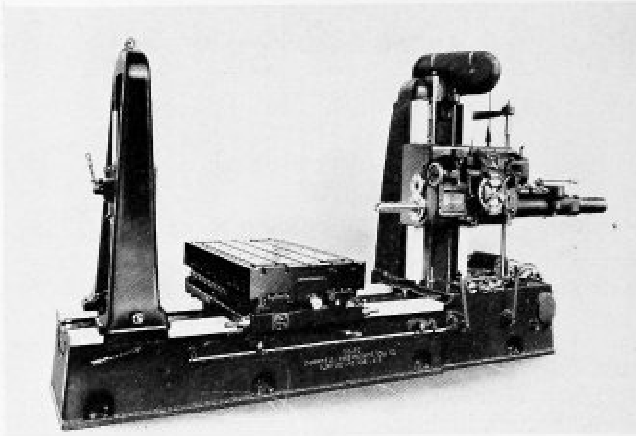
AREA OF RIVETS AND SCREW PLUGS

Diameter inches	Area of rivets, square inches	Area of 12-thread plugs, square inches
3/4	.4418	.288
13/16	.5185	.351
7/8	.6013	.419
15/16	.6903	.494
1	.7854	.575
1-1/16	.886	.662
1-1/8	.994	.755
1-3/16	1.107	.855
1-1/4	1.227	.960
1-5/16	1.353	

Boring, Drilling and Milling Machine

Two spindles, the conventional main spindle and an auxiliary high-speed spindle, comprise one of the important features of another machine recently added to the line built by the Giddings & Lewis Machine Tool Company, Fond du Lac, Wis. This machine is known as the No. 30 horizontal boring, drilling and milling machine. The main spindle, 3 inches in diameter, gives 36 speeds in fine geometrical progression between 8.3 and 500 revolutions per minute. The auxiliary high-speed spindle, 2 inches in diameter and mounted within the back gear shaft of the main spindle, gives an additional 36 speeds between 25 and 1500 revolutions per minute. These two spindles give a combined speed range of from 8.3 to 1500 revolutions per minute. It is fitted with herringbone gears and preloaded combination radial and thrust ball bearings.

The bed of the machine is of heavy box-type construction, internally ribbed to support the various units of the machine. A large cutting lubricant tank is cast within the bed; and when required, provision is made on the different units for directing the solution back to this tank.



Giddings & Lewis No. 30 two-spindle horizontal boring, drilling and milling machine

The table is of semi-steel and of ribbed box section. The top of the table has 1-inch stop holes and five standard tee slots for ¾-inch diameter bolts. Chip pockets are cast in the table at each end and the tee slots run the full length of the table. The bottom of the tee slots is drilled so that chips can fall through to the center cored hole.

The table is supported on a saddle which supports the table at every position of its cross travel. A multiplying lever clamp is used for clamping the table to the saddle and also the saddle to the bed.

Within the front head end of the bed is built a separate feed unit for moving the different units. The milling feeds are obtained from a separate drive shaft ahead of the start, stop and reverse clutches. In this way the reversal of the machine does not reverse the feed or rapid traverse. The rapid traverse is always in the same direction as the feed. The levers for engaging the feed to any unit are engaged by moving the lever in the direction the unit is to move, either by feed or rapid traverse. This feature removes all uncertainty as to which direction the units will move as soon as the feed or rapid traverse is applied and permits a directional control of the different units of the machine, independent of every other unit.

The hand feed for moving the different units is through a safety crank handle. To feed by hand, the crank handle must be held in a jaw clutch against the spring. As soon as the hand is removed the crank is disengaged and swings free. This safety feature prevents injury to the operator and possible damage to the machine if the rapid traverse should be engaged without first removing the crank handle. The mechanism for the movement of the different units is equipped with micrometer dials, which are adjustable by a thumb screw permitting them to be set in any position desired by the operator.

This No. 30 machine can be furnished in the table-type, planer-type and floor-type models, using the same principal units in all three types.

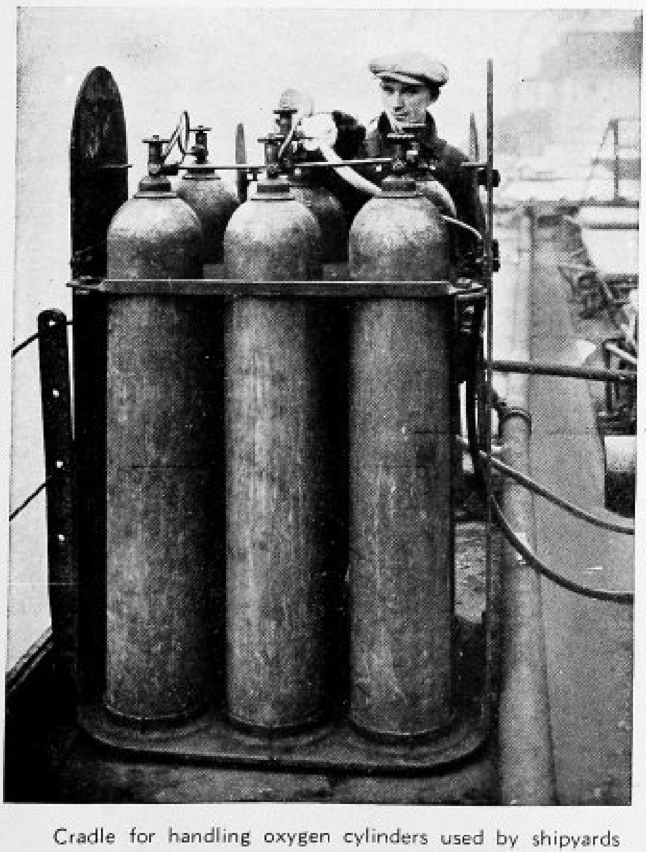
Additional principal specifications of this machine are as follows: Range of feeds to main spindle in inches per revolution of spindle—.007 inch to .375 inch; range of feeds to auxiliary spindle in inches per revolution of spindle—.002 inch to .125 inch; range of milling feeds in inches per minute—.8 inch to 40 inches; rapid traverse to all units—120 inches per minute.

Joseph T. Ryerson & Son, Inc., Chicago, Ill., has issued a bulletin on cold-finished steel bars.

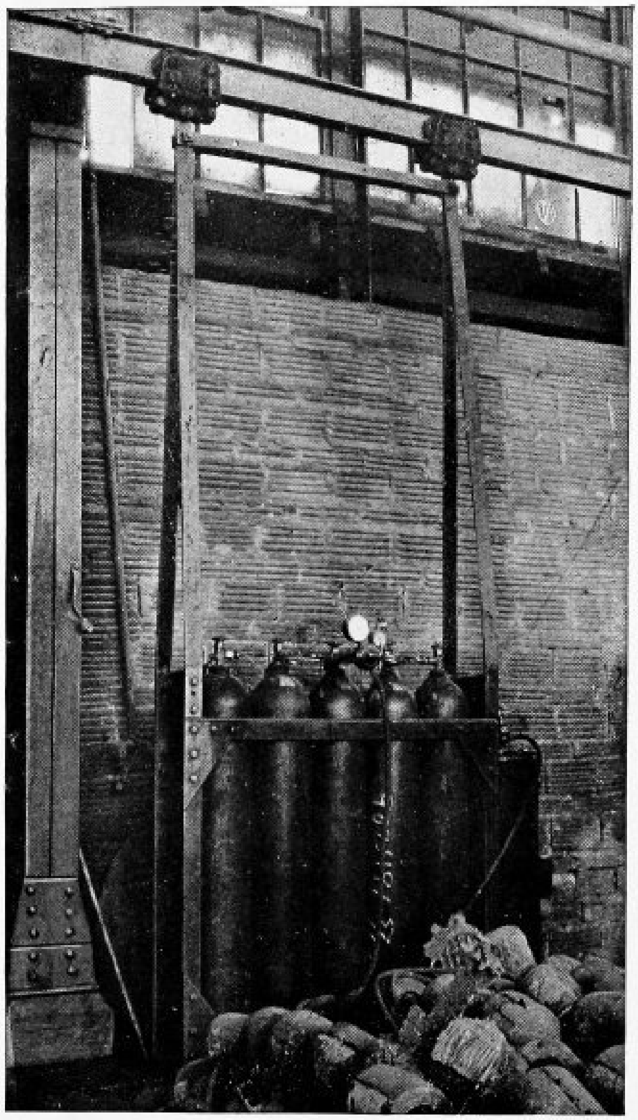
Safe Practices in Handling Cylinders

Thousands of oxygen and acetylene cylinders are in daily use wherever the cutting or joining of metal is a part of an industrial operation. Oxy-acetylene equipment is designed for use under the wide variety of operating conditions that exist in plant and field work, and this is particularly true concerning the portable cylinders.

The design and manufacture of these cylinders is carried out strictly in accordance with the specifications required by the Interstate Commerce Commission, which cover the grade of steel to be used, the heat treatment necessary to develop the required strength and toughness of the steel, and the tests that the cylinder must undergo before they can be put into



Cradle for handling oxygen cylinders used by shipyards



Cylinder sling runs the length of steel foundry

service. Furthermore, the manufacturer of oxygen and acetylene puts them to regular periodic tests and inspection so that any weakening or damage that may have occurred during use can be promptly remedied.

In order to prevent undue abuse to the cylinders while they are being handled, certain precautions should be observed in their use.

Oxygen is charged into the oxygen cylinder to about 2000 pounds per square inch pressure at 70 degrees F. Since all gases expand when heated and contract when cooled, the pressure in the cylinder will increase or decrease according to any varying temperature; for instance, should a fully charged cylinder be permitted to stand outdoors in freezing weather, the pressure of the oxygen may register only 1800 pounds per square inch, but the total amount has not changed, the pressure only has been reduced. If the cylinder was then placed in a warm room, the pressure would increase.

On each cylinder a specially designed valve is fitted, so constructed that it is perfectly tight either closed or fully open. A safety device, which provides against any sudden or excessive increase of pressure is an integral part of each valve, so that should the cylinder be exposed to too much heat and the pressure rise to an excessive degree, the device releases, permitting the oxygen to escape into the air, and the pressure is relieved. For this reason, it is advisable to store oxygen cylinders in places where they will not be exposed to too great increase in temperature. In fact, since oxygen supports combustion to such a marked degree, it is advisable that a separate room clear of any combustible material and kept at a moderately even temperature, be used for the storage of oxygen cylinders.

Regulators of approved design should be used to reduce the pressure of the oxygen as it is released from the cylinder since complete pressure control is a practical necessity for good welding and cutting. In order not to damage the regulator through too sudden release of the high pressure of the oxygen, the cylinder valve should be barely cracked to allow the gage hand to move up slowly. Then it should be opened fully.

When the work is completed or the cylinder is emptied the regulator should be removed, and the cylinder cap replaced over the valve.

Under no conditions should oil or grease be allowed to come in contact with the oxygen cylinder, regulator, or hose, nor should the cylinder remain where oil or grease may drip on it. Oxygen should never be used as a substitute for compressed air for such work as operating pneumatic tools, starting Diesel engines, operating paint sprays, or for head-pressure in a tank of any kind.

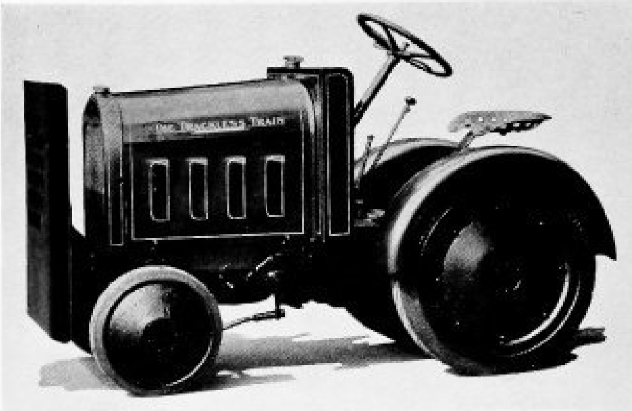
Acetylene cylinders are also constructed in strict accordance with the specifications of the Interstate Commerce Commission. They are, however, due to the difference of physical properties of acetylene from oxygen, of quite different structure than oxygen cylinders. The acetylene cylinder is completely filled with a porous substance and a liquid solvent, having the property of absorbing many times its own volume of acetylene, is then soaked into the porous substance. The acetylene is then charged into the cylinder. When pressure is applied, the solvent continues to absorb acetylene. Fully charged the cylinder contains dissolved acetylene at a pressure of about 225 pounds per square inch. In this way it is possible to ship large quantities of acetylene in relatively small containers with perfect safety.

Like the oxygen cylinder, valves and safety devices are provided as an essential part of each acetylene cylinder. The same precautions apply with regard to valves, the use of pressure regulators, and the storage of cylinders.

When a large volume of acetylene is to be used and more than one cylinder is required, manifolds should be used for coupling the cylinders together, but they should be of a design approved by insurance underwriters and recommended by the manufacturer of acetylene. This applies equally as well with regard to oxygen manifolds.

These cylinders have been built to withstand the ordinary incidental shocks and wear, but in handling or moving them from place to place reasonable care should be used. Where derricks or cranes are used to carry them about a plant they should always be firmly secured to suitably designed cradles, or boats, such as those shown in the illustration. In small shops two-wheeled portable trucks that may be secured from the manufacturers of oxy-acetylene welding equipment are recommended. Rope slings, chains, or electric magnets should never be used.—*Oxy-Acetylene Tips.*

Taylor Forge & Pipe Works, Chicago, Ill., has prepared an 88-page catalog on forge-welded pipe of large diameter.



The Mercury type-D tractor for hauling trailing loads

Mercury Type-D Gas Tractor

In the illustration is shown the Mercury Type-D gas tractor designed and built by the Mercury Manufacturing Company, 4118 South Halstead Street, Chicago. The tractor is for use as a pulling unit to handle trailing loads. It is equipped with a Ford Model-A industrial engine with a Model-AA truck clutch and 4-speed transmission. The driving axle is of the Mercury balanced internal-gear type which is of full floating design. All shafts, gears and pinions are of alloy steel, the rear-axle shafts being chrome-nickel steel.

The frame of the tractor is made from channels which are bolted at the front to a steel bumper plate and riveted to a cast weight block at the rear. The power plant is mounted within the frame with a three point suspension for the engine. The driving axle is bolted to the frame; no spring suspension is used, this design being adapted to secure minimum overall length, large diameter driving wheels with low center of gravity and simplicity in connecting the power plant to the axle. The front axle is a steel casting that supports the frame on semi-elliptic springs.

The tractor is designed to travel at a speed of 13.5 miles per hour at an engine speed of 1750 revolutions per minute and to deliver a suspension drawbar pull of 750 pounds at 10 miles per hour. Under unusual operating conditions a low gear is made available in order to produce 2500 pounds drawbar pull. The tractor is 85 inches long, 59 inches high and 45 inches wide with single tires and 57 inches wide with dual tires. The short wheel base of the tractor permits it to negotiate 75-inch intersecting aisles, the minimum inside radius of which is 43 inches and the outside radius 104 inches.

Byers Company Has Option On Canonsburg Plant

A. M. Byers Company, Pittsburgh, Pa., manufacturer of wrought iron products, has taken a six months' option to purchase the Canonsburg Steel & Iron Works, Canonsburg, Pa., maker of black and galvanized sheets. The Canonsburg company, which is controlled by the Edwards Manufacturing Company, Cincinnati, O., was founded in 1902 and has an annual capacity of 38,000 tons of black sheets and 16,000 tons of galvanized sheets. It is understood that the company will roll wrought iron sheets in an experimental way for the Byers organization over the next few months.

Northern Pacific Rules for Testing Stationary Boilers

Stationary Boilers—These rules shall apply to all steam boilers and their appurtenances, except the boilers of locomotives or boilers used solely for heating which carry pressure not exceeding 15 pounds per square inch.

The chief mechanical officer of each division will be held responsible for the inspection of all boilers covered by these rules. He must know that all inspections are made in accordance with the rules, and that the defects disclosed by any inspections are properly repaired before the boiler is returned to service.

The working pressure of each boiler shall be determined by the mechanical engineer, using the formula commonly used in determining safe working pressures, and after a thorough inspection and report by a competent inspector. The minimum factor of safety allowed shall be four.

In determining safe working pressure, the maximum allowable stress shall be 7500 pounds per square inch for staybolts, and 9000 pounds per square inch for round or rectangular braces supporting flat surfaces.

Each boiler shall be given a serial number by the operating railroad. A metal badge plate showing this number and the safe working pressure shall be attached to each boiler.

Each boiler shall have at least one safety valve of sufficient capacity to prevent an accumulation of pressure more than five percent above the working pressure and shall be connected direct to boiler.

Safety valves shall be set at pressure not to exceed 6 pounds above the allowed working pressure.

Working safety valve on boiler shall be tested each day boiler is in use. Failure of safety valve to open before an excess pressure of ten pounds has been reached must be immediately reported to the proper authority, and repairs made.

Not less frequently than once each month all safety valves on boiler shall be tested and adjustments made, if necessary. At this test, as well as at all other tests where the safety valves are adjusted, two steam gages shall be used, one of which shall be in full view of the person adjusting the valves.

Where two or more boilers are connected in parallel to one steam main, the maximum period between the testing of safety valves will be six months. This test should be made at the time the annual inspection certificate and semi-annual inspection certificate are prepared.

Each boiler shall have a steam gage, graduated to at least 50 pounds above the working pressure, connected direct to steam space of boiler, equipped with a suitable siphon and with not more than one cock or valve between boiler and gage. This cock to be located near steam gage.

Steam gages shall be tested at least once each month, or whenever any irregularity is shown and shall also be tested before any adjustment is made of the safety valves. Each time gage is tested, siphon pipe and cock must be cleaned and examined.

Where two or more boilers are connected in parallel to one steam main, the maximum period between the testing of steam gages will be six months. This test should be made at the time the annual inspection certificate and semi-annual inspection certificate are prepared.

Each boiler shall have at least three gage cocks and one water glass, so located that the lowest reading shall be at least three inches above the lowest safe water line. Each water glass shall be equipped with a valve at each end of glass and with a blow-off or drain at bottom of glass. Gage cocks, water glass, and water column valves, cocks and connections shall be maintained in an operative condition free from leaks and shall be cleaned of scale each time boiler is washed.

Suitable lights shall be provided for water glass and steam gage.

Annual Inspection—Before being placed in service and not less than once each twelve months thereafter, each boiler shall be subjected to a hydrostatic pressure 25 percent greater than the working pressure and the boiler and appurtenances carefully examined while under pressure.

After hydrostatic pressure has been applied, a thorough inspection shall be made of every accessible part of the boiler. Manhole covers shall be removed to permit of interior inspection.

Boilers having lap joint longitudinal seams should be examined with special care to detect grooving or cracks at edge of seams.

Watertube boilers should be examined with special care to detect blistering on the tubes, tubes bending and leakage or corrosion where tubes are fastened to headers.

Soot and cinders shall be cleaned from furnace and combustion chamber and a thorough inspection made of the brick lining and setting, the fire wall, baffles and grates.

Threaded and flange joints on steam header, steam pipe and blow-off line shall be carefully examined for signs of corrosion or wasting.

After repairs are completed the boiler must be fired up, safety valves set, and boiler and appurtenances examined. All cocks, valves, seams, pipes, flanges and joints must be tight under this pressure.

All defects disclosed by any of the above inspections must be repaired before the boiler is returned to use.

A certified report of the inspection and repairs shall be filed with the chief mechanical officer of the railroad.

Locomotive type boilers working under a pressure of 125 pounds or more shall have the staybolts tested at least once each month. Locomotive type boilers working under a pressure of less than 125 pounds shall have the staybolts tested at least once each three months. Vertical boilers working under a pressure of 100 pounds or less shall have the staybolts tested each time the hydrostatic test is applied. No boiler shall remain in service with five or more broken staybolts.

Boilers shall be thoroughly washed as often as water conditions require, but not less frequently than once each month. Special care shall be given to the watertube boilers to prevent an accumulation of scale in the tubes and the tubes must be scraped, if necessary. At washout periods, soot, ashes and cinders shall be cleaned from furnace and combustion chamber, and brick lining, setting and fire wall examined.

Semi-Annual Inspection—Not less frequently than once each six months an inspection of the boiler under steam shall be made by a competent inspector. He shall test the safety valves, gage cocks and water glass, blow-off valves, examine and test the feed pump or injectors, examine steam pipes for leaks, giving close attention to leaks around threaded joints, see that pipes are well braced, that all valves are operative, examine the setting of the boilers and the general condition of the boiler room, with especial reference to fire risks. He shall report any defects found to the division officer in charge and to the local officer in charge so that proper repairs can be made.

A certified report of the inspection and repairs shall be filed with the chief mechanical officer of the railroad.

Boilers equipped with fusible plugs shall have plug cleaned of scale not less than once each three months.

Boilers in batteries connected to same steam header shall each have a suitable valve between boiler and header, which must be maintained in proper condition.

Each steam outlet from boiler (except safety valve connections) shall be equipped with a suitable valve, which must be maintained in an operative condition.

Injectors and pumps must be kept in such condition that they will feed water into the boiler against the maximum pressure allowed on the boiler.

Feed-water heaters shall be cleaned and inspected as often as water conditions require, but not less than once each three months.

Boilers with any of the following defects shall be withdrawn from service until after proper repairs are made: Cracks in cylindrical boilers or headers; bags or bulges in shells of external fired boilers or unstayed surfaces of internal fired boilers; bulges in arch or water tubes; more than one gage cock inoperative; safety valve inoperative.

Boilers showing indications of having been low in water or of mud burning shall not be used until after inspection by a competent inspector.

Where necessary to plug flues, the plugs shall be tied together with a rod not less than ¾-inch in diameter and a report of same made to the officer in charge, who will have proper repairs made.

When making internal inspection of one of a battery of boilers, another employee will be stationed outside of boiler, whose duty shall be to prevent steam valves from other boilers being opened into boiler being inspected.

The boiler room shall be kept in a clean and sanitary condition, old clothes, waste, etc., must not be allowed to accumulate in or around boiler room.

An annual certificate of inspection shall be posted under glass in a conspicuous place in the boiler room. This certificate shall show the number of the boiler, the allowed working pressure, the date of inspection and the signature of the inspector.

Boilers of Other Equipment—Wrecking cranes and rotary snow plow boilers will be given the same inspection and test as stationary boilers.

Boilers, of other equipment such as pump boilers steam shovels, ditchers, pile drivers and concrete mixers will be given the same inspection and test as stationary boilers with the following exceptions: Steam gages must be tested at least once every six months and oftener if possible, and not less frequently than once each six months all safety valves on boilers must be tested and adjustments made if necessary.

Riveting and Welding

That there is a distinct field technically and economically fixed for both riveting and welding is the opinion expressed in an address by Pierre Champion, vice-president of the Champion Rivet Company, Cleveland, Ohio, before a recent conference of building officials held in Toronto. There is little likelihood that either process will supplant the other but rather that the future will develop means for supplementing one with the other.

In the boiler industry for example, where it has been the practice to rivet and calk seams, welding can well be and is utilized to weld around rivet heads and seams to prevent sweating. An analogous situation exists in the building industry where a great deal of truss weld can be welded safely but with the main supports riveted.

In referring to comparable situations in the past, Mr. Champion mentioned the fact that 35 years ago his company attempted to introduce the steel rivet. "At that time," he stated, "iron rivets were in general use and so skeptical were the fabricators as to the steel rivet, that we, as a last resort, were forced to offer a dollar for every rivet head that came off. Fortunately for us, we did not have to give many dollar bills away. But even the widespread adoption of the steel rivet has not entirely supplanted the iron rivets, for today in the hulls of our ocean-going vessels iron rivets are used extensively because of their resistance to corrosion."

In considering some of the factors which will insure for rivets their position in the construction industry, Mr. Champion made the following statement:

It does not occur to us to question the safety of riveted construction. It has been used so extensively that it never occurs to us to doubt its security. Riveting has been in use for many years, and is a thoroughly known process. Welding has been used for comparatively few years. The character and strength of the finished weld unless subjected to exhaustive and costly tests, are practically unknown. The weld itself depends upon the skill and integrity of the welder himself, whereas with riveting this human element is reduced to an absolute minimum. The safety of a rivet can be predetermined by exacting physical and chemical tests. The heat necessary to drive rivets does not deprive them of these essential characteristics. Regardless, therefore, of the adaptability of the welding process to building construction, the factor of human safety alone precludes the uncertain results obtained by this process from supplanting the known and certain results obtained by riveting.

Closely allied with the factor of safety is the factor of inspection. Not only during the course of construction are rivets more easily and readily inspected than a welded joint could possibly be, but in subsequent years wherever rivets are exposed in the structure, they are more readily and economically examined in accordance with prescribed periodic inspections.

There are a number of cases on record where failure of pressure containers such as boilers have been attributed to non-detectable weakness in the welded seams. Rivets are generally accepted as the safest and most positive method of sealing pressure vessels.

Business is organized for profit and efficiency, and regardless of the dramatic appeal of a construction process a satisfactory existing method will not be discarded in favor of a new process the cost of which is no less.

(Continued on page 218)

Development and Application of Fusion Welding in Pressure Vessels

By Dr. Comfort A. Adams*

In this concluding instalment of an address delivered at the recent annual meeting of the American Boiler Manufacturers' Association held at Skytop, Pa., the author outlines his early experience with the fusion welding processes, particularly with the Emergency Fleet Corporation. From the experimental work commenced at that time, the American Bureau of Welding, the research branch of the American Welding Society, had its outgrowth. In replying to various questions from members of the Association on the technique and testing of welded pressure vessels, Dr. Adams extended the scope of his discussion to cover many practical phases of the work. These points are all developed in more or less detail in the present article.

I have spoken of the accidental defects which are likely to occur in welds. That brings me to the question of qualification of welders. It just happens that very recently, within a few weeks, there was brought to my attention the failure of a large storage tank, containing a rather valuable oil. The bottom was welded and the weld was not only undersize but whole sections had no bond with the base metal.

During the War the Emergency Fleet Corporation wanted to employ every method possible to hasten ship construction. I happened to be chairman of the General Engineering Committee of the Council of National Defense and had had a talk with government officials. They asked me to take the responsibility of organizing a welding committee, which I did. Frankly, at the time I knew little about the scientific problems involved, for while I had had some experience in resistance welding, my experience was very limited in the other processes.

We went about the job of finding out some things in rather a crude, blundering, cut-and-try fashion. We cut up and tested ten tons of ½-inch plates, welding all kinds of ways with all kinds of currents. We had before us the claims of the various manufacturers of welding machines. As it happened, I knew something about the subject of electrical machine design, and their claims were perfectly absurd. Their statements showed they knew little about the machines they were marketing and less about the arc itself. We also found that welding as practiced was almost entirely in the hands of the welder.

As this committee had established co-operation between the welding interests, it seemed desirable at the close of the War to continue this work, and the American Welding Society was organized. I, probably more than most of those concerned, felt the need of scientific investigation, and in order to be sure that we were clear of any possible commercial influences we organized the American Bureau of Welding, the research branch of the American Welding Society, and had it attached to the National Research Council as a branch of its Engineering Division, of which I also happened to be chairman at the time.

The work of the American Bureau of Welding in its struggles to carry out the scientific research work necessary to put welding on a firm and solid foundation is typical of the development of any new art. We tried some eight years ago to get pressure vessel manufacturers to contribute to a research program to provide information for the Boiler Code Committee, the welding fraternity being very anxious that the Boiler Code Committee should extend its rules. I think five or six manufacturers made small contributions and we carried out a very limited piece of research.

A few years later, realizing that those experiments were very limited, the vessels being all of small size, we went again to the pressure vessel manufacturers but they were not interested. Finally we turned to the universities, colleges, and engineering schools, where the only cost would be the making up of the welded samples, and possibly some apparatus. This has resulted in some of the finest research work in the welding field being done during the past two or three years in this way.

One of the things that I want to leave with you more than anything else is a realization that the welding problem is not a mechanical job like riveting. It requires for its solution a very thorough knowledge of metallurgy and the physical sciences and some degree of chemistry.

The thing that has held back the development of the art for all these years has been the fact that those handling the job have been practical men who thought welding was a rather simple operation, and a lack of appreciation by management of the possibilities of welding in improving the quality of their product or reducing its cost or both. In other words, the final thought that I want to leave with you, is that the welding problem or its proper solution cannot be handled merely by cutting and trying unless you want to waste time and money. It can be handled rationally and economically by welding engineers who are qualified along the lines I have mentioned.

In replying to various questions Dr. Adams spoke as follows:

An intelligent man ought to be trained in about 15 minutes to diagnose X-ray plates of welds. You present to him a series of X-ray photographs, or radio-

* Professor, Harvard University and president of the Welding Engineering and Research Corporation, New York.

graphs, good, bad and indifferent. Let him get those pictures fixed in his mind and he has something definite to work on. X-rays do not tell you anything except the extent of porosity and pockets and lack of fusion. I will say that to send an ordinary inspector into a shop to watch welding while it is being done is worthless. I can tell a welder to do certain things in making the weld and you can send your best inspector and tell him to watch the arc through a colored glass every instant, while that work is being done, and yet the X-ray will disclose defects that he did not know were in the weld he had carefully watched.

The real advantage of the X-ray is that radiographs are so simple to read. There are definite signs of pockets, porosity, and defective fusion; and having for different thicknesses of plate a definite schedule of exposure, proper tube voltages and suitable distances from the tube target to the film of the plate, the whole matter is perfectly definite and positive, and there is no question about the interpretation.

I have not said anything about the other methods of testing welds. I have followed very closely all the electro-magnetic methods including the iron flour method. The iron flour method will detect in rather marvelous fashion minute cracks in the surface of metal which you cannot see with the naked eye or even with a moderately powerful magnifying glass. The reason is that the little molecules or elementary magnets, if you like, will line up along the crack.

If this magnetic field meets a minute crack that you cannot see at all, it forms a resistance in the path of the field and it tends to collect and bulge upwards in a line of fine powder that clings to the steel surface. If the flour is sprinkled over the surface and the piece rapped sharply in a vertical position, the powder will shake off except where the magnetic lines diverge and come out of the little cracks.

Suppose you have a piece of metal 3 or 4 inches thick and right in the middle there is a pocket as big as the end of my thumb. The disturbance of the magnetic field now being inside of the metal, its effect at the outer surface would be very slight and you cannot tell whether the defect is only a very minute one close to the surface or whether it is a very big one down deep. In other words, it is not a definite quantitative method of measurement.

There are two other types of electro-magnetic tests, the so-called Sperry method—I wont describe it electrically more than to say that it will detect the disturbance of a current flow through and across the joint by the electro-magnetic effect over the surface. In this case you can detect in a 2-inch plate, for example, a ¼-inch hole which has been plugged up mechanically on the surface by traversing the joint with a detector which disturbs the magnetic field produced by the current flowing through the joint.

In other words, these methods are in every case as far as I know, and I have studied a half dozen of them, not definitely quantitative as they do not locate as regards the depth or thickness of plate exactly where your defect is or how large it is.

The second method I referred to is also difficult to describe to a non-electrical audience. Alternating current is used and one can examine a steel tube of, we will say, ¼-inch thickness and tell not only the mechanical defects, but the spots of decarbonization or strain in the material.

I do not wish to leave the impression that only the X-ray is effective or useful in the detection of defects in welds, and I will therefore suggest a plan of procedure to those advocating these methods. It is this: Produce a welded joint of the thickness that you wish to investigate with known defects of different shapes, both transverse and longitudinal at the joint. Produce these defects mechanically and at different depths. Now apply these tests to both sides of the joint until you have been able to determine their significance in as nearly as possible a quantitative manner.

If I had that job, that is the procedure that I would employ and it is entirely possible that in plates of 1 inch thickness or possibly 1½ inch thickness and below, some of these methods which are much less expensive perhaps than the X-ray might readily be employed. Here is a case where some research must be carried out and it should be carried out by those who understand the job.

The results of such a careful experimental investigation might readily yield sufficient evidence to warrant the use of some of these methods in vessels up to say 1½ inches thick.

On the matter of the relative value of machine-made and manually-made welds, if the man making the manual weld has been qualified there would be no appreciable difference, but it must not be overlooked that defective welds can be made by a machine, and a machine welder should therefore be just as skilful as a manual welder.

Riveting and Welding

(Continued from page 216)

The proponents of welding may point to remote cases where welding is a cheaper method of construction than riveting; they will ask us to accept these remote examples as a basis for all future work. It is generally acknowledged by contractors and fabricators alike that riveted construction in by far the great majority of cases, affords costs that cannot be approximated in welding. The factor of economy itself is a vital deterrent to the encroachment of welding upon the field of riveting, especially when one considers the tremendous loss a fabricator will have if he scraps his riveting equipment.

Speed, as well as safety and economy, will play an important part in keeping the rivet in its present state of use. It will be difficult for the welders to match the present speed of riveting and still maintain its necessary factor of safety.

It is hard to make good welders out of good riveters, and expect them to have the nerve and courage of a good riveter working stories above the ground in precarious positions. An available and ample supply of the required type of labor is one of the primary requisites of any business.

I can also reply to the layman's complaint against the noise of riveting by appealing to his dramatic instincts, and by reminding him that the staccato clatter of the rivet hammers heralds progress and accomplishment.

One of the severest tests to which riveting is put is in the high-pressure boiler field. It is true that some of these drums are being welded, but they are being welded under the strictest scrutiny. All finished welds are subjected to X-Ray and magnetic tests. After the welds are made the drums are subjected to an annealing process which takes days.

Let us be sane in our acceptance of welding, it will find its proper place in industry as an aid to riveting, and not as a substitute.

Front Ends, Grates and Ash Pans ...

By F. P. Roesch*

At a convention of the Traveling Engineers' Association held in Chicago some time ago among other subjects discussed was that of the effect of various steaming conditions in the locomotive on front-end design. In the opening part of the paper, the author traced the history of locomotive front-end arrangements both in this country and abroad, from early times down to the Purdue tests, resulting in the Master Mechanics' standard self-steaming front end. He then went on to discuss the changes made necessary by the introduction of superheated steam. An abstract of this portion of the paper follows:

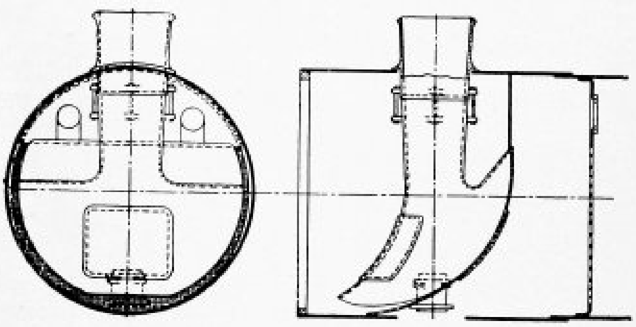
The principal change consisted of moving the draft sheet, i.e., the adjustable plate, ahead of the nozzle, and the introduction of the superheater damper, practically all other parts were retained intact. About this time, however, the locomotives grew larger; this meant a reduction of stack height above the smoke arch or a shortening of the stack. This reduction in external stack height was in a measure compensated for by lowering the exhaust stand and in some cases extending the stack down into the smokebox; in other cases the petticoat pipe generally out of line with either the nozzle or stack, or both, and supported on flimsy hangers, with its so-called overdraft and underdraft, was religiously adhered to. Zerah Colburn (writing in 1853) said the space between the top of the petticoat pipe and the base of the arch was to permit the smoke to escape. He never claimed, even in that day when there was nothing between the petticoat pipe and the flues, that the draft could be equalized by increasing or decreasing this opening. We wonder what answer he would make to a present-day engineer who claimed he could regulate the draft in this manner regardless of the interference of diaphragm, table plate, etc. It may be possible, but it is hard to see.

The Pennsylvania Railroad in the Altoona testing plant long ago demonstrated the fallacy of this reasoning. They also proved that it was possible to dimension the various parts entering into the front-end draft appliances so that everything could be nailed into place in the back shop; then if the locomotive did not steam, some one would look for the real cause instead of moving draft plates, petticoat pipes, etc.

All tests have shown a difference in front-end vacuum behind and in front of the diaphragm; the difference depending on the total vacuum. Does this not indicate that the diaphragm plate is an interference? Then why keep it? The Type E superheater is rapidly coming in, which removes the necessity for a damper, even if one ever were necessary, which some are inclined to question; therefore, why not do away with the diaphragm also, and, while we are at it, with the table plate and petticoat pipe? We offer the arrangement illustrated as a suggestion. Look it over and think it over before criticizing. This design will give you a netting area greater than you have now; a drum-head effect that will help keep it clean; a shorter nozzle, a longer stack, and a direct pull on the tubes. If it looks good to you, try it. The idea may not be as crazy as it looks. Of course, some one will say, "How will we get at the superheater units with that big thing in there?" The answer is, "How do you get at them now?"

Locomotive grates have been subject to about as many changes as the front-end draft appliances, and while possibly due to the variation in the character of the coal used in different parts of the country, it may not be practical to adopt a standard design, yet in the light of recent experiments it would appear that some modification of present types, particularly in stoker-fired engines, may be worth our serious consideration.

Designed originally simply to support the fuel and permit the inflow of the air necessary for its combustion, no particular uniformity appears to obtain insofar as the ratio of air opening to total grate area is concerned, or the relative size of the openings. Furthermore, up to



A suggested self-clearing front end

the time of federal operation it seemed to be an open question as between finger and so-called table grates or modifications thereof.

It may be of interest in this connection to remark that in English practice the fixed, i.e. non-rocking grates are generally used, while on this side the rocking grate is favored, and, in the opinion of the writer, justly so, as in American practice the grate must possess another function in addition to those mentioned above; viz., to permit the easy and rapid cleaning and dumping of fires, removal of clinkers, etc., especially on locomotives used on extended runs.

It is not the purpose of this paper to recommend any radical departures, but simply to call attention to some recent developments on the Atchison, Topeka & Santa Fe and Northern Pacific, believing that the results obtained are well worth careful investigation and consideration as perhaps pointing in a direction heretofore passed unnoticed.

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While under ordinary operation there is a difference of only about two ounces in pressure between that in the ash pan and that in the firebox, yet this difference is sufficient to set up an air or gas current, if you prefer, having a velocity of approximately twenty miles per hour immediately above the fire, and increasing very rapidly in its passage to the flues. A blast of this velocity is capable of lifting and carrying with it quite large particles of coal, and, especially where the grate openings are fairly large and so spaced as to permit the formation of holes through the fire-bed, can be considered the direct cause of the stack loss due to the discharge of unburned or partially burned coal commonly called cinders. Would it not, therefore, appear that a grate having fixed openings, small in size and equally spaced, would be the logical grate to apply?

With engines hand fired the type of grate or size of air openings is not of as much importance; as generally the lumps of coal fired are larger, and again, as the fireman looks at his fire with each supply of coal he can readily fill up any holes as fast as formed. Furthermore, knowing that too much air admitted is just as detrimental from a combustion standpoint as not enough, he restricts this flow by increasing the depth of the fire, as necessary. Again, as a man can only shovel a certain amount of coal in a given time, he must of necessity carry a fire of sufficient depth to meet any emergency.

Stoker firing is an entirely different proposition, however. In the first place the coal is reduced to a size best adapted for mechanical distribution. Naturally in crushing lump coal to these dimensions, more fines—¼ inch or less—are produced than where the lumps are broken with a coal pick. The fire in stoker-fired engines should be carried much thinner also, as all stokers have sufficient reserve capacity to meet any sudden demand, thus obviating the necessity of heavy fires; therefore, it would appear that the grate best adapted for stoker firing is one that will permit carrying a very light fire without the possibility of too much waste through the grates or the possibility of tearing holes through the fire no matter how thin, or even admitting too much air should any part of the grate surface be actually uncovered. Remember, in stoker firing the fireman is not checking the condition of his fire at freqent intervals, as in hand firing, and therefore the possibilities of an uneven fire are much greater. Therefore, is it not logical to design the grate so as to reduce the detrimental effect of uneven fires—banks and holes—to a minimum?

The amount of air opening through the grates has long been a moot question, ranging in hand-fired engines from 22 to 55 percent of the total grate area. Experiments on the Santa Fe and Northern Pacific with practically all kinds of coal, excepting anthracite and including lignite, would indicate, however, that with a fire carried at the proper depth, a grate having a ratio of from 12 to 18 percent—small openings equally spaced—will not only admit enough air under practically all conditions and with any kind of bituminous or related coals, but at the same time reduce the possibility of an over-supply. The experiments have also apparently demonstrated that such a grate reduces the stack loss, particularly in stoker-fired engines, as well as the formation of clinkers; that the fire can be kept at the right depth just as easily as with other types of grates, and be cleaned as readily at terminals or where necessary. At any rate, it would appear that this type of grate is worth looking into as another item of design affecting locomotive operation.

There is another and a rather compelling reason that should cause us to consider the adoption of a grate with smaller air openings, viz., the possibility of taking advantage of the market and burning screenings when they are available at a price sufficiently below that of mine-run coal to justify. Screenings make an ideal stoker fuel, although not well adapted for hand firing; but, even if used in connection with a stoker, it is necessary to have a properly designed grate in order to realize the fullest possible economy.

While, strictly speaking, the brick arch cannot be considered a draft appliance, yet as an improperly designed or improperly applied brick arch has such a material effect on locomotive operation, we think it well to refer briefly to this very important adjunct.

In the early development of railroads in the United States, apparently no objections were raised either to noise or smoke. Therefore, while in the beginning some roads followed English practice insofar as the application of brick arches is concerned, not so much to eliminate smoke, but because the more progressive railroad officers realized the fuel economies obtainable through its application, yet owing to the difficulty in maintaining arches (generally supported on studs tapped into the side sheets), the general use of the arch was later discontinued, and not revived until an arch supported on arch tubes was designed, as is our present practice. Even then it is doubtful if the arch would have been generally adopted had it not been for the universal campaign, especially by large cities, for smoke abatement.

The railroads applying brick arches with this end in view soon found that in addition to reduced smoke, very material economies in fuel were also obtained. This fact was stressed by the International Railway Fuel Association, and later by the Fuel Conservation Section during Railway Administration days, so that practically all railroads fell into line, until now it is more uncommon to see a locomotive without a brick arch than formerly to see a locomotive with one.

In the design and application of brick arches, however, the same lack of uniformity appears to obtain as with grates, front-end draft appliances, etc. It was at one time considered good practice, and a practice which in many cases is still adhered to, to use a spacer brick between the arch and the throat sheet so as to leave an opening varying anywhere from 3½ inches to 10 inches presumably on the theory that as the draft carried the cinders over the top of the arch they would fall down again through this opening and so be consumed, or on the theory that if the arch was against the throat sheet, making what is called a sealed arch, cinders would collect on top of the arch and stop up the lower flues. Both of these theories, however, apparently have little if any foundation in fact. On the contrary, the open arch was one of the most prolific causes of flue leakage.

In the earlier locomotives the brick arch was not extended back as far as might have been economically advisable, as any rearward extension had a tendency to throw the flame back correspondingly, resulting in there being so much heat at the firedoor that locomotives could not be hand fired with any degree of comfort. Therefore, arches were kept moderately short.

With the advent of the mechanical stoker, however, the same objections could not be raised against bringing the flame back against the door sheet so as to obtain the full benefit of all the firebox heating surface. It was also found that, owing to the tendency of the finer particles of coal being carried further, a bank was liable to form where the open arch was used. Therefore, in order to settle the question as to the best design of brick arch, taking everything into consideration, i.e., fuel economy, smoke elimination, evaporation per pound of coal due to increased firebox temperature, etc., tests were conducted, and it was found that a sealed arch, extended back until the opening between the top of the arch and the crown sheet was equivalent to about 115 percent of the total flue area, a reduction in fuel consumption ranging from 10 to 15 percent would be obtained over an open and short arch wherein the opening between the top of the arch and the crown sheet was equivalent to from two to two and one-half times the total flue area.

We believe this is a subject well worth your serious consideration.

Obviously, ash pans were originally applied as a receptacle for the ashes shaken through the grates. There is no need to go into the development of the ash pan, as naturally it had to change with the change in locomotive construction, but apparently some designers are still of the opinion that the only purpose of the ash pan is that for which originally intended, viz., a receptacle for ashes, and apparently not realizing that it is one of the most important adjuncts affecting combustion that is placed on the locomotive. In the beginning of this article we spoke of the draft appliances located in the front end, the function of which was to maintain a partial vacuum in the firebox. The amount of vacuum necessary in the firebox to burn fuel at a certain rate depends, of course, on the difference in pressure above and below the grates. The fact was also mentioned that under ordinary operating conditions the pressure in the firebox is only about two inches less than that of the surrounding atmosphere. If, therefore, the ash pan is so designed that sufficient air cannot flow under the grates to maintain atmospheric pressure, it follows that in order to obtain the necessary difference in pressure a higher vacuum must be created in the firebox, and this, as previously shown, is usually obtained by reducing the nozzle, which, in turn, results in higher back pressure and so affects locomotive operations.

It has generally been recognized that an ash pan air opening equivalent to 14 percent of the total grate area is sufficient under practically all conditions to maintain atmospheric pressure under the grates. Some very recent tests have demonstrated, however, that even with this ratio of air opening a partial vacuum equal to 0.6 inches of water frequently occurs under the grates under certain operating conditions, and, of course, this partial vacuum under the grate is equivalent to reducing the vacuum above the grate by an equal amount. Therefore it might be well to take this into consideration, and in designing ash pans increase the effective air opening to, say, 16 percent of the grate area instead of 14 percent.

With the present-day wide firebox extending beyond the frame, it is sometimes quite a difficult matter to develop an entirely satisfactory ash pan; the construction of what is termed the cradle casting being such as to make it necessary to pinch the center of the pan in so as to permit it to come between the frame, and then flare it out to the width of the mudring or a little beyond. Therefore if the pan is dropped far enough below the mudring to obtain the necessary air opening, it often follows that the flare of the pan has not sufficient slope to permit the ashes to slide down into the tapered part of the pan, and particularly where the grate connecting rods are brought well out from the center line. The result is that where the design of the pan shows plenty of air opening so long as the pan is clean, yet as soon as the grates are shaken once or twice, enough ashes will accumulate on the comparatively flat surfaces to restrict very materially the inflow of air, and in this way defeat the very purpose aimed at when dropping the pan below the mudring.

Inasmuch as the lack of sufficient air under the grate so very materially affects combustion, coal consumption, steaming of the engine, etc., it would appear that a little more consideration could be given to the ash pan design, with a view to developing one that will meet every requirement.

It might sound like a far cry from the design of a coal gate to locomotive operation, but when we stop to consider a recent case wherein an important passenger train, pulled by a hand-fired engine, was delayed 40 minutes due to the design of the coal gate (of course, the size of the coal also entered into the proposition), it shows that there is, nevertheless, a very intimate relation between the two.

It has been observed that in recent construction a type of practically solid sheet iron coal gate is favored. Usually they are made in four sections, in the form of gates swinging inward. Reinforcing strips in the shape on angle irons are riveted to the inner sides of the gates. There is no question but that a gate of this construction is strong, substantial and effective insofar as preventing the loss of coal from the gangway is concerned, regardless of whether the tender is loaded with lump, mine-run, or screenings.

There is another factor to be taken into consideration in this connection, however, besides a gate that forms an effective barrier against the loss of coal, viz., the possibilities of train delays when such a gate is used in connection with a stoker-fired engine, due to the arching of the lumps of coal over the conveyor trough, and the fact that when these lumps do arch in this manner, particularly when the tender is carrying practically a full load of coal, it is often almost impossible to break the arch down so that coal will again feed into the conveyor trough.

During the war there was a form of coal gate developed and used on locomotives built for the government, termed the Dunham gate. This consisted of a series of heavy planks set into pockets on each side of the coal space, being set at an angle so that each of the boards which extended clear across the coal space sloped back, leaving a space between the bottom of one plank and the top of the next through which a shaker bar could be used for breaking down any lumps that were too large to pass under the lower board.

We are not advocating the return of this type of gate, but believe that the principle involved might with profit be incorporated in the iron gates now being used. At any rate, if there would be objections toward incorporating this principle, the angle iron reinforcing pieces could at least be moved from the back to the front side of the coal gate where they would be equally as effective as stiffeners, would serve as toe-holds when one wished to climb over the gates, and would remove what practically forms a series of shelves when placed on the inside, which go far toward causing the arching of lump coal above referred to. It is a little thing, but locomotive operation is made up of a series of little things. Sometimes the loss of a cotter key results in an engine failure.

The location of a coal gate at times also affects locomotive operation, as, for instance, if the coal gate is located immediately above the crushing zone in the stoker-conveying mechanism, it is a hard matter to exclude tramp iron from the coal. If the tender is fully loaded and a piece of tramp iron too large to pass through the crusher happens to feed into the coal, it is often a difficult matter to remove the obstruction where the coal gate is located too far ahead. The amount of coal space sacrificed by placing the coal gate a little further back, or at least angling them back at the center, is negligible compared with the possibility of overcoming train delays due to tramp iron getting caught in the crusher.

Explosion Results from Corrosion of Blind Head

Corrosion that had taken place unobserved behind the masonry in which the blind head of a mud drum was buried caused the explosion of a watertube boiler at a municipal light and pumping plant on the night of April 5, 1931. Three men were killed and three were injured. The fireman, his brother, and another workman were the ones who lost their lives; the injured were unemployed men who were in the boiler room in search of work.

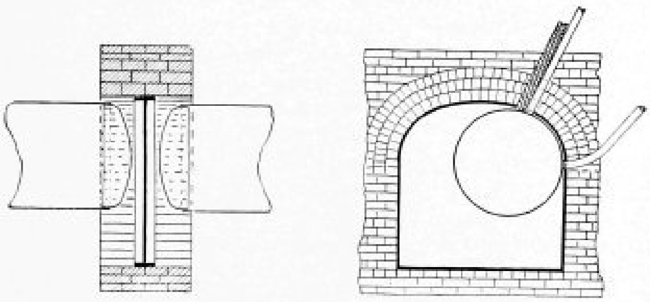


Fig. 1.—Recommended division plate

The explosion demolished the boiler house and damaged the engine room to such an extent that for a short time the town was without light and the water supply was jeopardized.

The boiler, rated at 150 horsepower, was the older of two comprising the battery. For several years the load had been carried by the newer and larger boiler, the old one being fired up occasionally to permit the cleaning of its companion. In common with many similar boilers built years ago, the vessel that exploded had drums in which the heads were bumped to a long radius with a somewhat sharp turn at the flange.

From the appearance of the head after the accident, it was suspected that the thinning of the head by corrosion had progressed to a point where cracks had started near the turn of the flange, and leakage through these cracks had encouraged corrosion at an even more rapid rate, so that the under side of the shell plate was pitted as far back as the blow-off connection.

When the explosion occurred the head tore loose from its skirt around almost the entire circumference, but remained hinged at the top where the metal had not been so deeply corroded. The shock loosened the tubes in the three top drums, the rear drum being hurled into the pump room, the center drum landing on top of a 200-kilowatt engine-generator, and the front drum traveling 550 feet to come to rest in a field.

Several weeks prior to the accident the plant engineer noticed corrosion on the under side of the shell plate and by drilling a hole through the plate satisfied himself that the metal was still sufficiently thick. However, as so frequently is the case, the place where corrosion had made the greatest inroads was on the head—and that was buried in masonry.

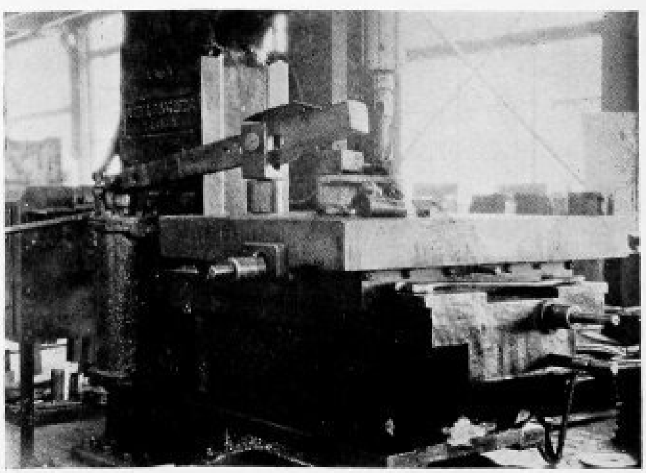
Throughout the country there are still in use thousands of the older watertube boilers set in such a way that the blind heads of mud drums are concealed in brickwork. Because of the expense involved it is sometimes difficult for an inspector to induce the owner to tear down enough brickwork to permit a thorough examination. Nevertheless, an occasional examination of these heads should be made for the protection of life and property.

The old-style bumped head generally used in watertube boilers until a few years ago has a sharp turn at the flange that renders it particularly susceptible to corrosion because of the stresses set up by the flanging process and those caused by "breathing" action. When such heads are buried in brickwork, an accumulation of soot and ash will often pack between the head and the masonry. When this soot becomes moist, its sulphur dioxide content will form sulphurous acid, a substance that is very corrosive to steel.

In order that mud drum heads may be readily accessible for inspection and that there may be less opportunity for the accumulation of ash around the heads, The Hartford Steam Boiler Inspection and Insurance Company recommends the use of either a furnace wall division plate as illustrated in Fig. 1 or else some similar arrangement. This plate may be made of cast iron, or of plate steel at least ¼-inch thick reinforced with angle irons. Not only are these division plates urged for all new installations, but it is strongly recommended that they be installed in the settings of boilers now in use where heads are covered by masonry. The expense of altering the setting is not great and is more than justified in the interest of safety.—*The Locomotive.*

An Air Clamp For Drill Press

Pneumatic clamps for drill presses are not new, as compressed-air power is frequently used to clamp the tools in a wheel lathe, and to clamp down the tail stock of the same machine. The illustration shows a shop-made drill-press clamp which utilizes an old locomotive ash-pan cylinder. The fulcrum hole in the lever is slotted and the lever may be swung about to serve practically any part of the table. This press is used on brake shoes, brake beams, equalizers, and other flat work where many duplicate parts are handled.



Air clamp for drill press made from an ash-pan cylinder

The Boiler Maker

VOLUME XXXI NUMBER 8

PUBLISHED Monthly by the Simmons-Boardman Publishing Company, 34 North Crystal Street, East Stroudsburg, Pa., with Executive Offices at 30 Church Street, New York City.

Edward A. Simmons, President. Henry Lee, Vice-President. C. R. Mills, Vice-President. L. B. Sherman, Vice-President. Samuel O. Dunn, Vice-President. F. H. Thompson, Vice-President. Roy V. Wright, Secretary. John T. De Mott, Treasurer. George Slate, Business Manager.

Chicago: 105 W. Adams Street. Washington, D. C.: 17th and H Streets, N. W. Cleveland: Terminal Tower. San Francisco, Cal.: 215 Market Street.

Subscription Price: United States, Canada and Mexico, $2.00, Foreign Countries, $3.00 a Year. Single Copies, 35 Cents.

Request for change of address should reach us on or before the 15th of the month preceding the issue with which it is to go into effect. It is difficult, and often impossible, to supply back numbers to replace those undelivered through failure to send advance notice. In sending us change of address, please be sure to send us your old address as well as the new one.

THE BOILER MAKER is a member of the Associated Business Papers, Inc. (A. B. P.), and the Audit Bureau of Circulations, (A. B. C.)

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Communications

Steel Testing Method Improved

TO THE EDITOR:

A generally accepted method of discovering defects in steel is the so-called sulphur print process. Its application for flat external surfaces is relatively easy, although certain difficulties arise when it is necessary to take prints of, for example, the inside of boiler rivet holes. It is no easy matter to ensure that photographic paper is uniformly applied to the bore of the hole.

A handy apparatus has now been devised for this purpose by a member of the Steam Boiler Supervisory Association in Berlin. It consists essentially of a rubber finger stall which is inserted after the photographic paper has been applied and then inflated by pressing a bulb. The expanded finger stall presses the paper firmly and uniformly against the wall of the hole. After five to ten minutes the finger stall is deflated by opening a pinchcock and removed. The print is then extracted, washed, and fixed. Such prints can then be filed, thus forming a permanent record to which reference can be made should it be necessary to carry out a further examination of the same part.

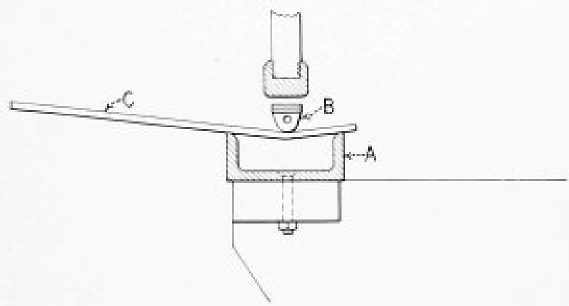
London, England. G. P. BLACKALL.

Adapting the Punch Press for Flanging and Fairing

TO THE EDITOR:

Some punch presses can be adapted for flanging and fairing by making a suitable form to take the place of a die, and using the punch (suitably rigged up) as a hammer. Then, by introducing various shaped tools on a plate resting on the bottom form, plates can be bent to various shapes.

The illustration is self-explanatory. A block *A*



Punch press adapted for flanging

suitably shaped, and preferably of forged steel, is drilled and bolted to the press in place of the die. The plunger of the press to which the punch is usually attached has an adapter which at each stroke of the punch comes down on the tool *B*, which rests on the plate *C*. The tool is held on a line on the plate, and, as the bending proceeds, liners are placed on top of the tool.

It is possible to flange enough of a curved surface to definitely establish the bend without distorting the plate.

Various top and bottom tools can be made to suit different bends. An adaptation can also be made for dishing and straightening by using a ring on the bottom and a suitable tool on the top.

Short kinks and lumps which are difficult to roll out of a sheet, can easily be straightened in the punch press, and it is surprising how much can be accomplished in this manner.

Houston, Tex. GEORGE GARDNER.

Ellsworth L. Mills, formerly sales manager for the Bastian-Blessing Company, makers of the well-known Rego and Red Star line of welding equipment, has been elected vice-president of the company. Mr. Mills continues in charge of sales. As president of the Gas Products Association, he has done considerable to promote better marketing methods among all competitive companies. Mr. Mills' experience in welding dates back to days, when as a young engineer, graduate of Cooper Union Institute, he foresaw the possibilities in the development of the welding field, and he has devoted himself to this since that time.

Questions and Answers Pertaining to Boilers

By George M. Davies

This department is maintained for the purpose of helping those who desire assistance on practical boiler shop problems. Inquiries should bear the name and address of the writer. Anonymous communications will not be considered. The identity of the writer, however, will not be disclosed unless the editor is given special permission to do so.

Calculation of the Outside Row of a Diamond Patch

Q.—Will you please advise if the following method of calculating the outside row of a diamond-shape patch is correct:

Rows *A-B* and *B-C* each have three rivets in a row, and according to the Locomotive Inspection Bureau it will not be necessary to calculate the efficiency through a row of rivets containing less than four rivets.

However row *A-B-C* should be regarded as one row, for the reason that when angles α increase towards 90 degrees, row A-B-C will advance towards a straight line with five rivets in a row.

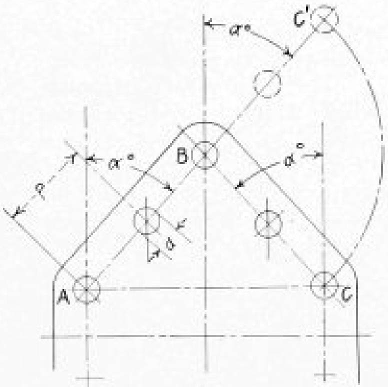
Therefore, row *A-B-C* should be considered as one straight line placed on an angle of α degrees with the vertical line and containing five rivets. (Line A-B-C' on the sketch.)

The efficiency is to be calculated by the well known formula:

$$E = \frac{2\ (P-d)}{P\sqrt{3\ \sin^2+1}}$$

A. B.

A.—The method of computing the efficiency of the patch as illustrated in the question is satisfactory with



Typical diamond patch

the exception that no consideration has been given to the value of the rivets in shear on each side of the patch.

The value of the rivets on each side of the patch should be at least equal to the value of the metal lost by the crack

$$N \times A \times S \geqq l \times t \times TS$$

where,

N = number of rivets in single shear.

A = area of rivet driving, square inches.

l = length of crack in inches.

TS = tensile strength of course to which patch is to be applied.

S = shearing value of rivet in single shear in pounds per square inch, 44,000 pounds.

t = thickness of shell in inches to which patch is to be applied.

Area of Irregular Surface

Q.—Would you kindly describe a method for obtaining the area of an irregular surface as the development of a section of pipe elbow? G. M.

A.—Referring to Fig. 1, showing development *A-B-C-D*, an approximate area of this development can be obtained as follows:

Divide *A-B* into any number of equal parts, seven

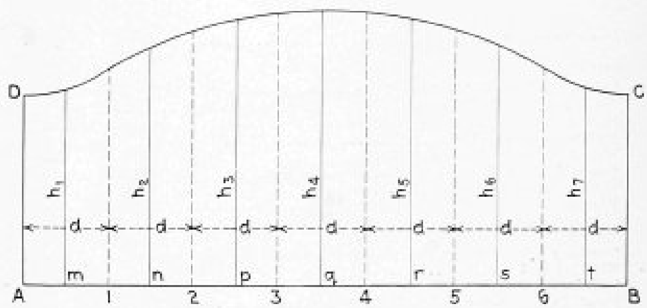


Fig. 1.—Method of determining area of irregular surface

being taken in this case, the greater the number of parts taken the more accurate the answer. Number these divisions *1* to *6* as shown, erect perpendiculars to *A-B* at points *1* to *6*, dividing the pattern into a number of parallel strips of equal widths, *d*.

On the line *A-B* midway between *A* and *1* at *m*, erect perpendicular *h*, cutting the line *C-D*. In the same manner between *1* and *2*, *2* and *3*, *3* and *4*, *4* and *5*, *5* and *6*, *6* and *B* erect the perpendiculars h_2, h_3, h_4, h_5, h_6, and h_7 respectively.

Measure the distances h_1, h_2, h_3, h_4, h_5, h_6 and h_7. The area of the pattern is then equal to:

$$A = d \times \Sigma h,$$

where, A = area of pattern in square inches

d = width of one parallel strip in inches

Σh = sum of the middle ordinates h_1, h_2, h_3 to h_7 in inches.

Reliability of Inside Calking

Q.—As an interested reader of THE BOILER MAKER, I shall appreciate receiving an answer to the following question: Do you consider a riveted boiler or tank calked only on the inside a reliable job? Is it practical to build riveted tanks up to 1200 pounds test pressure calked entirely inside? If so, how are they tested? G. W. M.

A.—I do not consider a riveted boiler or tank calked only on the inside a reliable job.

In calking, when driving back the edge of the welt strip to tightness, the plate is severely sprung up and reacts against the shell plate after the manner of a deflected cantilever, with sufficient intensity to keep the fluid pressure from passing the calked edge.

To be proof against leakage the lap of the welt strip acting like a deflected cantilever must react against the shell with an intensity of pressure greater than that of the fluid within. Tests have shown that while there are areas under the rivet heads where the fluid pressure does not penetrate, in general the calked edge itself, especially in new work, is the final barrier to leakage. It is perfectly evident, therefore, that short laps and rivets close together render calking easy, while large pitches and long laps, due to the continuous springing back, render the process difficult.

For this reason, on tanks or boilers having butt seams, it is the better job to calk the outside welt strip where the rivet spacing is the minimum instead of the inside welt where the rivet spacing is at a maximum.

The accepted practice for boilers and tanks is to calk all circumferential seams, under pressure, inside and outside, and all longitudinal seams along the edges of the outside welt strip.

Geometrical Formulas

Q.—Will you send me the workings of the formulas of your book "Laying Out for Boiler Makers and Sheet Metal Workers," fourth edition? The formulas I desire are for the circumference of an ellipse, length of the arc of a sector, length of the arc of a segment and the length of an angle to any triangle.—R.R.

A.—(1) An approximate formula for determining the perimeter of an ellipse is:

$$P = 3.1416\sqrt{2(a^2 + b^2)}.$$

A closer approximation is:

$$P = 3.1416\sqrt{2(a^2 + b^2) - \frac{(a-b)^2}{2.2}},$$

where, P = perimeter in inches,
a = one-half major axis in inches,
b = one-half minor axis in inches.

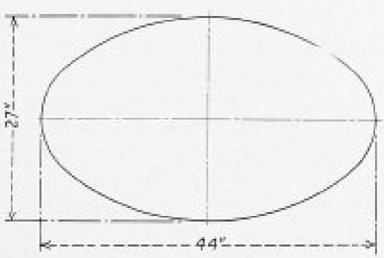


Fig. 1.—Ellipse

Considering the ellipse shown in Fig. 1,

$$a = \frac{44}{2} = 22 \text{ inches}$$

$$b = \frac{27}{2} = 13.5 \text{ inches.}$$

Substituting in the first formula, we have:

$$P = 3.1416\sqrt{2(22^2 + 13.5^2)}$$
$$P = 3.1416\sqrt{2(484 + 182.25)}$$
$$P = 3.1416\sqrt{1332.5}$$
$$P = 3.1416 \times 36.5$$
$$P = 114.668 \text{ inches.}$$

Substituting in the second formula we have:

$$P = 3.1416\sqrt{2(22^2 + 13.5^2) - \frac{(22 - 13.5)^2}{2.2}}$$
$$P = 3.1416\sqrt{2(484 + 182.25) - 32.8}$$
$$P = 3.1416\sqrt{1332.5 - 32.8}$$
$$P = 3.1416\sqrt{1299.7}$$
$$P = 3.1416 \times 36$$
$$P = 113.097 \text{ inches.}$$

(2) The length of the arc of a sector is found as follows:

A sector is that part of a circle included between two radii and the arc.

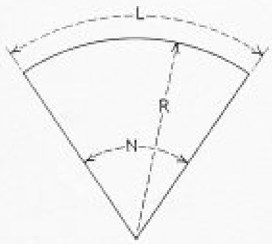


Fig. 2.—Sector of circle

Referring to the sector of circle shown in Fig 2,
R = radius of arc in inches
N = number of degrees in arc
L = length of arc in inches
and $L = 2R \times N \times .0087266$.

Assuming $R = 24$ inches
$N = 36$ degrees,
then $L = 2 \times 24 \text{ inches} \times 36 \times .0087266$
$L = 1628 \times .0087266$
$L = 15.0796$ inches.

(3) Length of the arc of a segment is found as follows:

Given: The segment of a circle *A-C-B-D* shown in Fig. 3.

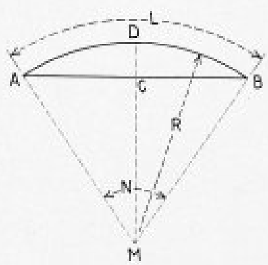


Fig. 3.—Segment of circle

To find the length of the arc *A-D-B* where *A-B* = 27½ inches and *C-D* = 4¼ inches.

First, determine the radius of the arc *A-D-B* by the formula

$$R = \frac{\left(\frac{AB}{2}\right)^2 + CD^2}{2\,CD}.$$

Substituting, we have

$$R = \frac{\left(\frac{27.5}{2}\right)^2 + 4.25^2}{2 \times 4.25}$$

$$R = \frac{189.0625 + 18.0625}{8.5}$$

$$R = \frac{207.135}{8.5}$$

$$R = 24.36 \text{ inches.}$$

Next, determine the angle N from the formula

$$\text{Sine } \tfrac{1}{2} \text{ angle } N = \frac{\frac{AB}{2}}{R}$$

$$\text{Sine } \tfrac{1}{2} \text{ angle } N = \frac{\frac{27.5}{2}}{24.36}$$

$$\text{Sine } \tfrac{1}{2} \text{ angle } N = \frac{13.75}{24.36} = .5644$$

Referring to the tables of "Natural Trigonometrical Functions" found in any engineering handbook we find

Sine $.5644 =$ angle $34° \ 20' = \tfrac{1}{2}$ angle N

Angle $N = 2 \times 34° \ 20'$

Angle $N = 78° \ 40'$.

Having determined the radius of the arc of the segment and the number of degrees in the arc, the length

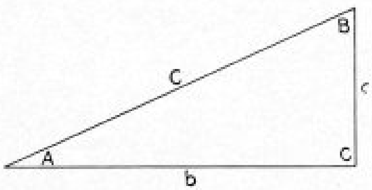


Fig. 4.—Right triangle

of the arc can be determined by the same formula as for the length of the arc of a sector just given.

(4) In reference to the length of an angle to any triangle, the question is not clear as to just what is required. The following trigonometric solution of triangles answers practically all questions on triangles.

RIGHT TRIANGLE

Given	To Find A	B	C	a	b	c
a, b	$\tan A = \frac{a}{b}$	$\tan B = \frac{b}{a}$	90°			$\sqrt{a^2 + b^2}$
a, c	$\sin A = \frac{a}{c}$	$\cos B = \frac{a}{c}$	90°		$\sqrt{c^2 - a^2}$	
A, a		$90° - A$	90°		$a \cot A$	$\frac{a}{\sin A}$
A, b		$90° - A$	90°	$b \tan A$		$\frac{b}{\cos A}$
A, c		$90° - A$	90°	$c \sin A$	$c \cos A$	

Trade Publications

INSULATING FIREBRICK.—B. & W. No. 80 insulating firebrick for furnace work is the subject of a bulletin issued by the Babcock & Wilcox Company, 85 Liberty street, New York.

WRIGHT ELECTRIC HOISTS.—Outstanding features in electric-hoist design are pointed out in an eight-page folder issued by the Wright Manufacturing Company, Bridgeport, Conn. A more complete catalog gives prices and specifications on new Wright Electric hoists.

WATER GAGES.—A new water gage, the Reliance Micasight, is described in a folder issued by the Reliance Gage Column Company, 5902 Carnegie avenue, Cleveland, Ohio. No glass is used in the design of this gage, the water line being clearly visible through windows of mica.

LATHES.—The important units, features and specifications of the new model 9-in. Junior South Bend back-geared screw cutting precision lathe are described and illustrated in Junior catalog No. 22-C issued by the South Bend Lathe Works, South Bend, Ind. These are carried in stock by the A. C. Colby Machinery Company, 183 Centre street, New York, from whom copies of the catalog can also be obtained.

"BOILER WATER CONDITIONING."—This is the title of a new 16-page treatise published by the Elgin Softener Corporation, Elgin, Ill. The book, printed in two colors, discusses various problems in the conditioning of boiler water and is profusely illustrated. There are chapters on Conditioning Boiler Water, Major Problems in the Use of Boiler Water, Chemistry of Boiler Water, Embrittlement, Standard Hook-Ups of Sludge Deconcentrators for Typical Types of Boilers, etc.

Tables of "Natural Trigonometrical Functions" can be found in any engineering handbook.

The formulas for use in "Laying Out Plate Work" as given in "Laying Out for Boiler Makers" are self explanatory and should be easy to follow. However, if

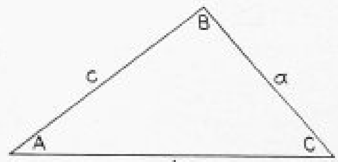


Fig. 5.—Oblique triangle

there is some particular question you have about any of these formulas, I would be pleased to answer same.

OBLIQUE TRIANGLE

$a^2 = b^2 + c^2 - 2bc \cos A$; $b^2 = a^2 + c^2 - 2ac \cos B$; $c^2 = a^2 + b^2 - 2ab \cos C$; $s = \frac{a + b + c}{2}$

Given	A	B	To Find C	b	c
a, b, c	$\cos \tfrac{1}{2}A = \sqrt{\frac{s(s-a)}{bc}}$	$\cos \tfrac{1}{2}B = \sqrt{\frac{s(s-b)}{ac}}$	$\cos \tfrac{1}{2}C = \sqrt{\frac{s(s-c)}{ab}}$		
a, A, B			$180 - (A + B)$	$\frac{a \sin B}{\sin A}$	$\frac{a \sin C}{\sin A}$
a, b, A		$\sin B = \frac{b \sin A}{a}$			$\frac{b \sin C}{\sin B}$
a, b, C	$\tan A = \frac{a \sin C}{b - a \cos C}$				$\sqrt{a^2 + b^2 - 2ab \cos C}$

Associations

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Steamboat Inspection Service of the Department of Commerce

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California	New Jersey	Utah
Delaware	New York	Washington
Indiana	Ohio	Wisconsin
Maryland	Oklahoma	District of Columbia
Michigan	Oregon	Panama Canal Zone
Minnesota	Pennsylvania	Territory of Hawaii

Cities

Chicago, Ill.	St. Joseph, Mo.	Memphis, Tenn.
Detroit, Mich.	St. Louis, Mo.	Nashville, Tenn.
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Kansas City, Mo.	Seattle, Wash.	Parkersburg, W. Va.
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	Evanston, Ill.	

States and Cities Accepting Stamp of the National Board of Boiler and Pressure Vessel Inspectors

States

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Delaware	New York	Utah
Indiana	Ohio	Washington
Maryland	Oklahoma	Wisconsin
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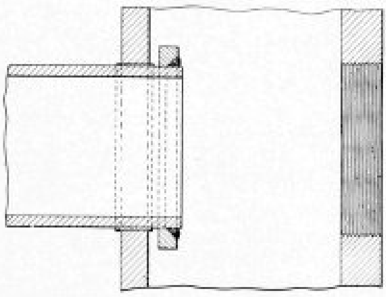
Detroit, Mich.		

Selected Boiler Patents

Compiled by Dwight B. Galt, Patent Attorney, Washington Loan and Trust Building, Washington, D. C. Readers wishing copies of patents or any further information regarding any patent described, should correspond directly with Mr. Galt.

1,701,256. METHOD OF APPLYING LOCOMOTIVE ARCH TUBES. RAY M. BROWN, OF YONKERS, N. Y.

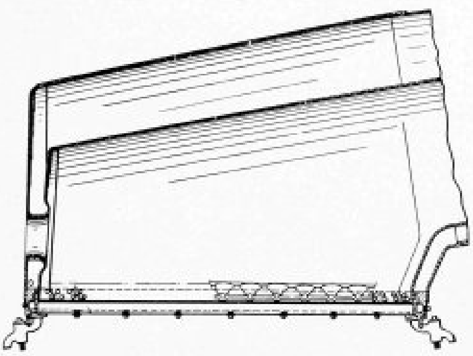
Claim.—The herein described method of securing arch tubes in firebox sheets which consists in inserting the tube from the fire side, rolling the



tube into close contact with the aperture in the sheet, introducing a ring through an aperture in the opposite sheet, and welding the ring on the end of the tube. Two claims.

1,770,939. LOCOMOTIVE BOILER. NEAL T. McKEE, OF BRONXVILLE, N. Y., ASSIGNOR TO GENERAL STEEL CASTINGS CORPORATION, OF GRANITE CITY, ILL., A CORPORATION OF DELAWARE.

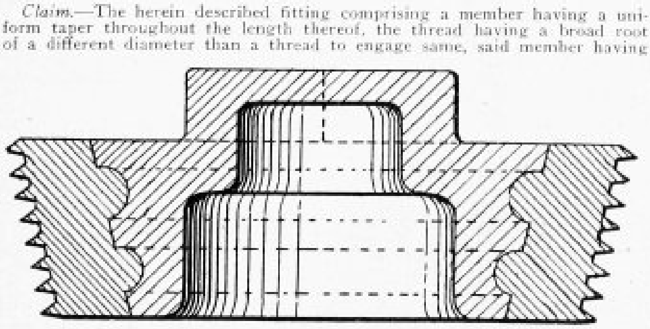
Claim.—In apparatus of the class described comprising a firebox with the usual water legs on its sides, the combination with the sheets forming said water legs of a mud ring fitting between the sheets, a grate to carry



a fuel bed at substantially the level of the upper surface of the ring, said ring having a cavity extending lengthwise and below the fuel bed, and ducts extending from its upper surface to the cavity, and means securing the sheets to the mud ring, there being normally closed washout openings from the cavity. Eight claims.

RE. 17,667. CLEAN-OUT PLUG. FREDERICK J. MERSFELDER AND PAUL BALZE, OF LEONIA, N. J., ASSIGNORS TO M. & B. MANUFACTURING CO., INC., OF LEONIA, N. J., A CORPORATION OF NEW JERSEY.

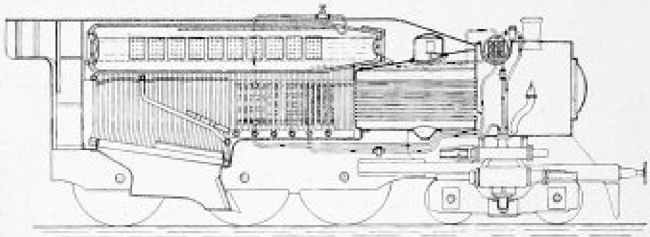
Claim.—The herein described fitting comprising a member having a uniform taper throughout the length thereof, the thread having a broad root of a different diameter than a thread to engage same, said member having



a soft metal body to permit a new thread to be cut into the said root on engaging said member with a hard metal threaded device, the taper of the thread of the soft metal member being greater than that of the other member, the pitch of the angles of the sides of the thread being substantially the same for both members. Eight claims.

1,768,319. SUPERHEATING IN HIGH-PRESSURE LOCOMOTIVES. OTTO H. HARTMANN, OF CASSEL-WILHELMSHOHE, GERMANY, ASSIGNOR TO SCHMIDT'SCHE HEISSDAMPF-GESELLSCHAFT M. B. H., OF CASSEL-WILHELMSHOHE, GERMANY, A CORPORATION OF GERMANY.

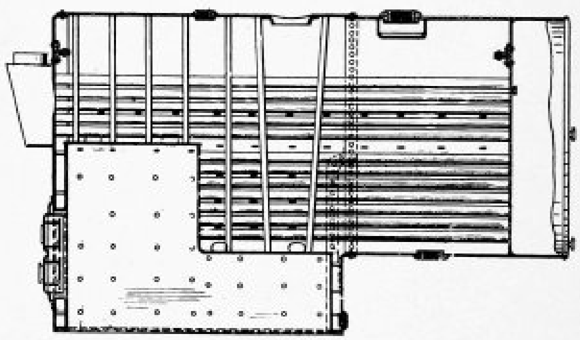
Claim.—In a high-pressure locomotive the combination of a high-pressure watertube boiler, a low-pressure smoketube boiler receiving the furnace



flue gases from the high-pressure boiler, at least one superheater to superheat the high-pressure steam, and at least one superheater to superheat the low-pressure steam, the high-pressure boiler having a series of steam generating watertubes crossing the channel of flue gases and the lengths of the high-pressure superheater tubes passing between the said series of steam generating watertubes in planes transverse to the direction of flow of the flue gases. Six claims.

1,703,084. BOILER. HOMER ADDAMS, OF OSWEGO, N. Y.

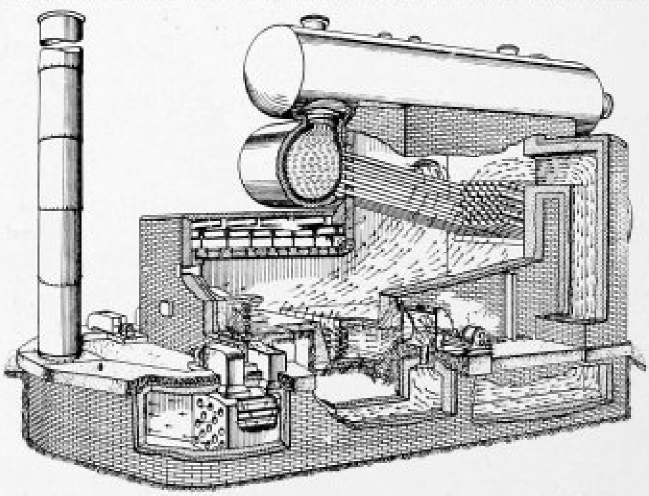
Claim.—In a steam boiler, the combination with a firebox rectangular in horizontal cross section and having an upper constricted extension at its front end, of a fire door formed in the front end of said firebox, a housing, a shield mounted in said housing and spaced a short distance from the rear end of said housing to form a return chamber for the flue gases between said rear end and said shield and a water reservoir to the front thereof, the lower portion of the housing extending from the rear



face of the constricted extension of said firebox and across and beyond the rear end of the firebox, the upper portion of the housing extending across the top of the constricted extension of the firebox, a lower group of flue pipes extending through the lower portion of said housing from the rear face of said constricted extension to said shield to form communication between the firebox and the return chamber, a second group of flue pipes extending through the upper portion of said housing from the shield to the front end of said housing, and a chimney member in communication with the front end of said upper group of flue pipes. Five claims.

1,771,989. FURNACE. WARD T. BARKER, OF KANSAS CITY, MO.

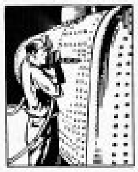
Claim.—A furnace comprising communicating combustion and heating chambers, a flue leading from the heating chamber, a conduit extending transversely beneath the furnace floor and communicating with said flue, a trench parallel to and communicating with said conduit and opening through the furnace floor for delivering flue gases to the combustion cham-



ber across the line of flow through the combustion chamber to the heating chamber for recirculating the flue gases through the heating chamber mixed with fresh products of combustion, and means for exhausting some of the flue gases to maintain the volume of flow through the heating chamber substantially constant. Fourteen claims.

The Boiler Maker

Reg. U. S. Pat. Off.



Master Boiler Makers

While it has been unfortunate that conditions have necessitated the postponement of the 1931 annual meeting of the Master Boiler Makers' Association, the activity of the officers and committee members during the present year goes far toward assuring a successful program when the next convention shall be held. At the present time, it is hoped that the twenty-second annual convention of the association will take place at the Hotel Sherman, Chicago, Ill., in 1932, the exact date to be announced later.

In an effort to continue the unbroken progress of the association, the executive board has authorized the publication of the reports of committees on topics assigned in 1930, and special papers prepared for the 1931 meeting, in place of the "Official Proceedings" which would have contained the discussions on the convention floor. Through the courtesy of the association, The Boiler Maker has been permitted to publish the president's address and the reports of the various committees as well as the special papers on the subjects of electric and gas welding and corrosion and pitting in locomotive boilers and tenders.

Inasmuch as the success of the next convention depends, in a large degree, on the quality of discussion prepared, The Boiler Maker offers its pages to members of the association and non-members for the discussion of the various topics presented. It is our earnest desire that the good work of the association shall be carried on. For this reason we hope that our readers, in lieu of the convention floor, will use the pages of this magazine for such discussion as may arise.

Repairing Boiler Tubes

Highly efficient motive power is dependent not only on the skill with which new locomotives and boilers are designed and constructed but also on the quality of workmanship with which locomotives are maintained in service. Inspection is important in attaining the highest efficiency of motive power over a period of time, but without proper procedure in effecting the recommendations of the inspector, the importance of determining the condition of the machine is reduced.

That the railroads of this country are maintaining the proper condition of the motive power is evidenced by the continually decreasing number of accidents due to failures of the locomotive or its accessories. This is particularly true in the case of boiler tube failures. With the increase in steam pressures and other difficulties under which locomotives are forced to operate, the maintenance of boiler tubes becomes a more vital factor and makes advisable the adoption of set standards of procedure for this type of work.

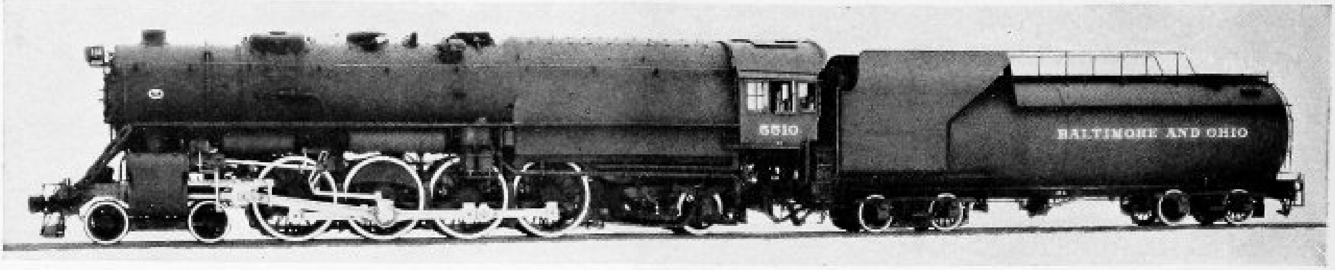
In this issue is outlined the standard practice of the Northern Pacific Railway Company for ordering, repairing and applying tubes to locomotive-type boilers. This set of instructions governs the actual operations to be performed, with explicit explanation for procedure. These rules are issued to all whose duty it is to maintain the locomotive for the railroad and, with these rules in mind, it is possible for every man to understand exactly the work he will be called upon to perform in any particular case. Individual interpretations are thus eliminated and errors in judgment or misunderstandings cannot occur.

Boiler Orders

According to the Bureau of the Census of the Department of Commerce, which publishes monthly statistics on new orders for steel boilers, these new orders are gradually increasing. Orders for July included 815 stationary boilers, the largest volume of business since October, 1930. This total of 815 stationary boilers, having a heating surface of 685,787 square feet, includes 87 watertube boilers, 45 horizontal-return-tubular boilers, 55 vertical-firetube boilers, 4 locomotive-type (not railway) boilers, 561 steel heating boilers, 33 oil-country boilers, and 29 self-contained portable boilers. In the marine field, however, only one Scotch boiler, with 1271 square feet of heating surface, was ordered.

In comparison with previous months of this year, with the exception of the marine field, the July orders show an increase of 230 boilers over January's orders, 320 over February, 213 over March, 150 over April, 177 over May, and 9 over June. The total boilers for the first seven months of the year amounts to 4725 with a total heating surface of 4,656,946 square feet. For the same period of 1930, this total was 7761 boilers with a total heating surface of 8,682,854 square feet.

While present orders compare unfavorably with those of previous years, every indication is that the trend is upwards. However slight that trend may be, it is a sign that business is improving.



Class T-1 locomotive built by The Baldwin Locomotive Works and equipped with the Emerson watertube boiler

Baldwin Locomotive Works Builds Four Test Locomotives

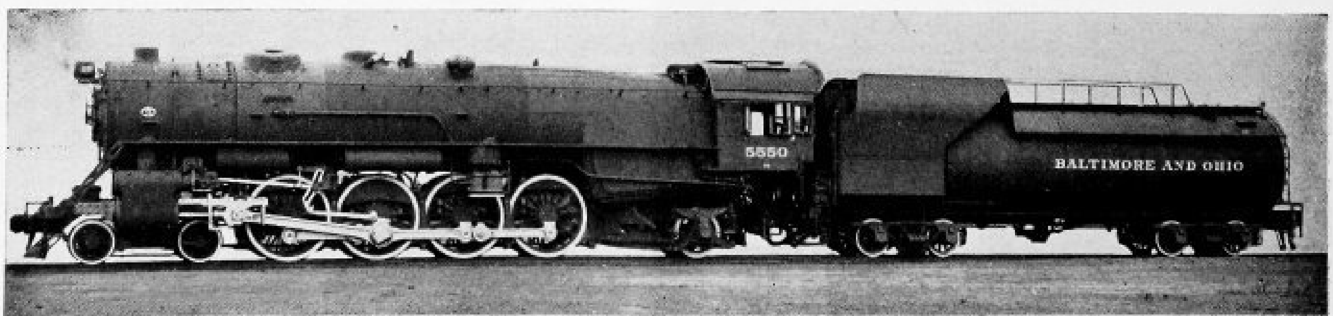
Baltimore & Ohio Railroad Orders two 4-8-2 types and two 2-6-6-2 types for test in passenger and freight service—One of each type is equipped with the Emerson watertube firebox —The new articulated power was designed by the railroad for service over all parts of the main line of the B. & O. system

Four locomotives, two of the 4-8-2 type and two of the 2-6-6-2 type, were delivered to the Baltimore & Ohio by the Baldwin Locomotive Works, Eddystone, Pa., in December, 1930, and January, 1931, for comparative tests in actual service over certain heavy-tonnage districts on the system. One each of the two types of locomotives are equipped with the Emerson watertube firebox. The 4-8-2 type so equipped is known as the Class T-1, and the 2-6-6-2 type with the watertube firebox has been assigned the classification KK-1. The 4-8-2 type built with the conventional stayed firebox is known as Class T-2, while the 2-6-6-2 type of conventional boiler construction is designated Class KK-2.

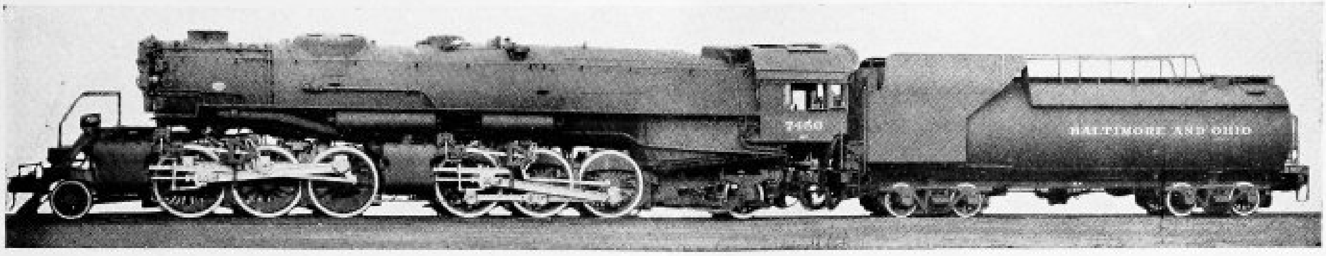
The two locomotives of the same type have essentially the same weights and dimensions. Locomotive Classes T-1 and T-2 develop a tractive force of 65,000 lb. They have 74-in. driving wheels and 27½-in. by 30-in. cylinders. The boilers operate at a pressure of 250 lb. locomotives Classes KK-1 and KK-2 have a rated maximum tractive force of 90,000 lb. and operate at a boiler pressure of 250 lb. They have 70-in. driving wheels and four 23-in. by 30-in. cylinders.

In the development of the design of the two articulated locomotives a careful study and comparison was made of the design and performance of various types of locomotives already in service on the Baltimore & Ohio. This study showed that a high-wheel light 2-6-6-2 single-expansion articulated locomotive with a tractive force of 90,000 lb. would meet the requirements. In addition, it was estimated that a locomotive of this design could be more economically used in the territories over main-line tracks where the heavy 2-8-2 and 2-10-2 types are used, because of the increased capacity and speed of the articulated power. The KK class locomotives can be operated anywhere on the Baltimore & Ohio lines between New York and Chicago, and East St. Louis, Ill. This includes the Reading and the New Jersey Central Lines.

There is also some territory on the Baltimore & Ohio, especially between Washington, D. C., and New Castle Junction, Pa., that is now served with heavy stoker-



Class T-2 locomotive built with the conventional stayed firebox



Class KK-2 single-expansion articulated locomotive

fired 4-6-2 type passenger locomotives. However, with trains of over eight cars it is necessary to use helper service over mountain grades. To handle important passenger trains over the grades without a helper and also to meet weight and clearance limitations as well as operating schedules, the T-1 and T-2 class 4-8-2 type locomotives were designed. These locomotives have sufficient flexibility to meet the requirements described and to be used on the main line between New York and Chicago, and Grafton, W. Va. They are also suitable for handling fast-freight trains which are now handled by 2-8-2 type locomotives of the Q-4 class having 64-in. drivers.

The T-1 and T-2 class locomotives were designed to meet weight limitations of around 658,000 lb. With this limit, tenders with a capacity of 18,000 gal. of water and 20 tons of coal were found to be practicable.

The Classes T-1 and T-2 and also Classes KK-1 and KK-2 locomotives, respectively, are identical with the exception of the firebox and some of the boiler details. The two locomotives equipped with the Emerson watertube fireboxes have Type A superheaters, while the two with the fireboxes of customary staybolt construction have two Thermic syphons and Type E superheaters. Other equipment applied to all four locomotives includes Sellers exhaust-steam injectors, Lower stokers, power reverse gears, General Steel Castings Company cast-steel cylinders, and General Railway Signal train-control equipment. During the period of the test an Elesco exhaust-steam injector was applied to locomotive No. 5510, Class T-1, and is still applied. Three locomotives, Classes T-1, KK-1 and KK-2, have the Barco power reverse gear, while locomotive No. 5550, Class T-2, is equipped with the Precision gear. A list of the special equipment and appliances on locomotive No. 7400 is shown in one of the tables. The items included in this list are practically the same as applied on the three other locomotives with the exceptions noted.

The Emerson watertube fireboxes on the Classes T-1 and KK-1 are designed with a single drum. While different in some details from other designs of watertube fireboxes which have been applied to other Baltimore & Ohio locomotives, they are designed on the same basic principles.

The preliminary plans for the four locomotives were prepared by the mechanical department of the Baltimore & Ohio, while the details of construction as affecting weight limitations were handled jointly by the builder and the mechanical department of the railroad. The necessity of minimum weight combined with strength of parts made it advisable to employ nickel-steel plate in the construction of the boiler shell with special saw-tooth butt seams, cast-steel cylinders, single-bar guides, and hollow axles and crank pins. The frames, crossties and bracing members are welded together, practically eliminating the use of joint bolts in the building of the frame structure.

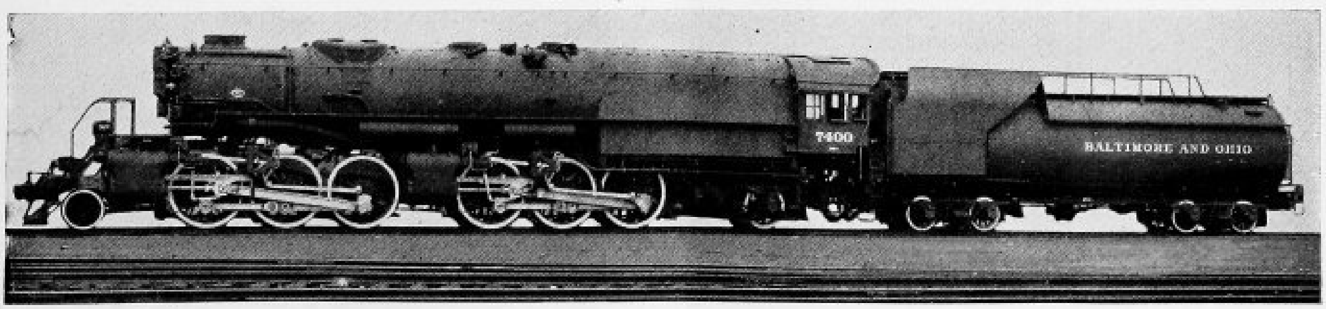
Feedwater is supplied by an exhaust-steam injector located on the right side and by a live-steam injector on the left side.

The fireboxes of the conventional boilers are of large volume, with combustion chambers. The radiant heating surface in the 4-8-2 type is about 9 percent of the total, while in the articulated type this proportion is less than 8 percent.

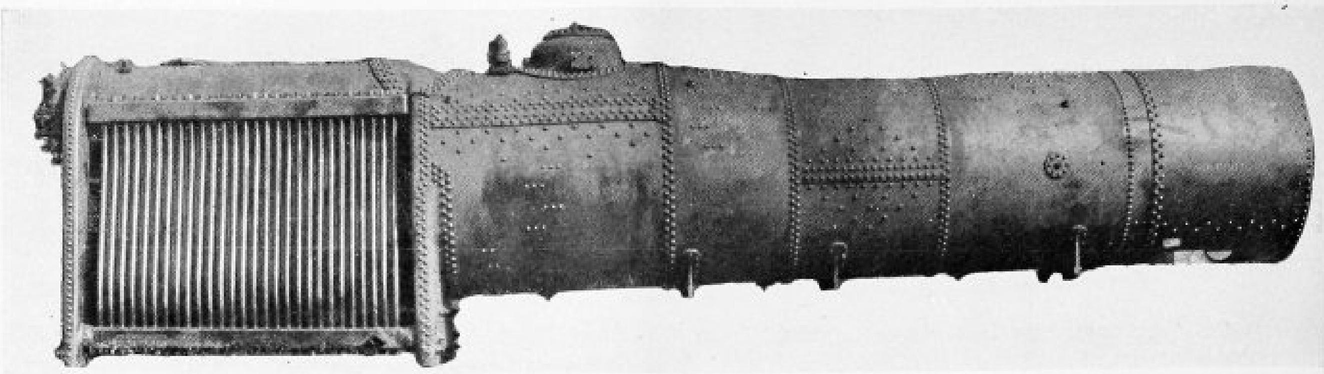
The Emerson watertube fireboxes of locomotives No. 5510 and No. 7400 considerably increase the ratio of radiant to convection surface and in this respect show an advantage that should make for higher evaporative efficiency. The direct heating surface in the 4-8-2 type is 16 percent of the total and in the articulated type, about 13 percent.

The boilers with the watertube fireboxes are constructed with the conventional barrel and longitudinal fire tubes. A single drum, 40-in. in outside diameter, is secured to the back tube sheet at the front, and to the backhead and door sheet at the rear. The back tube sheet is flanged toward the inside to form the riveted connection to the drum, instead of toward the fire side of the sheet. This construction eliminates the double thickness of metal exposed to the radiant heat of the fire. The drum extends rearward and terminates in a bulged head after passing through a back water leg with which it is connected by means of circulating ports. The front water leg is below the drum and is of conventional type as formed by the boiler throat and back tube-sheet.

The front and back water spaces are connected on



Class KK-1 single-expansion articulated locomotive built with the Emerson watertube boiler



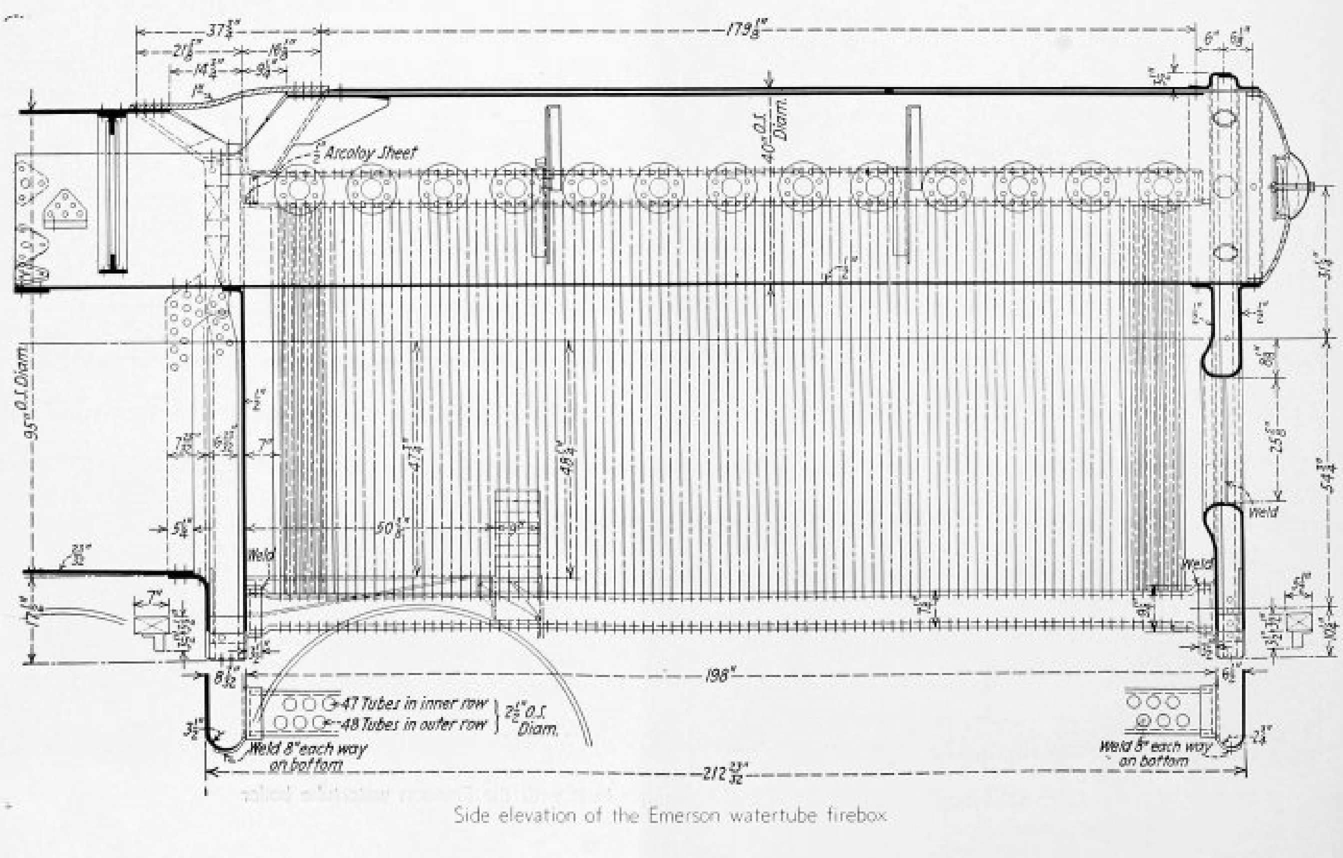
Side view of boiler equipped with the Emerson watertube firebox

each side at the bottom with a 5½-in. by 7½-in. seamless rectangular header. Headers of the same size as the top extend along the sides of the drum. The ends of the top headers are blank and have no direct connection with either the back water space or the shell of the boiler.

A total of 190 water tubes, 2½-in. outside diameter, are arranged in two rows between the top and bottom headers. Coarse-thread plugs are located in the top of the top headers opposite the ends of the tubes, convenient for rolling in and also for turbining the tubes at washout periods. Construction plugs are used in the bottom of the bottom headers for convenience in rolling in the tubes. However, these plugs are not removed at the time tubes are turbined. The top headers are connected to the drum along each side with a series of 13 short nipples 4-in. in outside diameter. A shallow pressed-steel hip sheet joins the top portion of the drum to the boiler shell. Insulation is applied between the drum and the upper side headers and over the water tubes at the sides.

The watertube firebox in locomotives Classes T-1 and KK-1 effected a substantial increase in heating surface over the stayed firebox without increasing the weight. For example, the watertube firebox has an evaporative heating surface of 866 sq. ft. as compared with 474 sq. ft. of evaporative surface for the stayed fireboxes, including the syphons—an increase of 82 percent. To increase the heating surfaces of the stayed fireboxes to obtain the same heating surface as the watertube fireboxes, the additional weight would have required a four-wheel trailing truck, and furthermore would have increased the total weight of the locomotive to such an extent as to prohibit operation over a number of divisions. The watertube fireboxes have large combustion chambers, part of which can be conveniently used for increasing the grate area if desired.

A series of road tests with a dynamometer car were made with the 2-6-6-2 type locomotive, No. 7400, which is equipped with the Emerson watertube firebox. These tests were made in slow-freight service eastbound on the east end of the Cumberland division, between Keyser, W. Va., and Brunswick, Md. This is not the operating territory for which the locomotive was designed, but is



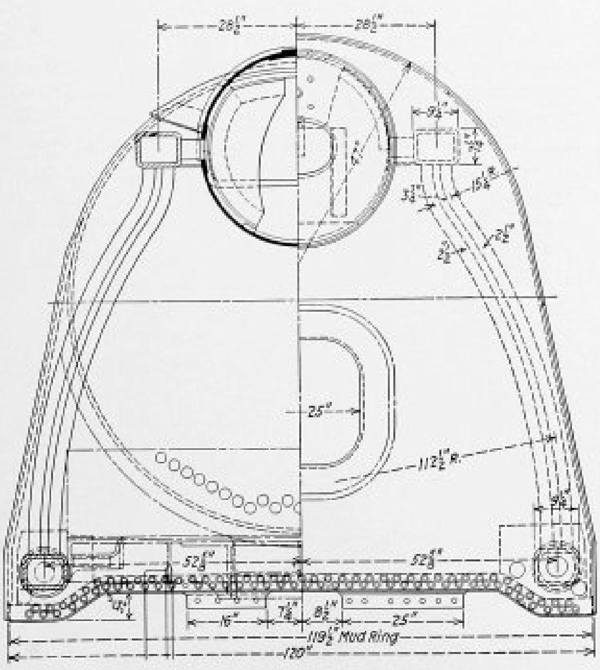
Side elevation of the Emerson watertube firebox

List of special parts, appliances and equipment applied on the Baltimore & Ohio 2-6-6-2 type locomotive No. 7400

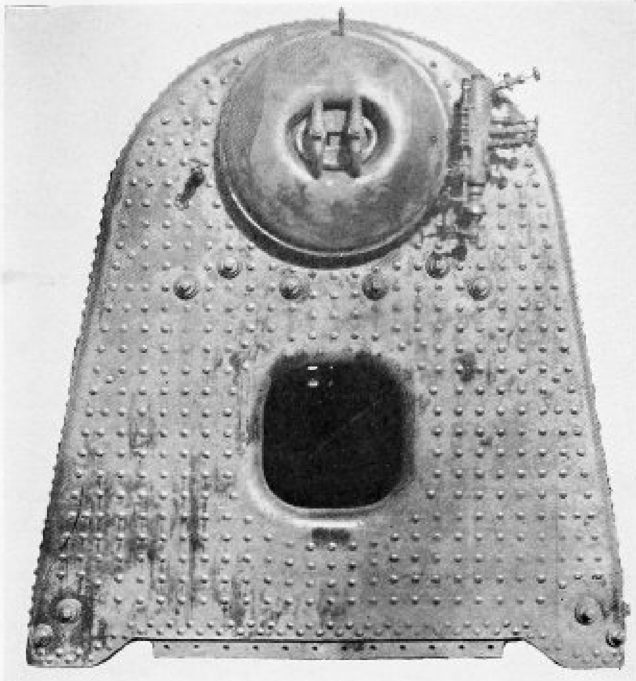
Railroad	B. & O.
Service	Freight
Boiler and firebox:	
Blow-off cock	Bird-Archer
Blow-off cock, auxiliary	Coale
Boiler jacket	Bethlehem Steel
Fire brick	Security
Firedoor	Franklin butterfly
Injector, Exhaust steam	Elesco
Injectors and injector check	Sellers
Lagging	Philip Carey
Smokebox hinges	Okadee
Staybolts	Ewald
Stoker	Lower
Superheater	Type A
Tubes and flues	National Tube
Valve, blow-off	Bird-Archer
Valves, safety	Coale
Valve, throttle	Chambers
Washout and arch-tube plugs and bushings	Huron

Average results of dynamometer-car tests between Keyser, W. Va., and Brunswick, Md., with locomotive No. 7400

Number of tests run	3
Season of tests	Winter
Train consist:	
Number loads	96
Number others	1
Total number cars	97
Actual tonnage	8,245
Total time en route	5 hr. 49.6 min.
Road delays	0 hr. 36.4 min.
Net running time	5 hr. 13.2 min.
Average speed, m.p.h.	20.91
Number of stops	3
Total coal as fired	31,500 lb.
Total water evaporated	27,204 gal.
Coal as fired per 1,000 gross ton-miles	35.14 lb.
Coal as fired per sq. ft. grate area per hr	86.82 lb.
Evaporation, water per lb. coal as fired	7.20 lb.
Coal per drawbar horsepower-hour, as fired	3.14 lb.
Water per drawbar horsepower-hour, actual	22.59 lb.
Average drawbar horsepower	2,546
Average drawbar pull	47,951 lb.
Average boiler pressure, lb. per sq. in.	246.2
Average steam-chest pressure, lb. per sq. in.	216.3
Average back pressure, lb. per sq. in.	3.7
Average cut-off, per cent	42.8
Maximum steam temperature, deg. F.	610
Average B.t.u. per lb. coal as fired	12,994
Per cent moisture in coal as fired	1.74
Overall thermal efficiency at drawbar, per cent	6.25
Pusher used for 8.2 miles over maximum equated grade of	0.85 per cent



Cross-section of the Emerson watertube firebox


Backhead of an Emerson watertube firebox applied to a 4-6-2 type locomotive class P9A at the Mt. Clare shops

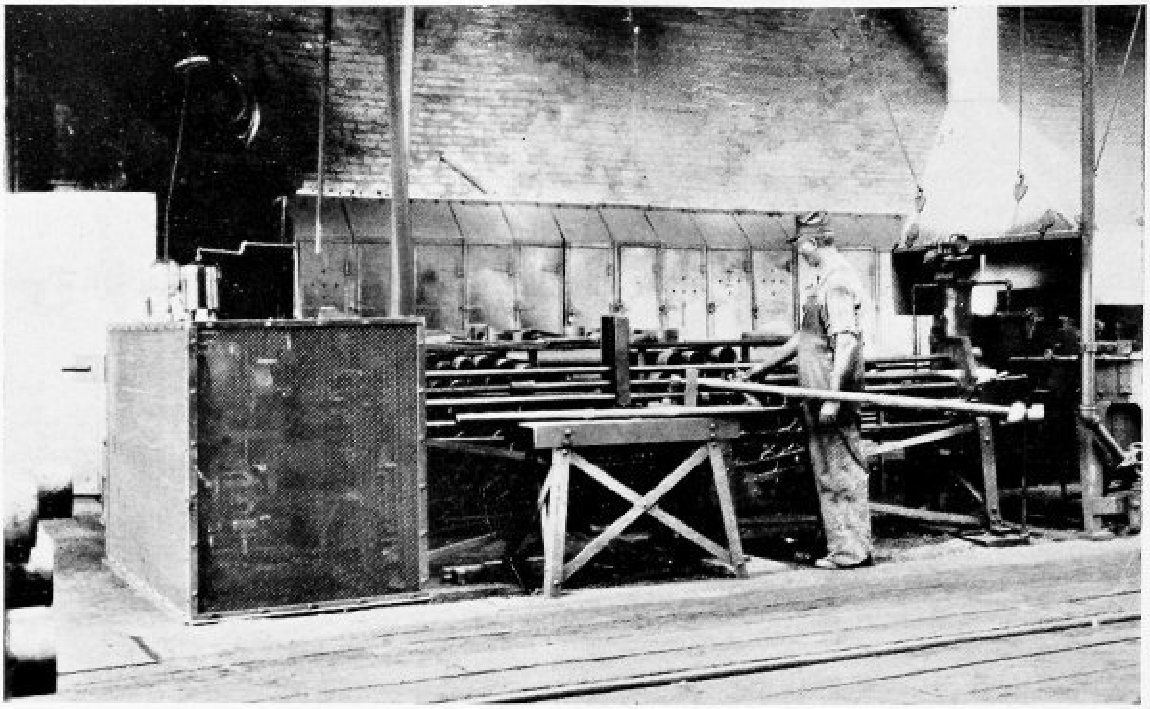
the division regularly used by the railroad for road tests. Owing to the fact that other locomotives have been tested over this same line, a comparison with other performances can be readily made.

The trains hauled during the tests averaged 9,700 adjusted tons. The trains were made up of loaded 50- and 70-ton coal cars. The average results of these tests are shown in one of the tables. Several preliminary runs were made to determine the correct size of nozzles which would properly draft the engine for this service. Two 5½-in. open exhaust nozzles gave the best results.

A study of the figures given in the table shows that exceptional economy was obtained, both in coal and water consumption. The coal and water consumption per drawbar horsepower per hour affords an accurate basis for this conclusion. This economy is also reflected in the high over-all thermal efficiency obtained at the drawbar. A relatively high average speed and an average drawbar pull of approximately 48,000 pounds was maintained over the division, indicating the advantage of large driving wheels.

Owing to the fact that an apparently large drop in pressure between the boiler and steam chest is shown, some explanation in regard to the source of these figures is necessary. The averages include the steam chest pressures observed while the locomotive was working with a restricted throttle opening for short periods. With full throttle opening and under good operating conditions, this drop was observed to be only about 10 lb. A study shows that the two units of the engine are well balanced, developing approximately the same horsepower. Although indicator cards were not taken with the object of determining maximum horsepower, they show that this would be reached at a speed well above 35 miles an hour.

As a result of these tests it is evident that a single-expansion articulated locomotive of the 2-6-6-2 type with 70-in. drivers will meet the actual load and clearance restrictions imposed, afford sufficient boiler capacity for cylinder requirements and give economical performance.



Flue reclaiming machine

Repairing Boiler Tubes on the Northern Pacific

In the July and August issues of THE BOILER MAKER there appear articles dealing with rules for boiler inspection and test as employed by the Northern Pacific Railway Company. A study of these rules indicates how completely the methods of inspecting and testing have been regulated. The following paragraphs continue the description of the practices of the Northern Pacific Railway Company and deal with ordering, repairing and applying tubes to locomotive-type boilers. This set of standard practices treats not only of the application of boiler tubes and flues but covers procedure in connection with replacing arch tubes as well.

Ordering Boiler Tubes and Safe Ends—Requisitions for tubes in all cases should show the outside diameter, length, gage and Northern Pacific specification for material. Tubes 2¼ inches outside diameter or smaller must be ordered one inch longer and superheater boiler tubes one and one-half inches longer than distance over tube sheets. Superheater boiler tubes will be ordered swedged and cut to dimensions according to the drawing for the class of locomotive for which they are ordered.

Material for tubes 2¼ inches in diameter and less is to be charcoal iron per Northern Pacific specification for boiler tubes and for superheater boiler tubes. Material for safe ends will be Swedish iron, "Algerite" or equivalent brand.

Requisitions for safe ends in all cases should specify the outside diameter, length, gage and material. Safe ends for boiler tubes 2¼ inches in diameter and less should be cut to length and ready to apply. Standard stock lengths will be 5 inches, 8 inches and 12 inches. Safe ends for superheater boiler tubes will be 5⅝ inches outside diameter for the front end and 4⅝ inches outside diameter for the back end. Gage should be the same as the body of tube to be safe ended. Random lengths will be furnished.

All tools and gages used must conform to standard drawings and must be kept in proper condition for the work for which they are intended.

Preparation of Tube Sheets for Setting—Tube sheets must be properly straightened before tube holes are drilled and before tubes are applied. Holes in new back tube sheets should be drilled 1/16 inch smaller than outside diameter of the tube. Holes in front tube sheet should be drilled 1/16 inch larger than the outside diameter of the tube. Tube holes must be smooth and the edges of holes chamfered to a radius of 1/16 inch on both sides of both front and back tube sheets.

When tube holes in the back tube sheets become 1/32 inch out of round they must be reamed true with a straight reamer.

Preparation of Tubes for Setting—Tubes must be straight and back end of tubes must be so swedged that they can be driven into the copper ferrule applied to the tube sheet, by striking three or four sharp blows with a 4-pound hammer. Both ends of tubes must be properly annealed. Ends of tubes both new and safe ended must be cut off square, and be free from burrs. All scale must be ground or filed off before application.

Method of Setting Tubes—Copper ferrules in the back tube sheet must be small enough to stand light rolling in order to make them tight in the flue sheet, and yet be a good snug fit for the tube. Drive the ferrule in flush with the sheet on the fire side and allow surplus copper to project into the water side. Use copper ferrules No. 18 B. W. G. for new tube sheets and No. 15 B. W. G. for worn sheets.

When placing tubes in the boiler, particular care must be taken not to injure or misplace the copper ferrules.

When driving tubes into the back tube sheet, slip a large round-headed bolt or tube backer into the front end of tube to strike against to avoid battering the tube.

Tube pockets shall be made from pieces of tubes 8 inches in length swedged to diameter which will permit of application from the firebox side of the tube sheet. One end shall be closed tight by welding and the other end applied to tube sheet as illustrated and described for small tubes.

Figs. 1 to 7 illustrate the method of setting tubes of saturated steam locomotives. Figs. 1 to 6 and 8 to 14 illustrate the method of setting tubes of superheater locomotives.

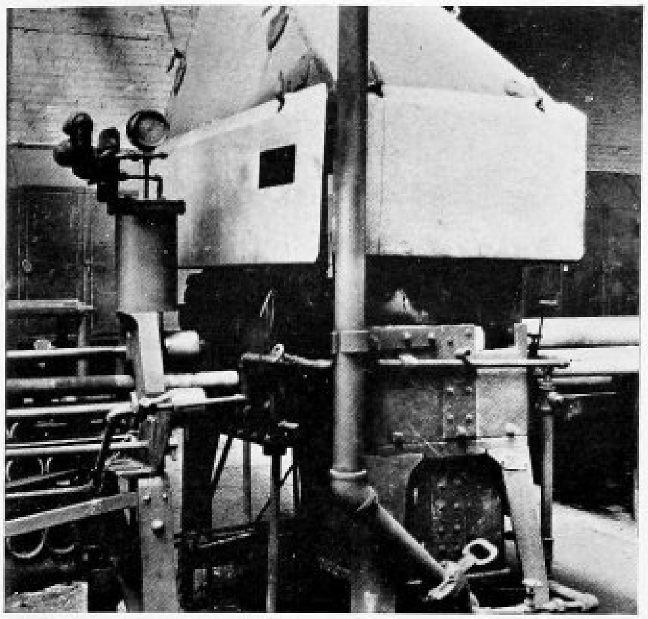
Ends of tubes must extend through sheets to gage as shown in Figs. 1 and 8 and be lipped over slightly with pein of hammer to prevent backing through the sheet, mandrel pin then being driven as shown in Figs. 2 and 9.

Tubes should be expanded as shown in Figs. 4 and 11 and worked as follows:

Belling tool should be used, as shown in Figs. 3 and 10 for partly turning flange before beading.

Drive the expander pin lightly until it is fairly solid, draw out the pin and give the expander a turn equal to one-half a section of the expander. Drive the pin, then withdraw it and give the expander a turn equal to one-quarter of a section and drive the pin a third time. Care must be taken in the use of the expander in the outer row of tubes at the flange of the tube sheet to avoid cracking. The expander used must be of the proper size corresponding to the thickness of the tube sheet as shown on detail drawings.

Beading tool should be used as shown in Figs. 5 and 12 being careful to hold the tool so as to give the bead outward set as shown and get the bead down to the sheet without raising a burr on the inside, or marking the sheet on the outside. Tubes should be finished by lightly rolling with roller as shown in Fig. 6 and 13.

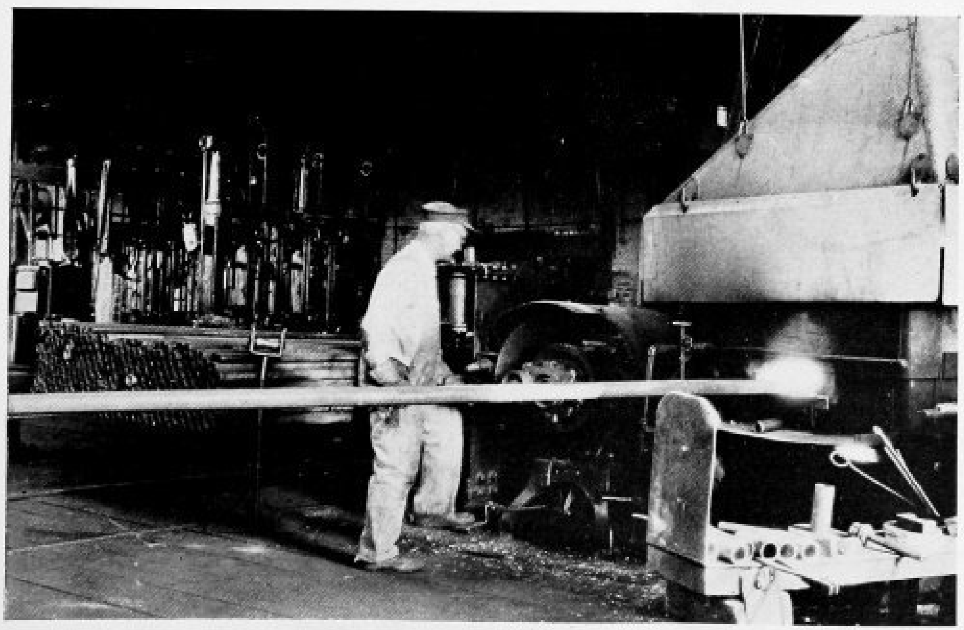


Close-up of flue reclaiming machine

When tube holes in the front tube sheets become enlarged over their standard diameter, the front ends of tubes must be heated and expanded a corresponding amount on standard mandrels as illustrated in Fig. 15. This expanding can be done at the same time flue ends are heated for annealing. Standard mandrels and casings will vary in size above the standard diameter of tube hole by sixteenth inches.

Power hammers and motors are to be used wherever possible.

Long stroke riveting hammers are to be used for pinning, belling, and expanding tubes. Short stroke riveting hammers are to be used for beading tubes.



Machine and furnace for safe ending small flues in operation at the Brainerd shops of the Northern Pacific Railroad

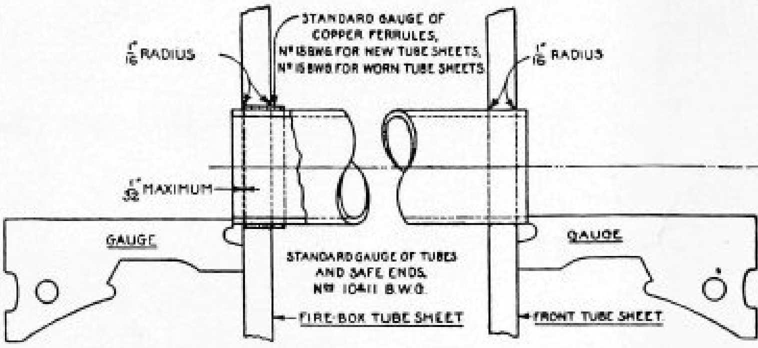


FIG. 1

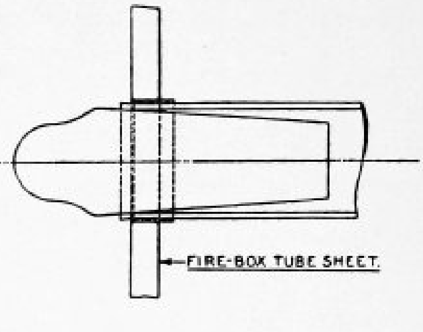


FIG. 2

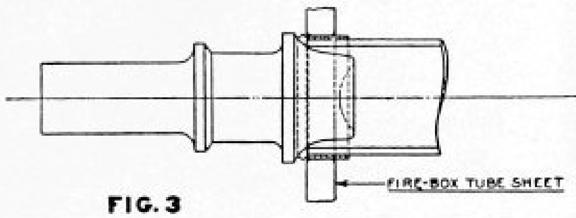


FIG. 3

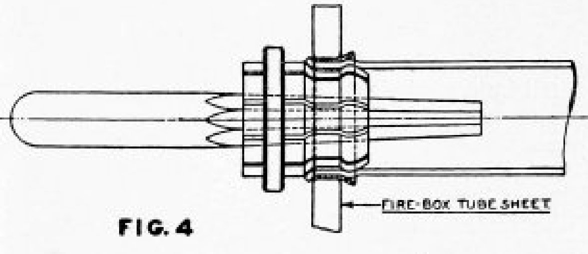


FIG. 4

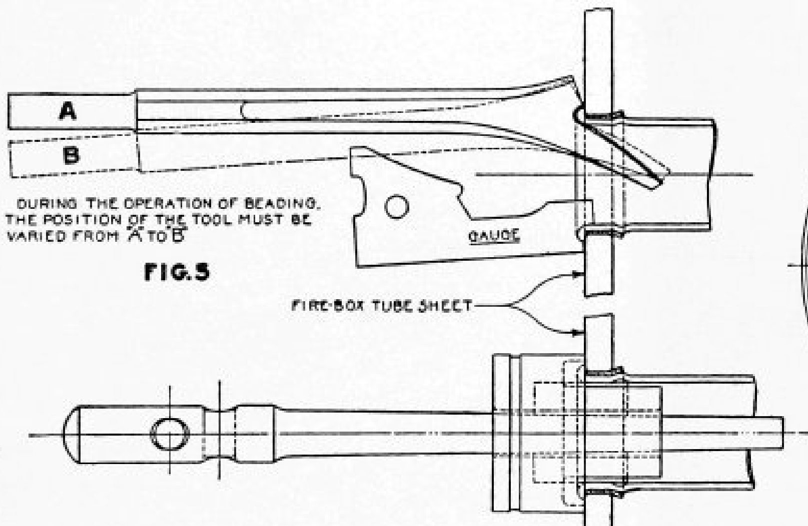


FIG. 6

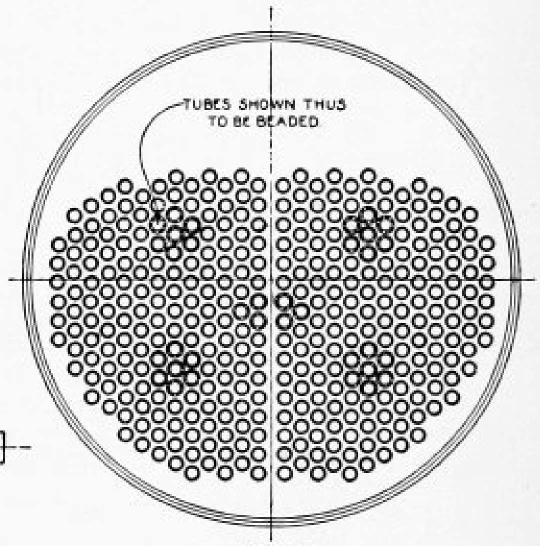


FIG. 7

Method of setting boiler tubes of saturated steam locomotives

Fig. 1 shows the front and back tube sheets, with tube and ferrule in place ready for setting. The tube should project through both sheets 3/16 inch as indicated by the gage.

Figs. 2 to 6 inclusive, show the several operations to be performed in setting the tube at the firebox end, and the order in which the work must be performed.

Fig. 2 shows the tube after being pinned, and the pinning tool in place.

Fig. 3 shows the tube after being belled, and the belling tool in place.

Fig. 4 shows the tube after being prossered and the prosser expander in place.

Fig. 5 shows the tube after beading, and the beading tool in place. After beading, the tube is finished by lightly rolling.

Fig. 6 shows the finished tube and the roller in place. At the front tube sheet the several operations will be as follows: For boilers having an allowed steam pressure of 200 pounds or over, about 35 tubes in groups of seven each, will be pinned, belled, beaded and rolled. All other tubes in boilers having this allowed pressure, and all tubes in boilers having less than 200 pounds allowed pressure will be pinned and rolled only.

Fig. 7 illustrates a front tube sheet and shows the groups of beaded tubes. If there are two parallel vertical center rows there will be but six beaded tubes at the center; on a boiler with a single vertical row there will be a group of seven.

Repairing and Scrapping Tubes—When the pneumatic tube cutter is used, first cut the tubes off ⅝ inch inside of the front tube sheet, then cut off the bead in the back sheet and remove the tube through the dry pipe hole, or through an enlarged hole which may be provided for that purpose, five rows up in the center of the front tube sheet. When the tube cutter is not used, split the front end of the tube back to ⅝ inch inside of the sheet, then cut off the bead at the back end and back tube out of the back sheet with the tube backer. If the tubes are not in condition to be drawn out through their own hole in the front sheet, they must be passed back to the water space and drawn out through the dry pipe hole or an enlarged hole in the front tube sheet as above specified. Under no circumstances shall a tube hole in the back tube sheet be enlarged for the removal of tubes.

Care must be taken when removing the tubes through the dry pipe hole to see that the dry pipe joint is properly protected.

Tubes should be thoroughly cleaned and carefully inspected for pits and weak points, and when found to be pitted or worn one-third of original thickness of the tube, the tube must be scrapped or have the defective

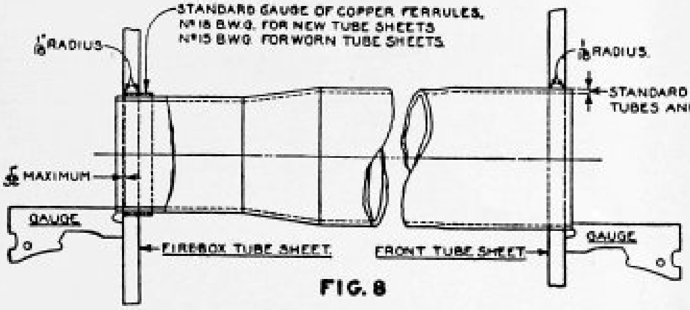


FIG. 8

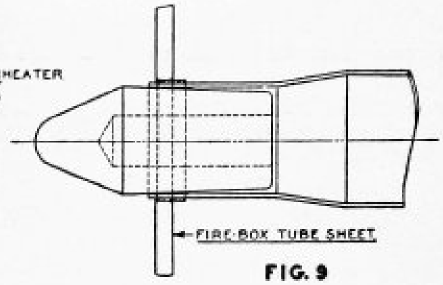


FIG. 9

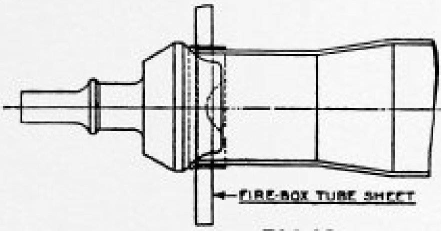


FIG. 10

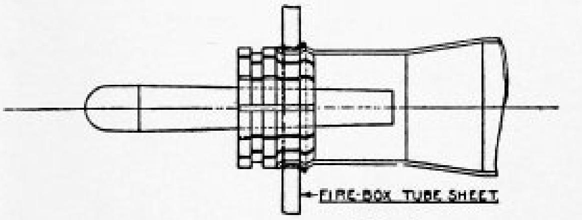


FIG. 11

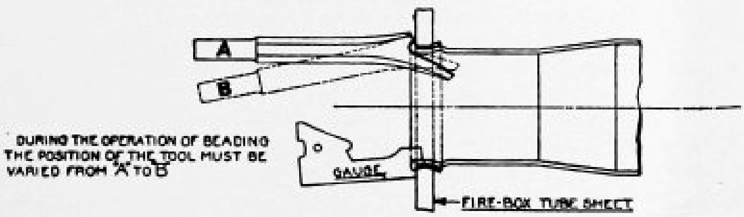


FIG. 12

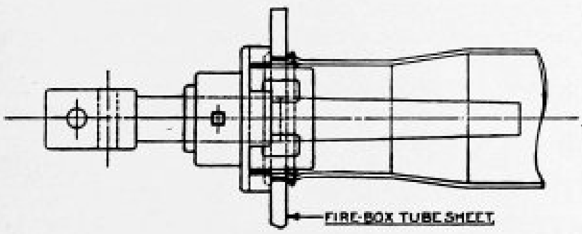


FIG. 13

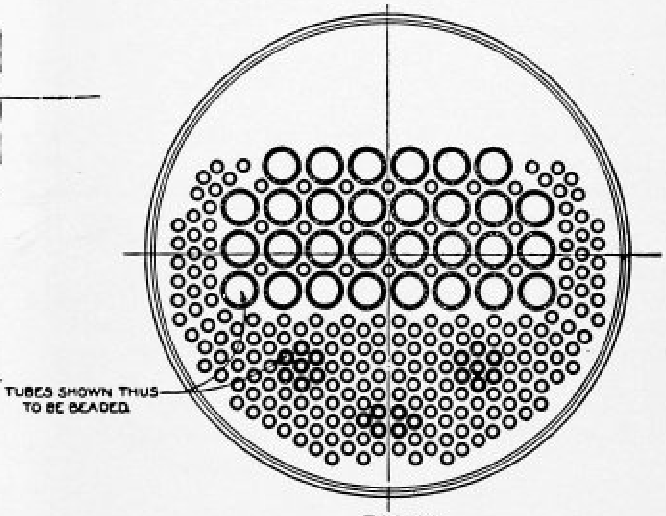


FIG. 14

Method of setting boiler tubes of superheater locomotives

Fig. 8 shows the front and back tube sheets with tube and ferrule in place ready for setting. The tube should project through both sheets ¼ inch as indicated by the gage.

Figs. 9 to 13 inclusive, show the several operations to be performed in setting the tube at the firebox end, and the order in which the work must be performed.

Fig. 9 shows the tube after being pinned, and the pinning tool in place.

Fig. 10 shows the tube after being belled, and the belling tool in place.

Fig. 11 shows the tube after being prossered and the prosser expander in place.

Fig. 12 shows the tube after beading and the beading tool in place. After beading the tube is finished by lightly rolling.

Fig. 13 shows the finished tube and the roller in place. At the front tube sheet the tubes will be pinned, belled, beaded and rolled.

Fig. 14 illustrates a front tube sheet of a superheater locomotive. Small boiler tubes are to be set in the same manner as on saturated steam locomotives, except beaded tubes are to be located as shown in Fig. 14. If there are two parallel vertical center rows there will be but six beaded tubes at the center; on a boiler with a single vertical center row there will be a group of seven.

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portion cut out and the good portion used in boilers having shorter tubes.

Tubes that are otherwise good, but have been reduced in weight to less than 1.66 pounds per foot for 2-inch tubes and 1.89 pounds per foot for 2¼-inch tubes, must be scrapped.

Tubes which are slightly pitted or otherwise weakened, but which are still serviceable, shall be kept together in sets so that a complete set of tubes in approximately the same condition may be applied when possible. It is desired that such tubes when re-applied be used in switch power or boilers, the allowed steam pressure of which does not exceed 150 pounds.

Good tubes should be safeended as described below.

Safe ends must be scarfed on one end for half an inch, being tapered to 1/32 inch thickness at end of scarfing, and cut square and smooth on opposite end by the manufacturer.

Tubes to be safe ended must be flared for scarfed end of safe end one half inch in length and opened up an amount equal to the thickness of the tube.

Safe end should then be placed in the end of the tube and both be heated to a white heat, drawn out quickly and welded on a flue welding machine, care being taken to see that the weld is smoothly made.

Small boiler tubes should be safe ended as follows:

First Safe Ending—Apply 5-inch safe end.

Second Safe Ending—Cut off old safe end and apply 8-inch safe end.

Third Safe Ending—Cut off old safe end and apply 12-inch safe end.

Fourth Safe Ending—Apply 5-inch safe end to the end of the 12-inch tube safe end previously applied.

Superheater boiler tubes should be safe ended as follows:

First Safe Ending—Apply a safe end at firebox end of no greater length than necessary (about 4 inches).

Second Safe Ending—Apply another safe end of no greater length than necessary (about 4 inches) at the back of the one previously applied.

Third Safe Ending—Cut off the two safe ends previously applied at the firebox end and apply safe end of proper length at smokebox end.

Fourth Safe Ending—Apply a safe end at firebox end of no greater length than necessary (about 4 inches).

Fifth Safe Ending—Apply another safe end of no greater length than necessary (about 4 inches) at the back of the one previously applied.

All tubes after being safe ended and swedged must be subjected to an internal hydrostatic pressure of 100 pounds per square inch before being placed in boiler. Any tubes which show leaks must be properly repaired before applying.

When tubes are sent to main shops from outlying points for repairs, they must be inspected, safe ended and tested as described above.

Tubes which are scrapped from any set must be replaced with tubes of approximately the same condition as balance of set and the same number of tubes returned as were received.

In such cases where it is necessary to scrap 50 per cent or more of the tubes of any set, a full set of new tubes is to be furnished in return, and the remaining good tubes held in stock to fill out other incomplete sets of tubes of approximately the same condition.

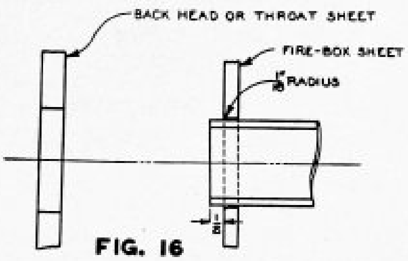


FIG. 16

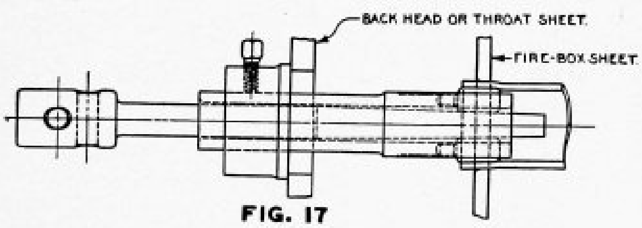


FIG. 17

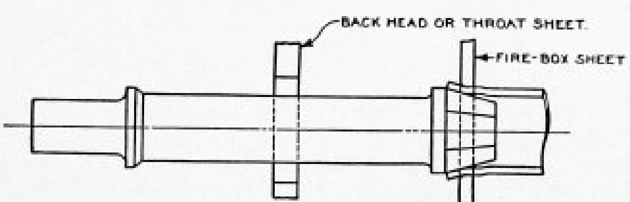


FIG. 18

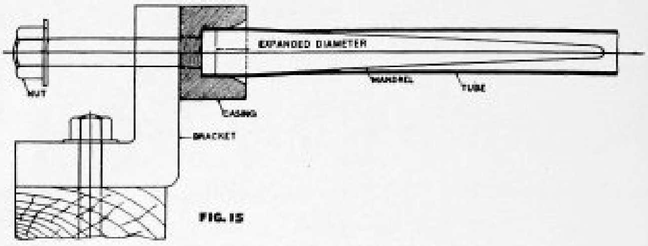
Method of setting arch tubes

Figs. 16 to 18 inclusive, show the operations to be performed in setting the arch tubes and the order in which the work must be performed.

Fig. 16 shows the arch tube in place ready for setting. The tube should extend through the sheet 1/2 inch as shown.

Fig. 17 shows the arch tube after being rolled, and the roller in place.

Fig. 18 shows the arch tube after being belled, and the belling tool in place.



Method of expanding front ends of tubes

Ordering of Arch Tubes—Arch tubes should be ordered in accordance with drawing for the class for which they are intended. Requisitions should show outside diameter, length, gage and material.

All tools and gages used must conform to standard drawings and must be kept in proper condition for the work for which they are intended.

Preparation of Sheets for Arch Tube Application—Sheets must be properly straightened, holes for arch tubes must be a true circle, and drilled 1/32 inch larger than the outside diameter of arch tube, outside edge of holes to be chamfered to a radius of 1/16 inch.

When the arch tube hole has become enlarged above normal size, it must be carefully measured so that the tube can be heated and enlarged with a mandrel pin to the required size before being applied. The use of shims of any kind whatever around the arch tube in the sheet is strictly prohibited.

Preparation of Arch Tubes for Setting—Arch tubes must be properly cut and formed in accordance with drawings for the class for which they are intended and thoroughly annealed at the large shops before being furnished for application to roundhouse points. All rust, scale and burrs must be removed from ends of tubes before application.

Method of Setting Arch Tubes—Figs. 16 to 18 illustrate the method of setting arch tubes.

Arch tubes which develop any defect whatever while being applied must be removed and replaced by new ones. The calking, welding, or safe-ending of arch tubes is strictly prohibited.

Inspection—Arch tubes must be inspected at every opportunity and must be removed at the first indication of any defect either in the tube itself or in its connections to the sheet.

The foreman in charge will personally inspect both ends of every arch tube applied and report each individual case to the shop superintendent or master mechanic, stating that the work has been correctly done.

General master mechanics and shop superintendents will make monthly report to mechanical superintendent, with copy to general boiler inspector of arch tubes removed, giving engine numbers, location of the engine, number of arch tubes removed and reasons for removal.

The proper application of tubes is extremely important, both as regards material and workmanship. Master mechanics, shop superintendents and those performing this work must keep in close touch with tube conditions at all times and see that they are in good condition, properly applied and maintained.

Consideration should be given when ordering boiler tubes, so that if practicable new tubes may be applied to long tube boilers, and the tubes that are removed, if condition permits, be applied to a boiler requiring a shorter tube, thus reducing the number of welds necessary in past practice. Good judgment, however, should be exercised in this, so that undue use of new tubes may be avoided.

Master Boiler Makers Prepare Reports for Next Year's Convention

In view of the current depression, the annual convention of the Master Boiler Makers Association, originally scheduled for this year, has been postponed until 1932. Rather than pass a year without activity, the standing committees have prepared their various reports which will appear from time to time in The Boiler Maker. In this issue the president's address and three reports dealing with "Fusion Welding as Applied to Pressure Vessels," "Clearance Between Flues and Tube-Sheet Flange" and "Cast-Steel or Cast-Iron Grate Bars" appear.

At a meeting of the executive board of the Master Boiler Makers Association, held in Chicago on January 10, 1931, it was decided not to hold the 1931 convention. Financial stress and the serious business conditions prevailing on railroads throughout the country, have for obvious reasons, made it desirable to cancel all mechanical conventions which were to be held in 1931. It is expected, however, that the Association will convene in 1932.

Through the courtesy of the executive board of the Master Boiler Makers Association, The Boiler Maker is exceptionally fortunate in being able to publish the reports of the various committees prior to their delivery on the convention floor in 1932. Because of this fact, members of the association should be able to prepare well thought out discussions of the various problems brought up in these reports. With ample opportunity to discuss reports and special papers which will be published from time to time during the coming months, there is little doubt but what the members will guarantee an active and successful convention in 1932.

At the present time it is anticipated that the twenty-second annual convention will be held at the Hotel Sherman, Chicago, at a date to be announced later in a special notice. Following is a statement by Kearn E. Fogerty, president of the association:

As president of your association during what is probably the most critical period in its history, it is my duty to outline the steps being taken by your officers to insure the continuance of its progress and prosperity. Further, I wish to point out the absolute necessity of both practical and moral support from every member of the organization, and this support is of vitally greater importance than anything else; for without a united membership the tasks of the officers will be hopeless.

There is little point in reviewing the disastrous business conditions with which you are all too familiar and which have brought on the present depression. There are, however, signs of early improvement at this time; railroad relief, settlement of international financial relations, and good crops predicted for the 1931 harvest will all have a bearing on our recovery. In connection with the crop situation, L. M. Betts of the American Railway Association recently stated that the southwestern roads will be called upon to supply cars for what is almost certain to be the largest winter wheat crop on record in that territory. With the movement of over 3,500,000 bushels which is forecast for this area into two widely separated storage centers, the demands on motive power will be very great. Surplus power has been reduced to a minimum in the past year, and every prediction is that shops will have to resume operations on a large scale in order to meet the demand. The necessity for moving all other crops, which will undoubtedly be large, will increase the demand for power in other sections of the country.

The most reliable statistical organizations upon whose records and analyses industry in general bases the trend of business, predict that the bottom of the depression has been reached, and that by the summer of 1932 the level of business will again have reached normal. There would seem, therefore, to be sufficient signs of relief for the near future to insure a marked improvement on the railroads. These statements are made, not with the idea of clouding over a situation that has adversely affected every member of the association as well as every man under him, but to express my belief in the ultimate soundness of the system under which we live and in the future of the railroads.

The welfare of the association is absolutely dependent upon the state of prosperity of the railroads, which has been amply demonstrated this year. Plans for the Master Boiler Makers' Association convention, together with those of other railroad associations are being made for the Spring of 1932. There is little doubt but that these conventions will be held.

In order to avoid any lapse in the work of the association, the officers have undertaken the issuing of committee reports prepared for the 1931 convention to all members. The committees have proceeded with these reports as carefully and thoroughly as would have been the case if the convention had not been postponed. By thus giving members an opportunity to study the reports over a period of months, it is our hope that when the convention takes place next Spring valuable additions to them will be made in the form of carefully prepared written discussions. If our conventions in the past have lacked in anything, it is in the failure of many members to contribute their knowledge and experience to the fund of information brought out in the discussions. This year ample opportunity is being given everyone to prepare carefully for the 1932 meeting. It is to be hoped full advantage will be taken of this to show the mechanical officers of the railroads, that above all the Master Boiler Makers' Association is striving to produce something of value to the industry in return for their support.

Signs are not lacking that the job of the master boiler maker in the future will be to maintain power greatly different in type than that of today. Locomotive design undoubtedly is in process of evolution. Isolated examples of such developments are familiar to many members in the form of locomotives with watertube fireboxes; locomotives built for higher pressures utilizing alloy steels; and now multi-pressure locomotives are in operation on at least two of the railroads in this country and Canada.

The first experimental locomotive of this type has recently been completed by the Canadian Pacific Railroad at the Angus shops in Montreal. The American Locomotive Company has still more recently completed the construction of a similar type for the New York Central Railroad. A few general details of this design will serve to indicate what may be expected in the boiler shop of the near future.

This experimental locomotive is the first of this type locomotive on this Continent and the most powerful of its kind in the world. The boiler design represents a radical departure from the present type and because of the high steam pressures used, economies in fuel are gained without adding to the cost of boiler maintenance. The Canadian Pacific locomotive will have a 2-10-4 wheel arrangement. Superheated steam will be delivered to two low-pressure cylinders located outside the frames at 250 pounds per square inch while high-pressure cylinders situated between the frames will utilize superheated steam at 850 pounds per square inch. The tractive effort of the locomotive is 90,000 pounds.

The low-pressure boiler of the conventional firetube type located ahead of the firebox is constructed of nickel steel plates. This section has a working pressure of 250 pounds per square inch. The high-pressure boiler is a seamless forged nickel steel drum located centrally above the entire length of the firebox. This section is designed for a working pressure of 850 pounds per square inch. The firebox unit is made up of six small-diameter forged nickel steel drums designed for 1700 pounds per square inch pressure with an average working pressure, however, of about 1350 pounds. This closed circuit forming the firebox unit extends into the boiler drum in the form of a number of heat transfer coils.

In Europe at the present time there are three locomotives of this type which show a saving in fuel ranging from 25 to 35 percent in comparison with locomotives of conventional design. The largest of the European locomotives is only 42 percent of the weight and develops only 36 percent of the power of the Canadian Pacific locomotive.

When this statement is issued the details of these locomotives will probably have been published in the technical and trade press devoted to the railway field, but I wish to call special attention to the possibilities which face those who have the maintenance of the motive power of the country in charge. Radical developments are not put into effect over night, but the trend is certainly in the direction of designs that will increase economy of operation.

Since the very life of the railroads of the country depends on meeting the competition of other means of transportation, efficiency and economy must be the basis upon which they will operate in future. This necessarily means that our jobs as a part of the railroad organizations depend on our ability to solve the maintenance problems on whatever type boilers may have developed. Fortunately, since changes come comparatively slowly, there is time to prepare ourselves to handle new types of power.

Even more rapid than the change in types will be the wider application of new materials—alloy steels and the like—to conventional designs, allowing greater pressures, longer life of parts, and economies both in operation and maintenance. We must fit ourselves to handle such materials, first of all by becoming familiar with their characteristics, methods of working them, and the tools that must be used. A study of modern high-speed steel tools becomes essential in this connection, and one of the committee reports this year deals with high-speed steel taps.

The use to be made of fusion welding in boilers of the future opens up another wide range of possibility deserving very careful attention. The two papers which appear in the proceedings of this year—one on oxy-acetylene welding by Frank C. Hasse, secretary of the Boiler Makers Supply Men's Association, and also connected with the Oxweld Railroad Service Company, and the other on electric arc welding by J. C. Lincoln, president of the Lincoln Electric Company, Cleveland, O., point out recent developments in this art and deserve careful study by every member. We greatly appreciate the opportunity to include these excellent papers in our 1931 report.

Just what actually will develop in the next few years in this art of boiler making cannot be predicted. There is only one sure way in which we as individuals and as an association can maintain our position as an important factor in the developments, and that is by using every means in our power to keep pace with progress. The association activities entered into by every member whole heartedly and individual study of the trade will do much to insure our future.

In another direction the present year has shown that changes in organization are sometimes necessary, namely, in the case of our good friends the Boiler Makers Supply Men's Association, without whose co-operation and support, the success and value of the conventions in past years would have been extremely limited. In the interests of economy and efficiency the supply associations serving the various railroad departments, each of which is organized separately, have found it necessary to arrange their exhibits so that they will not be called upon to move them between widely separated points, and over a considerable period of time. Probably in the future, conventions of all smaller associations will be held at the same place within a period of a few weeks in order that the supply companies may be relieved from the difficulty stated. It is to the advantage of our association to co-operate with the supply men to the fullest possible extent and, by conforming to the centralized exhibit plan, to make their task easier. They may be assured of the fullest support of our association and of our sincere appreciation of their efforts on our behalf in the past.

A word also in appreciation of the support given our work by publications devoted to the railway field—particularly THE BOILER MAKER, which has co-operated in many ways with the officers of the association. In return for their efforts, both in supporting us through their pages and in more direct ways, I am going to appeal to our members as individuals to assist this magazine in every way possible in their shops. There is a real necessity in any field for a medium which reaches every branch of an industry—from the highest officials to the men in the shops. In our field, THE BOILER MAKER is the only medium accomplishing this. If we are to keep pace with progress, and if we are to have some means, other than the association, for exchanging knowledge and experience, it is essential to support this one magazine working with us. I sincerely trust that all our members and those supply companies serving this field of railroad boiler making will supply this support.

In closing I wish to thank the officers of the association who are doing their utmost to minimize the effect of the trying conditions of the past year on the welfare of the association. One other group which has our thanks for its hearty co-operation is that of the Water Service Engineers, who have for many years worked closely with us as individuals and as an association in attempting to solve the greatest source of our maintenance difficulties, namely, pitting and corrosion. Many of them have contributed written discussions to the 1931 report on boiler corrosion.

With a constructive spirit of co-operation among all those contributing to the success of our conventions, the ultimate progress of the Master Boiler Makers' Association will never be in question.

Cast-Steel or Cast-Iron Grate Bars

Our investigation regarding the use of cast iron and cast-steel grates on the locomotives of the United States, Canada and Mexico embracing a canvass of 73 percent of equipment involved, discloses that cast-steel grates are used on a very small percentage of the locomotives, these being 6 percent or a total of 4100 locomotives.

These cast-steel grates are of various types—rosebud, finger and slotted table design, the former being in the majority, there are about 1600 locomotives at the present time equipped with rosebud type cast-steel grates.

By far the larger majority of locomotives at present have cast-iron grates, a total of 84 percent using this type. The design is the finger, rosebud and table. A total of 56,000 locomotives use cast-iron grates with the rosebud type in the majority.

The balance of locomotives involved are either oil burning or equipped with some special patented design grate, about which your committee has not obtained any information.

Regarding costs of application, as weights of the complete installations on the different size locomotives vary, a direct comparison hardly can be made. The cost per pound for cast-iron grates ranges from 3 to 5½ cents, whereas the lowest price for cast-steel grates is 8 cents per pound. No reliable figures are available regarding maintenance cost between shopping.

On the largest system using cast-steel grates, considerable difference of opinion still exists among the mechanical officers as to whether steel is cheaper in the long run than iron. It is not possible at this time to give any comparative figures of value on the use of these two materials.

On another road where cast-steel grates were applied in 1922 and the use thereof gradually extended, the original installation was primarily made because of the saving made in weight. Their experience has not been entirely satisfactory, as it is necessary to renew these grates more frequently than grates of cast iron. Trouble is experienced with the cast-steel grates being distorted and sagged at the center.

Taking into consideration the difference in weight, cast-steel grates cost considerable more than cast iron.

On another large road using cast-steel grates, they report this use to be successful. The steel must have heat-resisting qualities, otherwise the grates will burn out when there is fire in the pan. This road is seriously considering a special high-grade cast iron. They cannot estimate the life of the cast-steel grates. Occasionally they burn out, sometimes they break off, and a review of the situation with the master mechanics on that road indicates a preference for cast iron as compared with cast steel.

Summing up the situation, a very small percentage of locomotives are using cast-steel grates and even where used, considerable difference of opinion exists regarding their economy as compared to cast-iron grates.

This report was prepared by a committee composed of W. R. Hedeman, chairman, R. A. Pearson, and T. J. McKerihan.

Laying Out Miters on Angle Irons

By George Gardner

To make a square or rectangular angle-iron frame marking all miters and the butts before bending, the following is a simple method: Fig. 1 represents a plan of the proposed frame. In laying out begin from the

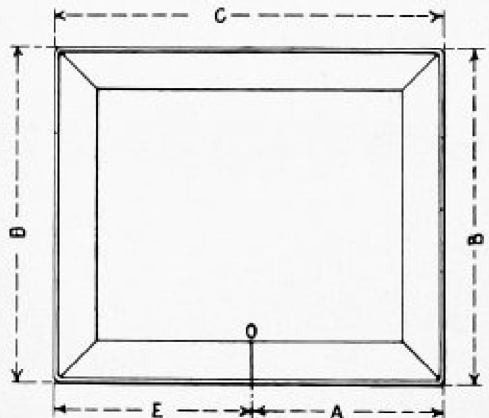


Fig. 1

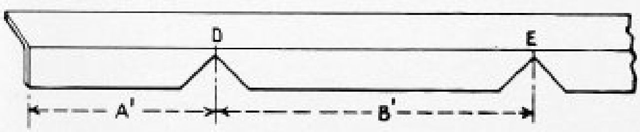


Fig. 2

Method of making a square angle-iron frame

butt *O*, making the first measurement *A'* on the angle bar, Fig. 2, equal to *A* in the plan less one times the thickness of the angle. This will give the position *D* of the first miter. From this point on the angle make the distance *B'* equal to the distance *B* on the plan less *twice* the thickness of the bar. This will give the position of the second miter. Continue in this way deducting twice the thickness for *C* and *D* and only once the thickness from the measurement *E* which gives the location of the other butt. The miters and the butts can all be cut in this manner before bending.

The Reading Iron Company, Reading, Pa., has consolidated its general executive and general sales offices in Philadelphia, Pa. These offices will occupy the tenth floor of the Terminal Commerce Building, 401 North Broad street.

Fig. 1—C. B. & Q. welded tie-treating retort

Fusion Welding . . . as Applied to Pressure Vessels*

During the past decade much has been said of welding in reports presented by special committees before the Master Boiler Makers' Association at the various conventions. It is well known that the uses of the fusion welding processes have improved along with the line of electric welding rods and electrodes, welders and welding equipment. Many readers can remember when fusion welding was at first used only for repairing metal parts, which had become defective from expansion and contraction strains or stresses. Today, however, fusion welding has become one of the most valuable assets to most of the master boilermakers in the shops. In fact, the fusion welding processes have become one of the most valuable assets to the metal trade industry. These processes are now not only used for making repairs, but also for the manufacturing of products from their beginning. In the past few years, under certain operating conditions, riveted seams were found not to be the most desirable, due to the fact that fusion welding has brought new features. One of these features is the possibility of designing seams that have less tendency to develop leaks, thus overcoming one of the main causes for high maintenance costs.

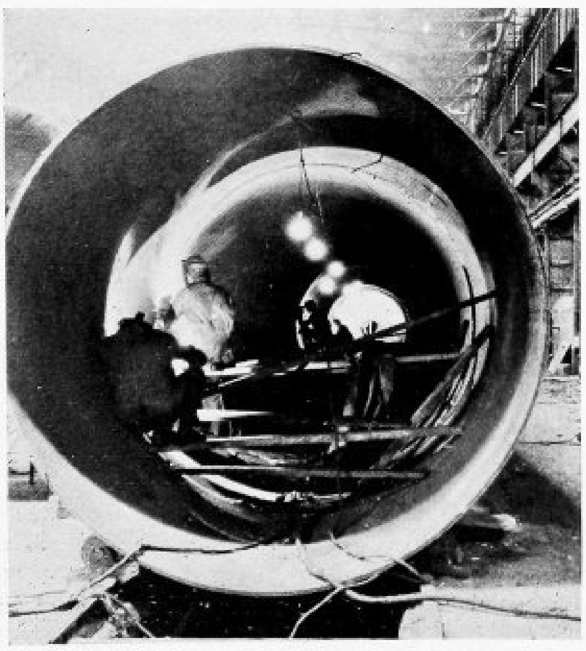


Fig. 2—Welding the inside of a retort

In some of the designs of vessels now being constructed, it is found that the welded vessel will cost more than the riveted vessel; but due to the maintenance cost being lower, the ultimate costs of both new construction and maintenance the welded vessel is found to be superior. In other words, the maintenance costs will be far less, consequently this will offset the higher construction figures in due time.

The Chicago, Burlington & Quincy Railroad recently decided that due to the excessive cost of maintaining riveted seams on their tie-treating retorts, they would spend additional money on the initial construction and minimize or eliminate the maintenance charges which they had previously encountered. Their engineers developed plans for a welded construction which would give a smoother bore to the treating cylinder. They also decided that a larger cylinder would enable them to load more ties on each car or tram and reduce the handling of the trams which enter into the cylinders.

* Committee report prepared for the twenty-second convention of the Master Boiler Makers' Association to be held in 1932 at Chicago, Ill.

The older type cylinders, which were 74 inches in diameter, are now being replaced with steel cylinders 98 inches in diameter with a shell of 1-inch material and 132 feet in length. Each of these vessels, upon completion, received a hydrostatic pressure of 355 pounds per square inch. They are now located at the Burlington tie-treating plant at Galesburg, Ill., and are used for impregnating creosote and other chemicals into railroad ties.

Your chairman visited Galesburg and inspected these cylinders before they were placed in service and was advised that these retorts will carry 175 pounds working pressure and are heated with steam to a temperature of 250 degrees F. Therefore, you can readily see that the hydrostatic test placed on these vessels was slightly more than double the working pressure.

At the time of my inspection all welded seams appeared to be very uniform and there was no evidence of calking on the welds as far as I could detect. I might add that from the appearance of all the materials, these vessels had not been heat-treated or annealed after the electric fusion welding had been completed. The illustrations will give an idea as to the assembly of these treating retorts.

There are 1-inch holes in each section about 18 inches apart. These are used to hold each course in its proper position prior to welding. After they are securely bolted in place, the fusion-welding procedure was performed using multiple operators, as is shown in Fig. 1. After all of the external seams were completely welded, the interior seams were also welded in a duplicate manner using the multiple operators which are placed in a like manner on the interior of cylinder, as shown in Fig. 2.

Upon the completion of all seams on the interior, a tramway, to support the trams that carry the railroad ties was applied. These tramways are also welded to the interior of cylinder. There were 314 holes adjacent to the seams in the entire assembly. These were used for the bolts during fabrication; and to hold each of these courses in line while the fusion welding was being performed. Fig. 3 shows a close-up view of the dome construction; each seam, you will note, is lap welded and the pipe flange on top of the dome is also welded to the dome cap. All base brackets or supports were applied to the outer shell. Therefore, it was necessary to have these vessels perfectly straight upon the completion of all welding operations and when placed on their foundations they are permitted to expand freely. Fig. 4 shows the second of two vessels constructed in this way which are to be used at the Galesburg tie-treating plant. This view will give an approximate idea of the length and side view of the vessel before being unloaded from the car.

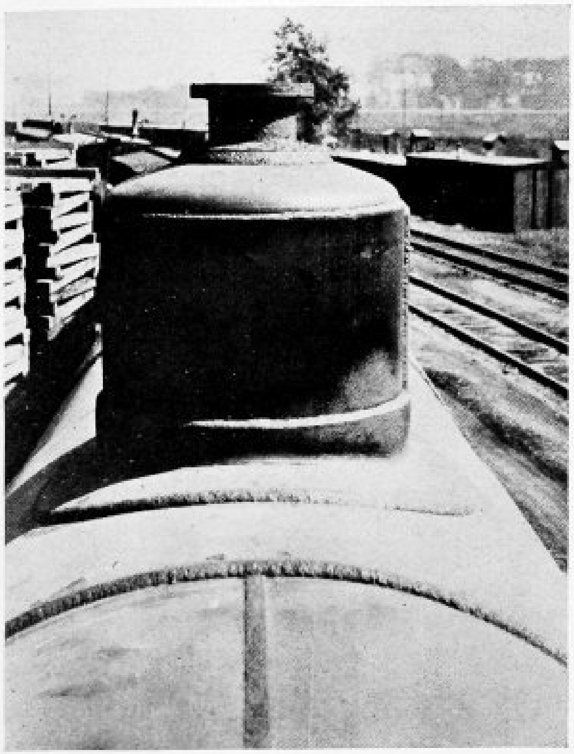


Fig. 3.—Close-up of dome construction

The details of the horizontal seams and circumferential seams are shown in Fig. 5, section *A* and *B*. Detail of the point where the door ring is welded to the outer shell is shown in Fig. 6.

Your chairman was advised that all the fusion welding operations were performed with 3/16-inch electrodes, 5485 pounds of welding electrodes being used. The time consumed for welding this vessel was 2628 hours. Your committee has dwelt entirely upon information on hand and has described the fabrication of two tie-treating retorts used by the Burlington Railroad.

Similar constructions, using oxy-acetylene welding instead of electric arc welding, are in existence. In these examples the circumferential seams are butt welded and are double beveled on both sides of the plate. Two operators are assigned to the welding on opposite sides of the plate at the same time. This type of welded construction has also been found to be superior for rotary kilns. Fig. 7 shows the general design of one of these kilns which was placed in service some six years ago for comparison with two kilns of riveted construction.

I am quoting, for your general information, the following statements taken from *Oxy-Acetylene Tips* for August, 1930, page 13:

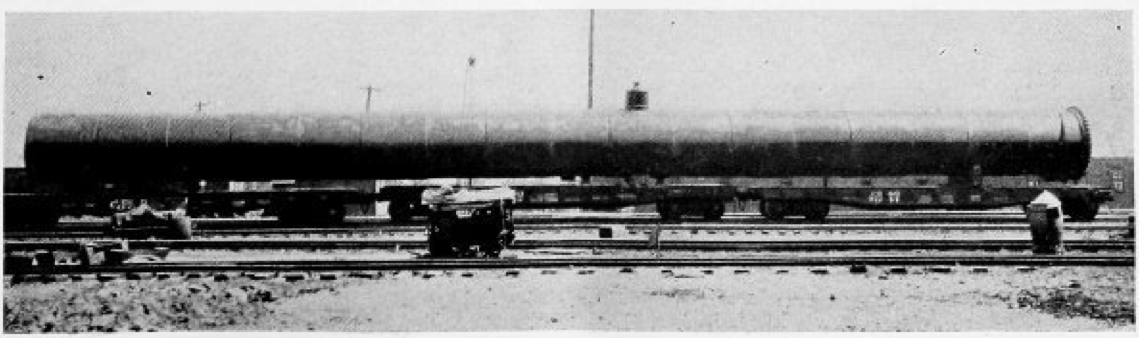


Fig. 4.—Welded tie-treating retort to be used at Galesburg plant

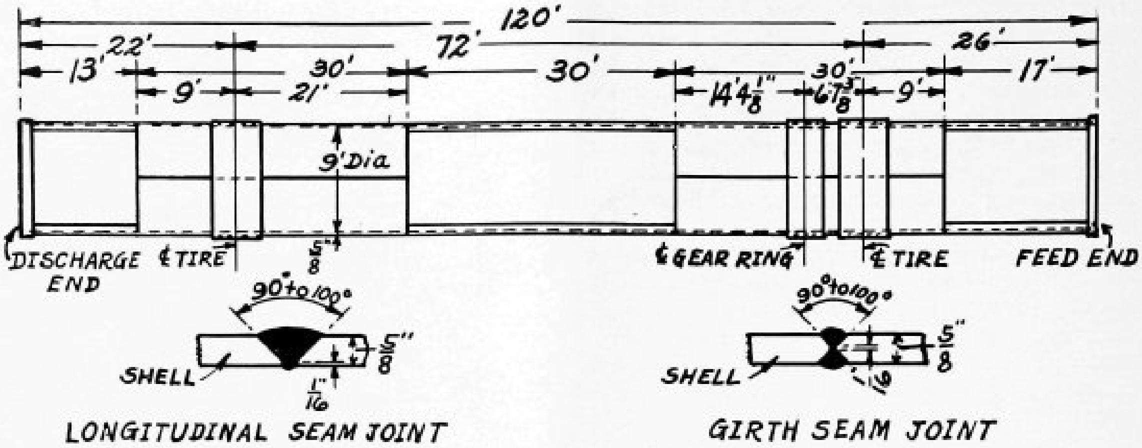


Fig. 7.—Welded construction for rotary kiln

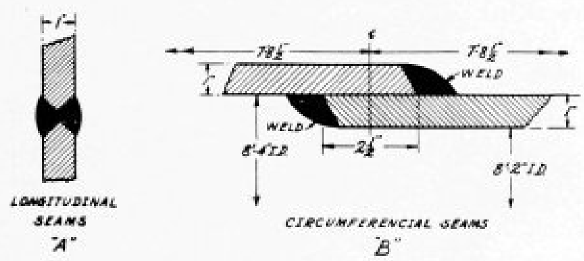


Fig. 5.—Details of welded seams

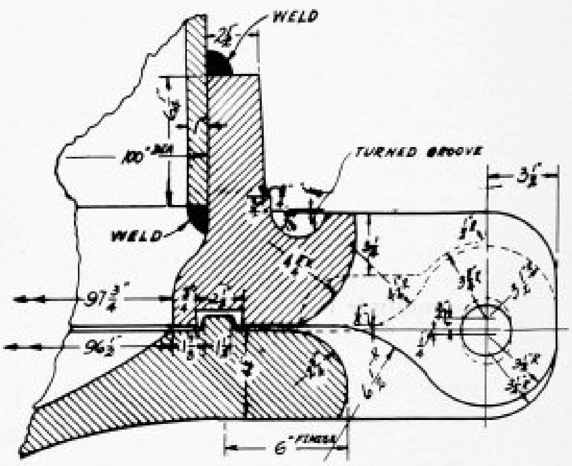


Fig. 6.—Detail of door-ring connection

"After these kilns had been in operation for about three years, a series of careful checks were made to determine, by means of strain-gage measurements, the exact stresses that existed in various parts of the kilns under various conditions of loads. Detailed results of these sketches were given in *Oxy-Acetylene Tips* June, 1926, page 197. These tests show that while the maximum stress in the kiln shell was only 4700 pounds per square inch, under the worst possible conditions of loading, measurements made across the triple-riveted butt joints in the riveted kiln showed movement of two to two and one-third times the amount existing in plates alongside.

"In the welded kilns there were no such points of excessive movement, and the welded kiln has remained more concentric and straighter than the riveted kilns throughout six years of successful operation.

"During the latter part of 1929, bids were issued by the same customer for two additional kilns 9 feet in diameter and 120 feet in length, with 5/8-inch wall thickness. Alternate bids were requested for welded and riveted construction. Due to the increased experience in the fabricating shops in handling of oxy-acetylene welding equipment of large size, the bids received for welded construction compared very favorably with that of rivet construction and the contract for both kilns was consequently let to the welding contractor."

At this writing the chairman of your committee is not very familiar with locomotive tank cisterns which have been constructed by fusion welding all seams. Therefore, he is not in a position to state what benefits are derived from this type of construction. However, your chairman has had some experience along the lines of welding of some seams on oil and water tanks which are assigned to similar purposes, and in many instances has found that the welded structure costs less than the original design of riveted tank.

The report was prepared by a committee composed of H. H. Service, chairman, H. E. May, L. M. Stewart, J. P. McGowan and W. H. Laughridge.

Clearance Between Flues and Tube-Sheet Flange*

In reading the subject of this report, the thought of flue sheet failures immediately comes to mind, and in collecting data on this subject we have found lots of food for thought.

At the present time it is not practical to set a standard dimension for the distance from the outside of the flange to the edge of the tube hole, because on the different railroads the sheets are not the same thickness, neither is the same radius used on all the railroads. On some of the railroads there is a difference in thickness of the front and back tube sheets. Some railroads butt weld the back flue sheets to the firebox, and one railroad uses the straight sheet without a flange. The American Society of Mechanical Engineers has no rule to cover this subject. This means that the subject is still a matter of experiment until something successful can be found.

The designer in the past has endeavored to give some clearance between the edge of the tube hole and the root of the radius, and still obtain all the heating surface pos-

* Master Boiler Makers' Association report.

sible. Therefore, it is the opinion that this particular feature has been sacrificed to some extent for heating surface. Good design today appears to tend toward liberal spacing of the tubes away from the rigid flanged edges of sheets, and best results are being obtained from the large radius and more clearance between root of flange radius and edge of tube holes.

The boiler designer and the boiler maker are confronted with many perplexing and difficult questions, affecting the various parts of the boiler, which they must solve. It would be ideal if the conditions which give rise to the problems could be altered once and for all, but due to the many kinds of water and fuel, some of which is unsuitable and frequently objectionable for boiler purposes, they are at once faced with breaking-down factors, bringing about corroded, cracked and leaking staybolts, sheets and tubes.

To overcome these harmful and injurious effects would be to provide good fuel and good water. If excessive or too rapid expansion or contraction is allowed, the whole fabric of the boiler is very severely strained and it can be only a matter of time before some part must give way. The practical way to avoid excessive expansion and contraction and keep the temperature of the boiler parts within reasonable limits is to provide hot water for washing out, allowing a reasonable time for cooling.

In attempting to analyze the contributing factors entering into the failure of flue sheets, it must be realized that this is a condition that exists quite generally on all railroads, particularly when flue holes are placed too close to the knuckle of flange. These occurrences are not so pronounced in good water territories where leakage seldom exists and where the re-expanding of flues is seldom necessary. The additional causes must be looked for in service conditions.

That difference exists in the directional expansion of the flue is apparent. The natural expansion of the flue is outward, increasing itself uniformly in diameter unless it is checked and forced in other directions. The expansion that takes place in the flue sheet is not such that each flue hole maintains a true diameter; the examination of an old flue sheet bears this out. In a great many instances it will be found that the expansion has been upward, causing the flue sheet to buckle at the top of the flange. Again, it will be found to exert itself in the center of the sheet, causing the sheet to bulge or warp; and at other times this expansion will be found working towards the center of the sheet, closing in flue holes and leaving them in an oblong shape. The internal or lock strains which have caused the distortion of the sheet have been of sufficient strength to stretch the metal in the flue sheet.

Admitting that certain strains are set up in the flue sheet during its application, the flue sheet has a tendency to relieve itself when heated and expansion takes place. Conceding that the expansion of flues is not in harmony with that of the flue sheet, it then follows that opposing strains which work against each other are set up. The flue sheet, being the heavier body and consequently having a greater expansive force, draws the flue with it regardless of the direction the flue may expand.

The chief contributing causes of the cracking of flue sheets may be summed up as follows: Unsuitable water, scaly conditions, repeated and alternate stress, the distortion of flue and sheet while engine is in service, sudden expansion and contraction, frequency of flue expanding, improper spacing of flue holes from flue sheet flange and the narrow bridges preventing sufficient water space and preventing circulation.

That a definite remedy exists, which is within our means for the prevention of all flue sheet crackage, is doubtful. However, there are a number of contributing causes over which we have control and it is felt that flue sheet crackage can be lessened greatly by exercising greater care in the flue hole layout, exercising greater care in flue sheet application, exercising greater care in the application of flues, keeping boiler free of scale, washing boilers with hot water, keeping the temperature of the boiler parts within reasonable limits and avoiding rapid contraction and expansion.

It must be understood that all of the credit for satisfactory flue sheet performance cannot be given to the flue hole layout. In this connection most railroads have established the practice of having the flue beads welded, together with the installation of a large number of water treating and hot water washout plants, the inauguration of long engine mileage, less frequency of blowing down engines, greater care exercised with steam blower on cinder pit when knocking fires, preventing the use of injector on cinder pit immediately after fire is withdrawn and boilers washed on a schedule based on mileage. All of these practices help considerably in preventing flue leakage, lessening flue expanding and beading, thereby increasing the life of the flue sheet.

After giving careful consideration to every feature connected with this subject your committee recommends a minimum of 1 inch between the outside edge of the flue and tube hole to the root of the flange in tube sheet with 1½ inches inside radius of flange.

For example, with a 1½-inch radius and a 1-inch clearance to the edge of the tube hole the distance from the inside of the flue sheet flange to the edge of the hole will be 2½ inches.

This report was prepared by a committee composed of L. E. Hart, chairman, A. W. Novak and James Doran.

Welding Equipment to Be Seen at Boston Show

At the National Metal Congress Exhibition, to be held September 21 to 25 at Boston, Mass., the Lincoln Arc Welding Company, Cleveland, will have on exhibition a number of new articles of equipment for electric arc welding. A special wire-feeding device for use with the electronic tornado process of automatic welding will be displayed. The electronic tornado welding head, which, with a magnetic field, focuses the stream of a carbon arc along the line of fusion, is now equipped with both the wire and autogenizer feeding device, the first to deposit additional metal and the second to shield the arc from the harmful effects of the atmosphere. This process will produce welds of extreme ductility and resistance to corrosion and of over 70,000 pounds per square inch tensile strength at the rate of 60 feet an hour on ¼-inch plate.

Oil Burning Locomotives.—The Chicago, Rock Island & Pacific plans the immediate conversion of 231 additional locomotives used on its lines south and west of Kansas City, Mo., from coal burning. Locomotives on the Arkansas-Louisiana and the Oklahoma divisions of the Rock Island were changed from coal to oil burning in 1930 and on the El Paso-Amarillo and Pan-Handle Indian Territory divisions in 1928

Investigation of Seams in Wood Pulp Digesters*

By J. P. Morrison†

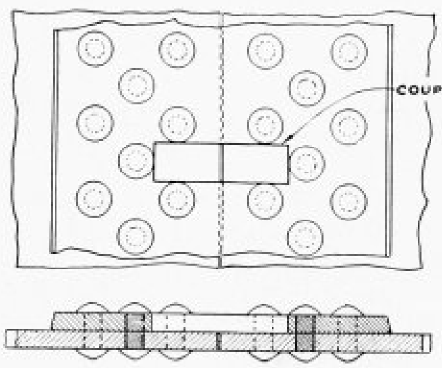
The wood pulp digester explosion at Berlin, N. H., late in 1930, which resulted in the death of two men, the serious injury of five people and a total loss reported to exceed $350,000 emphasized the immense amount of energy (approximately equal to 500 pounds of T.N.T.) stored in such a vessel under usual operating conditions. It also served as a reminder of the fact that in the operation of a digester a thin brick-cement lining of unknown condition and a thin steel plate of unknown condition and material, are the only bars to death and destruction.

Although seams of double butt-strap constructtion, instead of single strap seams, have been used in the fabrication of such vessels built in recent years, a considerable number of old digesters with single-strap seams remain in service. In view of this fact, The Hartford Steam Boiler Inspection and Insurance Company undertook an immediate investigation of a large number of such vessels. It is the purpose of this article to describe briefly the manner in which that investigation was conducted and to point out several interesting conclusions resulting therefrom.

The lining of a digester for the sulphite paper pulp-making process usually consists of two courses of special acid-proof brick with a silicate-cement backing to protect the steel plate from contact with the acid liquor. This brick lining, if intact, serves the purpose of protecting the shell, but if disintegration or cracking permits the liquor to reach the shell, corrosion immediately becomes active. If the break in the lining permits a circulation of liquor along the shell plate, the corrosion may impair the safety of the vessel in a short time.

While serving a most useful purpose in protecting the shell from corrosion, the lining expands as the charge of wood and liquor heats and thus sets up stresses in the shell plate which may be greater than the stress due to the internal steam pressure. These stresses are further complicated by the lack of conformity to a true circle, or the slight out-of-roundness of the shell plate.

After a vessel has exploded, the parts are available for a thorough examination. However, investigation of the material of the unexploded vessel which is under suspicion but which is to be continued in service is found to be satisfactory, involves the removal of a specimen of sufficient size for the determination of its chemical and physical properties, without materially weakening the structure. In determining the procedure for the investigation just completed, the decision to remove two test coupons from each longitudinal joint butt-strap was reached after a consideration of all the items pertinent to the problem. A coupon such as illustrated in Fig. 1 was cut from the butt-strap at a point one-third the length of the strap from each girth seam, and although in theory we would expect the greatest barrelling effect to occur in the longitudinal seam midway between the girth seams, the results of this investigation have justified the plan followed.



BUTT STRAP COUPON

Fig. 1

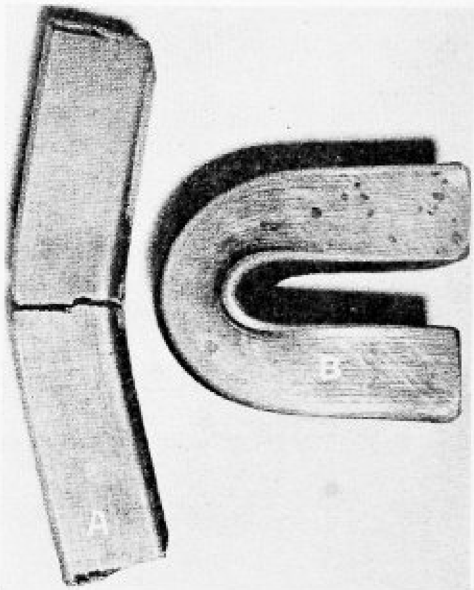


Fig. 2

The size of the specimens was controlled by the spacing of the rivets and they varied from 2½ inches by 7 inches to 1 inch by 4 inches. Of course, in each case the specimen had a thickness equal to the thickness of the butt strap from which it was taken. The coupon was removed by drilling or milling in preference to cutting with a torch as it was considered that the heat resulting from the use of a torch would produce a change in the structure which might affect the physical characteristics of the test piece.

Coupons were planed into rectangular shape with rounded edges for the bend test, or were turned into

* Reprinted from *The Locomotive* published by The Hartford Steam Boiler Inspection and Insurance Company.

† Assistant chief engineer, boiler division, The Hartford Steam Boiler Inspection and Insurance Company.

standard .505-inch diameter tensile test specimens to determine the yield point and ultimate tensile strength.

A comparison of the results of many tests shows that steel plate of flange or firebox quality manufactured a number of years ago may be judged as dependable or otherwise by the bend test and, with the exception of such other tests as were needed to check the results, the bend test was relied upon unless the coupon and butt-strap from which the coupon was removed were corroded to such an extent that the removal of the strap

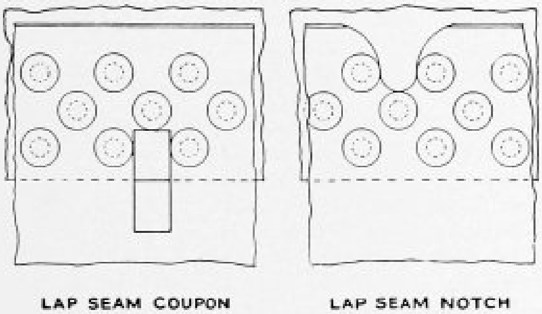


Fig. 3

was necessary regardless of its physical and chemical properties.

Bend tests were conducted at various institutions where proper equipment was available. A coupon was placed with its inside face upon a V-block or similar device and, by means of a mandrel having a diameter equal to the thickness of the coupon if 1 inch or less and equal to twice the thickness of the coupon if over 1 inch, pressure was applied to the surface which had formed the outside face of the strap. Thus in bending the coupon the arc of greatest curvature was imposed upon the face which, as the inside surface of the strap, had been subjected to the greatest stress as the result of the eccentric loading, the out-of-roundness, and the decrease in thickness where active corrosion had taken place.

While a bend test of new material of the grade used in digester construction requires that the bend extend through 180 degrees of a circle, it was decided to subject the coupon to a 90 degree bend and discard as unsatisfactory those butt-straps from which coupons failed to stand the test. In special cases where the coupon had not failed before a 90-degree bend was reached, the test was continued to 180 degrees with or without

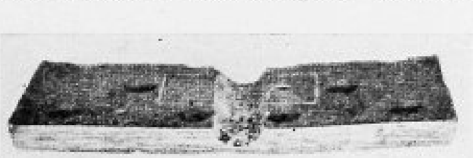


Fig. 4

the mandrel, as judged best to develop the point of special interest in that particular test.

Fig. 2-A illustrates a coupon 1¾ inches wide by 6½ inches long by $1\frac{3}{16}$ inches in thickness, which required an initial stress of 65,000 pounds to produce distortion between 5-inch centers but which snapped short when the bend had reached 15 degrees. Fig. 2-B shows a similar coupon cut from a digester built by the same manufacturer at the same time and possibly of the same grade of material, which did not develop fracture although bent to 180 degrees over a mandrel having a

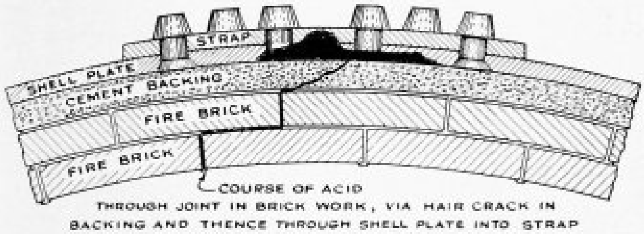


Fig. 5

diameter equal to one half the thickness of the coupon. These two specimens illustrate the great degree of variation represented by the 800 specimens tested. Fig. 2-A was a coupon about normal in carbon but high in phosphorous and sulphur. That condition existed in general in those coupons which failed before a 90-degree bend was reached. The amount of sulphur in one case was .079 percent and the amount of phosphorous in another case was .066 percent with the carbon .075 percent.

Some of the coupons which were bent to 180 degrees without fracture had physical properties well within the requirements for firebox steel but were low in carbon and high in phosphorous as compared to firebox requirements.

The stresses due to the working conditions appeared to have affected the physical properties of the material to the extent of causing brittleness or fatigue corrosion near the outside surface of the coupon, while a .505-inch diameter test specimen cut from the center of the coupon possessed all the physical characteristics considered essential for flange or firebox steel. It cannot be said that this condition exists in every case, for the records we have obtained of the investigation of material which failed when a digester exploded have indicated the reverse condition. That is, the center of the strap was brittle while the material near the surface of the strap was quite ductile. Segregation of the impurities during the steel manufacturing process apparently has a determining influence on this, as tests show that there is a great variation in the chemical properties as well as in the physical properties of coupons cut from the same strap.

Quite similar tests were instituted to determine the condition of the digester joint of lap-seam construction, a design subject to lap joint crack with which the users of pressure vessels have long been familiar and which caused the use of the lap joint to be discontinued in the

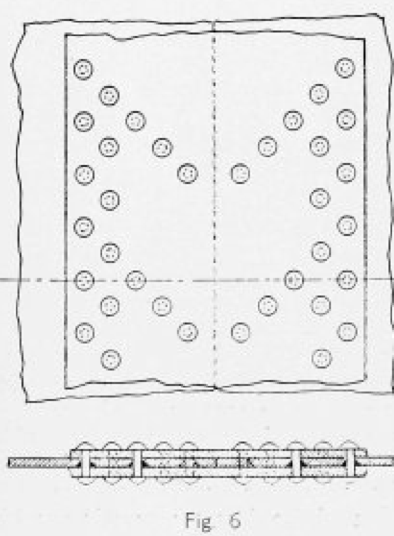


Fig. 6

construction of large high-pressure boilers. The location of the coupon and the manner of notching the caulking lap to permit the examination of the under sheet for possible cracks is illustrated in Fig. 3.

The action of the sulphite liquor upon the steel of which the digester is constructed has been referred to, and of course the break in the lining which permits the acid to reach the shell may occur at any place. However, it appears that it is most likely to take place at or near the longitudinal joint, possibly due to the change in form as the operating temperature and pressure vary. Many of the coupons were so severely weakened by corrosion that the removal of the strap was necessary. Except in special cases no attempt was made to determine the chemical or physical properties of those corroded coupons.

A section of a corroded butt-strap is shown in Fig. 4. The strap was of material $1\frac{3}{16}$ inches in thickness but reduced to $\frac{1}{4}$ inch where a break in the lining had permitted the acid to reach the shell. The shell plate was similarly grooved, and corroded to a less extent over a considerable area as indicated by the sketch in Fig. 5.

Breaks in the linings of several other digesters had permitted the acid to reach the shell and cause such severe corrosion that the linings had to be completely removed in order to permit a thorough examination of the inner surface of the shell plate.

This type of deterioration has been recognized for many years and can be detected by the use of tell-tale holes before serious damage has been done to the shell plate. The tell-tale hole is $\frac{1}{2}$ inch in diameter, drilled through the shell plate on 12-inch centers. Those in the butt-strap should pass through the abutting edges of the shell plate and through both butt-straps where the seam is of double strap construction. The brick-cement lining, if tight, prevents leakage of the liquor, but if the lining is not tight the leakage through the tell-tale holes will not only indicate the presence of a break in the lining but also give a fairly definite idea of its location. A number of digesters have been provided with tell-tale holes on 12-inch centers, while in other cases 24-inch and 36-inch centers have been used. Of course, the 12-inch spacing is preferable, but 24-inch and even 36-inch spacing for tell-tale holes is better than no tell-tale holes at all. However, the slightly greater expense of placing the tell-tale holes on 12-inch centers is more than justified by the increased probability of the early detection of leakage. Those tell-tale holes may be staggered longitudinally to advantage just as rivets are staggered in longitudinal seams.

Soda and sulphate digesters are unlined, for the liquor is presumed to be alkaline and thus non-corrosive. While this investigation was not primarily intended to include digesters of that kind, it led to the discovery of several which had been weakened to a dangerous extent as the result of corrosion at the head flanges or adjacent to forge-welded seams. While the stresses due to the fabrication of the vessel made the material susceptible to the effects of fatigue corrosion, there was also a decided appearance of an acid action.

The repair of the digester having a defective butt-strap presents quite a problem. A lining which has been disturbed to the extent necessary to remove the old outside butt-strap and install new double butt-straps cannot be dependably repaired, as leakage is likely to occur through the new joints. So when one strap is defective, its renewal can be accomplished most satisfactorily only by the removal of the entire lining. This increases the repair expense to an extent justified only by the reconstruction of all the longitudinal seams on the cylindrical section of the digester by using inside and outside butt-straps. The old single-strap in general had but six rows of rivets, three on each side of the abutting edges of the shell plate, and all rivets were in single shear as will be noted from Fig. 1.

The reconstructed seam used more frequently in cases where investigation revealed the necessity for repairs is wider than the old seam and includes two additional rows of rivets on each side of the joint. As there is an inside and an outside butt-strap, rivets are in double shear so that it is possible to use a smaller rivet and thus produce a stronger joint. Use of the wider butt-strap has the additional advantage in each case of placing the additional rivet hole in a sectiton of the shell plate where the metal has not been weakened either by corrosion or by stresses caused by the eccentric loading of the old seam.

Inside heads of the rivets of the old seam are driven into the countersunk holes which seem to have been necessary when sulphite digesters were lined with sheet lead, although the cement backing to the brick lining used in modern practice permits the use of button-head rivets. The strength of the rivets in the two additional rows at each side of the joint is sufficient to carry the normal operating stresses with safety, so in designing the new butt-strap the old rivet holes through the shell plates are disregarded except to the extent necessary to use them to hold the butt-straps and plates firmly together near the center of the joint. The number of those rivet holes used does not exceed 30 percent or 35 percent, as shown in the illustration of the reconstructed joint, Fig. 6.

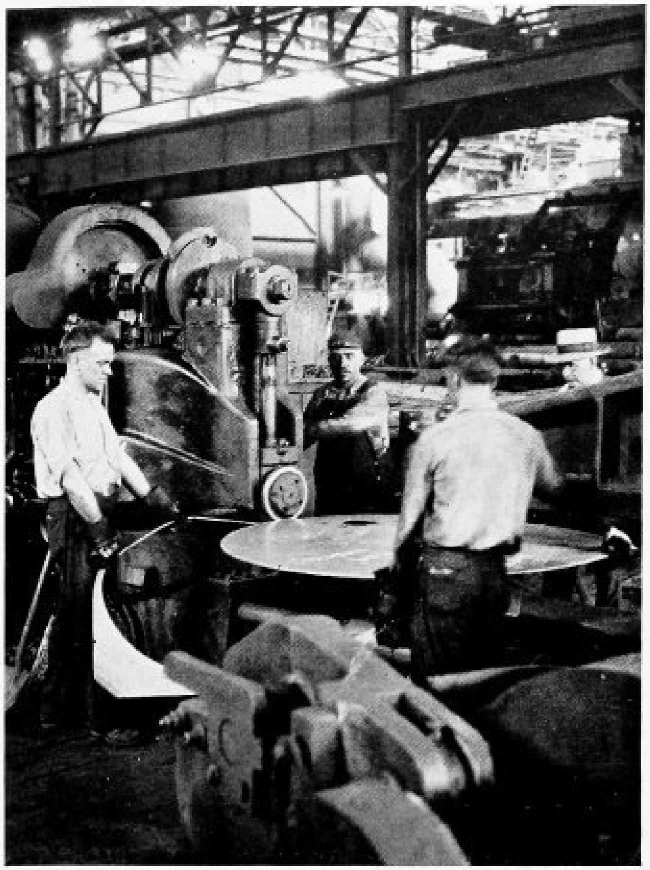
It may be said that one important result of the tests was to emphasize the necessity of using material of flange or firebox quality, properly stamped for identification, and accompanied by a mill test report. Another conclusion established was that the single strap butt-joint as well as the lap seam joint are not dependable when used in the construction of large vessels of plate 1 inch and upward in thickness. In such cases the seam should be of double butt-strap riveted construction or be welded by a process complying with "Hartford Steam Boiler" requirements.

With reference to the groove resulting from corrosion it should be noted that it decreases the strength of the plate in proportion to the amount of metal removed. In fact, a groove having a depth 10 percent of the thickness of the plate or even less affects quite seriously the ability of the material to withstand the bending and shock encountered in operation. The lining of a digester must be tight to prevent the liquor from reaching the shell.

Tell-tale holes, such as described, are necessary to decrease the hazard of digester operation. If the vessel is lined, these holes should extend through the shell plate. If the vessel is unlined the holes should extend from the outer surface into the plate a distance representing the minimum plate thickness permitted when not taking into consideration the seam efficiency. And in all cases, if the holes are to be of any value, attendants must exercise care to see that they do not become obstructed.

L. F. Wilson has been elected president of the Wilson Engineering Corporation, Chicago, a company organized to manufacture, engineer and market the mechanical equipment and devices heretofore handled by the Bird-Archer Company. V. E. McCoy has been appointed treasurer and mechanical engineer of this company.

Quickwork Shear for Cutting Circles in Steel Plate*



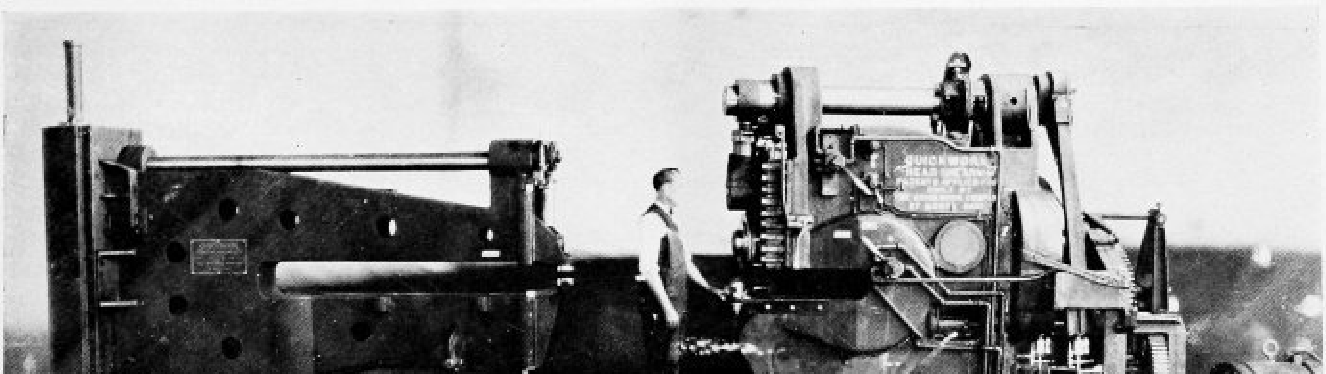
Operating rotary shear at the Lukens plant

The economy of using a Quickwork shear with a center-clamp type of circle-cutting attachment on steel plates up to ⅜-inch in thickness is clearly indicated from results obtained with an installation at the Lukens Steel Company mill in Coatesville, Pa. This machine because of the speeding up of production is showing an annual saving of $12,150 which is a return of 101 percent on the investment. Another important factor, however, is the greatly increased accuracy in shearing circular plates, owing to certain design features of the Quickwork circle-cutting attachment. The machine surveyed has been in operation since 1927; this report outlines the experience with the machine during the three years of service.

The Quickwork shear, manufactured by The Quickwork Company, St. Mary's, Ohio, is powered with a 50-horsepower variable speed direct-current motor and has a center-clamp type of circle-cutting attachment. The operator is stationed near the two cutters and within easy reach of all control levers. The machine is located in the shearing department of the plate mill turning out 112-inch plates. An overhead electric crane and an industrial railway spur track serve the machine. A roller-equipped feeding table is located adjacent to the cutters and other tables are located nearby for stacking the finished plates.

The outstanding feature of the circle-cutting attachment used on this shear is that perfect circles can be

* Survey made by A. C. Nielsen Company, Engineers, Chicago, in collaboration with and approved by J. L. McElhinney, General Superintendent, Lukens Steel Company, Coatesville, Pa.



General view of Quickwork circle-cutting machine cut from square or octagonal-shaped plates at one pass, without punching a hole in the center. This is an important feature because the machine is used largely for the purpose of cutting boiler end sheets.

The steel plate is secured between upper and lower revolvable clamping faces at the front end of the U-shaped clamping attachment. After the plate has been inserted between the cutters and is securely clamped by the pilot wheel at the rear of the circle-cutting attachment, the steel plate is automatically rotated about its clamping center by the action of the cutters. In other words, the cutters not only sever the metal of the plate, but because of friction actually rotate the plate. The outstanding feature of the Quickwork machine is its unusual accuracy; the cut in the plate after a complete revolution ends precisely at the point where it was started.

A patented design feature of the Quickwork circle-cutting attachment is the off-center pivoting of the clamping attachment. The clamping frame is so designed that the clamping faces swing freely in a small arc about a center which is offset laterally with respect to the longitudinal axis of the machine.

The machine is operated for an 11-hour shift each day for an average of 300 days per year. An operator and 3 helpers feed the plates in the machine. The operator adjusts the cutter settings for different thicknesses of plate and handles the actual cutting operation while two of the helpers handle the scrap and see that it is properly sheared for the scrap boxes. The operator changes the adjustment of the cutters with each change in gage size of plates, and also adjusts the circle-cutting attachment for the proper diameters. The operator does not have to lay out the circle, but must watch to see that the cut is started at a point which will permit the circular plate to fall within the area of the rectangular stock. The absence of any necessity for accurate centering of the plates saves considerable time in the operation of the machine. Moreover, the inherent design features of the Quickwork self-centering clamping fixture insure positive accuracy.

The plates received from the 112-inch mill are passed through shears which cut out squares of the proper size to obtain the circle diameters required. The scrap clearance on each edge ranges from 1½ to 3 inches, depending on the diameter of the circle. The plates for circles 50 inches in diameter or over are given a preliminary trimming by another shear located near the Quickwork machine, in order to reduce weight and make them easier to handle. From the standpoint of machine clearance, however, rectangular plates for circles up to 72 inches in diameter could be handled without preliminary trimming.

The shearing speed averages about 40 lineal feet per minute. Owing to the wide variety of sizes and gages handled it is difficult to express production figures in anything but number of pieces produced. It is seldom that more than 300 pieces of a single size are run. On the other hand it is sometimes necessary to make as many as 10 changes an hour in the cutter adjustments due to the preponderance of small-lot runs on a variety of plate thicknesses. For the purpose of computing costs conservatively it is proper to take an average figure of 750 pieces per day of 11 hours.

There have been but two breakdowns in operation during the past three years, both due to sheared pins in the reversing shaft collar. Repairs were made by the mill's shop mechanics in both cases. Beyond this there have been none but a few minor replacements of small parts, all of which, together with lubricants, clamp adjustments and motor work, are covered by an allowance of $50 a year. The operator oils the machine each morning and noon and is held responsible for all minor adjustments. The motors are inspected and oiled on a regular shop schedule. To insure accuracy, the clamping fixture on the circle-cutting attachment is kept in good adjustment and the clamps require tightening every few weeks.

Prior to the installation of the Quickwork machine all plates were cut on another shear of different make. This machine is still in operation and is utilized for handling plates ⅜ inch or over. The design of this older machine is such that there is not as much clearance for scrap behind the cutters. The clamps are mounted on a swinging base but do not have the automatic centering feature found on the Quickwork. On the older unit, the cutter adjustment is made by manipulating two screws with a hand wrench and a third screw must be adjusted when setting up the circle-cutting device for different diameters. Another drawback of the older machine is the necessity for centering the plates accurately by means of a gage before clamping. This is necessary in order to cut a perfect circle. In this respect, the Quickwork machine has a distinct advantage over its predecessor.

The older machine requires the same operating crew as the newer. The principal disadvantage of the old machine was the necessity of roughing-out the plates before they could be sheared. If more than about 3 inches of scrap was handled, there was likely to be trouble. As a result, all of the plates were roughed out nearly circular on another shear before they were set up on the machine for circle cutting.

About 300 pieces of the general run of sizes were handled in an 11-hour shift on the old machine. This estimate is based upon the experience of the management. Also, not less than two hours roughing-out time was required on the part of another crew of men when handling 300 pieces a day.

The Quickworth shear with circle-cutting attachment has speeded up production considerably because of the higher speed of cutting which can logically be expected of a machine having a motor of considerably higher horsepower. More than this, however, it has enabled greater accuracy in cutting circular plates, together with an additional saving in roughing-out time, owing to the improved principle incorporated in the automatic centering feature of the Quickwork circle-cutting attachment.

In arriving at fixed charges, the old machine has been given a life of 30 years, which is very close to its actual life. The new machine has been given an estimated life of 15 years, but it is highly probable that its actual life will exceed this figure considerably, judging from its condition after three years of service. The allowance for repairs and maintenance includes a liberal estimate to cover replacement parts and labor.

In arriving at the daily operating costs it was necessary to determine the cost of roughing-out the plates. This was determined on the basis of a shearing machine cost of $.75 per hour and a labor cost of $2.70 an hour, a total of $3.45 per hour. The power consumption is a relatively small item; this figure is based upon a test of the new machine, but a conservative estimate is used for the old machine.

The annual saving, $12,150, represents a return of 101 percent on the investment. The total cost per day, including fixed charges is $25.22 as compared to $26.50 for the old machine. Considering the increased production, the cost per piece is $.034 as compared with $.088, a saving of $.054 per piece sheared or a cost reduction of 61.5 percent.

The Boiler Maker

Volume XXXI Number 9

Published Monthly by the Simmons-Boardman Publishing Company, 34 North Crystal Street, East Stroudsburg, Pa., with Executive Offices at 30 Church Street, New York City.

Edward A. Simmons, President. Henry Lee, Vice-President. C. R. Mills, Vice-President. L. B. Sherman, Vice-President. Samuel O. Dunn, Vice-President. F. H. Thompson, Vice-President. Roy V. Wright, Secretary. John T. De Mott, Treasurer. George Slate, Business Manager.

Chicago: 105 W. Adams Street. Washington, D. C.: 17th and H Streets, N. W. Cleveland: Terminal Tower. San Francisco, Cal.: 215 Market Street.

Subscription Price: United States and Mexico, $2.00, Canada, $3.50, including duty. Foreign Countries, $3.00 a year. Single Copies, 35 Cents.

Request for change of address should reach us on or before the 15th of the month preceding the issue with which it is to go into effect. It is difficult, and often impossible, to supply back numbers to replace those undelivered through failure to send advance notice. In sending us change of address, please be sure to send us your old address as well as the new one.

The Boiler Maker is a member of the Associated Business Papers, Inc. (A. B. P.), and the Audit Bureau of Circulations, (A. B. C.)

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Contents

Communications

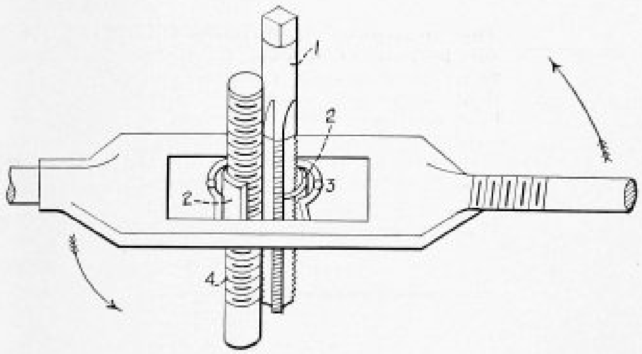
Cutting Left-Hand Thread with a Right-Hand Die

To the Editor:

Recently my mate and I were sent on an outside job to renew a broken staybolt, but when we arrived on the job we found that the staybolt had a left-hand thread. Being far from the shop, and having with us only a right-hand tap, we were up against it for a while until "Old Sandy" a real Scotch boiler maker, suggested that we try to thread the new staybolt as follows:

Referring to the drawing, *1* is the tap, the pieces, numbered *2*, are of copper placed between the tap and the die to prevent crossing the threads and to keep the die from tearing out the threads cut by the tap. The tap is right-handed and cuts a left-hand thread. Part *3* is the die that holds the combination of copper, tap and iron staybolt in place, while *4* is the rod on which the left-handed thread is to be cut.

It may be seen readily that by placing the combination on the rod, as shown, and turning the die in the direction of the arrow to the left, a left-hand thread can be



Method of cutting left-hand thread with right-hand die

formed with the right-hand die. After the first thread is started, the rest will follow and it will be found that a perfect left-hand thread will be formed.

Montreal, Quebec, Can. James Wilson.

Squares of Numbers

To the Editor:

It seems to me that your correspondent in the July issue, asking for information on squares of numbers above 100 from Smoleys tables, has received very little aid and comfort.

The "rough neck" way would be to solve a triangle whose dimensions are one-half the ones given and then double the result. My friends in the engineering department say that to get the square of any length under 1000 you can look up the square of 1/10 of the length and multiply this by 100.

Woodward, Ala. M. J. Sullivan.

Reliability of Inside Calking

To the Editor:

I have always followed with interest the Questions and Answers which are published in The Boiler Maker, and have found pleasure in going over again old problems and in occasionally meeting something unusual. However, I wish to voice my disagreement with the reply given in the current issue to the question, "Will inside calking make a reliable job for 1200 pounds per square inch test pressure?"

In the published reply, the question is answered by a discussion of theories, and a conclusion arrived at that, in the author's opinion, inside calking in itself will not make a good job.

The writer has had considerable experience in high-pressure work and inside calking, and has not the slightest hesitation in recommending inside calking for the highest class of high-pressure work.

That this opinion is shared by many others is evidenced by the fact that practically all of the modern high-pressure boilers installed in America in recent

(*Continued on page 253*)

Questions and Answers Pertaining to Boilers

This department is maintained for the purpose of helping those who desire assistance on practical boiler shop problems. Inquiries should bear the name and address of the writer. Anonymous communications will not be considered. The identity of the writer, however, will not be disclosed unless the editor is given special permission to do so.

By George M. Davies

Removal of Center Tube from Heine Boiler

Q.—Would you kindly describe the best way to remove a center tube from a Heine boiler, also to replace same. I would like very much if you would also describe how to remove and replace a center hollow stay in the headers or waterleg as they are sometimes named.—R.N.

A.—There are various types of Heine boilers as the horizontal cross-drum boiler, the horizontal longitudinal-drum boiler, also the V-type boiler.

The question is not clear as to what is intended as the center tube and the center hollow stay.

In the horizontal boiler the tubes and stays would all be taken out in the conventional manner.

Layout of Spiral Chute

Q.—I am writing you for information of a spiral chute which I am unable to develop. I have your third edition of "Laying Out for Boiler Makers." The nearest to what I want is on page 321 but it is tapering and I cannot get the true length lines for some reason.

The spiral is to be around a pipe 4½ inches outside diameter. One turn in 8 feet. The spiral is 20 inches wide making a total of 44½ inches outside diameter of pipe and spiral. On the outer edge is 8-inch retaining side to keep objects on the spiral.

The chute is to be used as a conveyor chute and fire escape. Herewith is a freehand sketch.—H.R.P.

A.—Two methods of laying out spirals or conveyors of this type were illustrated in the July issue of The Boiler Maker. The spiral shown on the attached sketch can be developed by either of these methods.

The 8-inch retaining edge should be rounded to suit the edge of the spiral after same is formed.

Corrugation of Side Sheets

Q.—I would appreciate having answers to the following questions published in The Boiler Maker. I have been a subscriber for several years and this is the first time I have asked for information: (1) What is corrugation of side sheets of fireboxes? (2) What is the general cause of corrugation between the rows of staybolts? (3) Would loose staybolts that leak cause corrugation? (4) When the sheets are straight and the bolts are properly applied, and, after two months of service the sheets are corrugated and the bolts are leaking, what, in your opinion caused this condition to arise? (5) Would it, or could it be possible to redrive the staybolts enough times to cause the sheets to corrugate between the rows of bolts?

The above questions are pertaining to coal-fired locomotives; some are stoker-fired.—C.H.M.

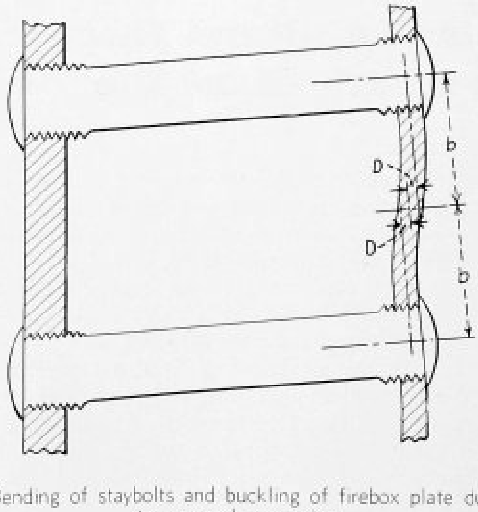
A.—(1) The corrugation of the side sheets of the firebox is the act of shaping the sheet into alternate parallel ridges and grooves by pressing due to stresses set up in the sheet.

(2) The corrugation or buckling of the side sheets is no doubt due to the difference in temperatures between the inside and outside sheets.

An actual test showed the mean temperature of the firebox sheet to be 659 degrees F. while the mean temperature of the wrapper sheet was 380 degrees F., the wrapper sheet being 279 degrees lower than that of the firebox plate temperature. Now, if these two sheets are bolted together with staybolts at 4-inch spaces, something is either going to give or else build up a big pressure or strain in the plates. If these plates were 10 feet long and were fastened together at one end only and one was 279 degrees F. hotter than the other it would expand about 0.260 inch or roughly one-quarter inch more than the one at the lower temperature.

If the hotter plate were compressed back to the length of the cooler plate it would require a load of approximately 12,000 pounds per square inch of cross section of the plate. For a strip of plate 4 inches wide by ⅜-inch thick, the cross section is 1½ square inches and the load would be about 18,000 pounds. If we have a row of rigid staybolts along the middle of this strip and 4 inches apart we would have 40 bolts to resist this movement on the part of the hotter plate. The illustration shows what happens with a rigid bolt construction. The staybolts bend, the plate buckles and actual measurements in the boilers show that the resistance of the staybolts cuts down the total movement between the plates to considerably less than it would be if the hotter plate were free to move.

G. S. Fowler took measurements on two engines, one with rigid bolts and one with flexible bolts and his report shows that the ratio of movement between sheets with flexible stays as compared with the sheets rigidly stayed is as 31 to 13. When the flexible bolted plate moved 0.031 inch more than the outside plate the rigid stayed plate showed only 0.013 inch movement. We have two opposing forces here. On the one hand we must contend with breaking staybolts due to repeated cycles of bending with every change in temperature of the plates. On the other hand with the flexible bolts we transfer the bending movement more to the plate and get the condition of greater buckling in the plates. Serv-



Bending of staybolts and buckling of firebox plate due to unequal expansion ice tests over long periods seem to show that the plates can absorb these strains better than the bolts and this accounts probably for the large number of flexible bolts in use today.

(3) Loose staybolts would not cause corrugation, these bolts are no doubt the results of the plates becoming corrugated and not the cause.

(4) The condition could have been caused by bad water causing scale or solids to accumulate on the water side of the firebox sheet making it necessary for the sheet to be heated to a higher temperature to produce the steam desired, at the same time this increases the difference in temperatures of the side and wrapper sheet, making unequal expansion greater.

Also contributing to the unequal expansion, the firebox side sheet is subjected to cold air every time the firebox door is opened and, on stoker-fired boilers, the air drawn through the grates is not distributed to any particular part of the firebox for there are holes in the fire where cold air enters just below the mud ring and the current of air flows next to the side sheets making it necessary to keep a hot fire or heavy body of fuel for the boiler to generate the steam desired of the power.

(5) I do not believe that redriving the staybolts frequently causes the sheets to corrugate between the rows of bolts.

Inspection of Hollow Staybolts

Q.—Rule 23-B. Interstate Commerce Commission Rules on Inspection of Locomotives reads in part: "On a locomotive with a complete installation of hollow flexible staybolts, caps need not be removed every two years, but the holes must be opened at every hydrostatic test." On some engines, one or two rows of flexible staybolts are behind grates and grate side bars and the holes cannot be opened unless the grates are removed. Is it complying with the law to open all the holes that can be opened with the grates in the firebox and then remove the caps from the bolts behind the grates?—N.T.

A.—Rules 21, 22, and 23 of the laws, rules and instructions for inspection and testing of steam locomotives and tenders and their appurtenances of Interstate Commerce Commission Bureau of Locomotive Inspection, part of which is referred to in the question is as follows:—

(21) *Time of Testing Rigid Bolts.*—All staybolts shall be tested at least once each month. Staybolts shall also be tested immediately after every hydrostatic test.

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

(23) *Method of Testing Flexible Staybolts with Caps.*—Except as provided in paragraph (b), all staybolts having caps over the outer ends shall have the caps removed at least once every two (2) years and the bolts and sleeves examined for breakage. Each time the hydrostatic test is applied the hammer test required by rules 21 and 22 shall be made while the boiler is under hydrostatic pressure not less than the allowed working pressure.

(b) When all flexible staybolts with which any boiler is equipped are provided with a telltale hole not less than $\frac{3}{16}$ inch or more than 7/32 inch in diameter, extending the entire length of the bolt and into the head not less than one-third of its diameter, and these holes are protected from becoming closed by rust and corrosion by copper plating or other approved method, and are opened and tested, each time the hydrostatic test is applied, with an electrical or other instrument approved by the Bureau of Locomotive Inspection, that will positively indicate when the telltale holes are open their entire length, the caps will not be required to be removed. When this test is completed the hydrostatic test must be applied and all staybolts removed which show leakage through the telltale hole. The inner ends of the telltale holes must be kept closed with a fireproof porous material that will exclude foreign matter and permit leakage of steam or water, if the bolt is broken or fractured, into the telltale hole. When this test is completed the ends of the telltale holes shall be closed with material of different color than that removed and a record kept of colors used.

(c) The removal of flexible staybolt caps and other tests shall be reported on the report of inspection form No. 3, and a proper record kept in the office of the railroad company of the inspections and tests made.

(d) Firebox sheets must be carefully examined at least once every month for mudburn, bulging, and indication of broken staybolts.

(e) Staybolt caps shall be removed or any of the above tests made whenever the United States inspector or the railroad company's inspector considers it desirable in order to thoroughly determine the condition of staybolts or staybolt sleeves.

Removing the caps of those staybolts that are behind the grates and grate side bars and testing same as prescribed in the first paragraph of rule 23 would be complying with the law.

In rule 23, paragraph (b) modifies the conditions of the first paragraph to the extent that the flexible staybolt caps do not have to be removed, if the bolts are examined at each hydrostatic test as prescribed in paragraph (b).

Of the two methods, I believe that the removal of the grates and grate side bars and inspecting the staybolts as prescribed in Par. 23 (b) would be a better job and more preferable to removing the staybolt caps.

Reliability of Inside Calking

(Continued from page 253)

years, have been inside calking jobs, where riveted construction was used. Furthermore, for new installations inside calking is the rule rather than the exception in specifications.

Referring to Mr. Davies' discussion of the subject, the assertion is made that, in calking, the plate is severely sprung up, but this is not in accordance with good workmanship.

In the first place, the rivets should not be driven unless the butt strap or welt plate is a good fit to the shell. Secondly, the action of driving the rivets will not open up the straps unless excessive pressure is used with very light straps. In fact with good pressures and good fits the joint should come down off the hydraulic riveter with an almost metal to metal contact, and a perfect seal should be obtained by a light calking of the strap edges.

In the third place, the purpose of calking is not to spring the strap edges, but to thicken them up, in order to close the almost imperceptible opening between shell and strap. Furthermore, there should not be any cantilever action. If the joint is tight on the inside strap, the pressure inside the vessel will act uniformly over the whole of the inside area, and as the laps of the straps are backed up by the shell, which is always considerably thicker than the straps, there would not be any cantileverage of the laps. If there should be an opening between the strap and the shell, the pressure would get between and tend to force the strap away from the shell; but as the pressure is also acting on the inside or steam side of the strap, the forces would balance each other, hence again there would be no cantilever action.

Mr. Davies is evidently thinking of unequal width straps; but for inside calking, a close pitch of rivets is required for the inside strap. In most cases, this is obtained by using equal width straps and double- or treble-riveted seams; but where higher efficiencies are necessary, the usual design would have to be modified, and saw-tooth straps used with quadruple- or quintuple-riveted seams. An alternative to this would be to reverse the usual practice, and to fit the wide strap on the outside, and the narrow one on the inside. Although this might look odd, it would make a good job.

However, a vessel to be tested to 1200 pounds would be, according to accepted practice, designed for 800 pounds working pressure; and at this pressure a riveted drum would have to be of small diameter because of the necessary thickness of the plate and the limitations of riveting. The smaller the diameter, the greater would be the proportion of the drum covered by the straps; so that higher efficiencies of joints would be offset by lost shell area, or, in the case of watertube boilers, of lost tube plate. Therefore for this class of work, double-riveted joints with equal width straps are popular.

In the last paragraph of Mr. Davies' reply, the statement is made that it is the accepted practice to calk all circumferential seams inside and outside, and longitudinal seams on the outside only. I believe, however, that such a practice would be found to be exceptional and no useful purpose would be served by the double calking of the girth seams.

Returning now to the original question, when inside calking is specified, the vessel is tested in the usual way. Should leaks be found when the pressure is applied, the places are marked on the outside of the shell, and the water is then drawn off to permit recalking of the defective places on the inside, the marks serving as guides for locating same.

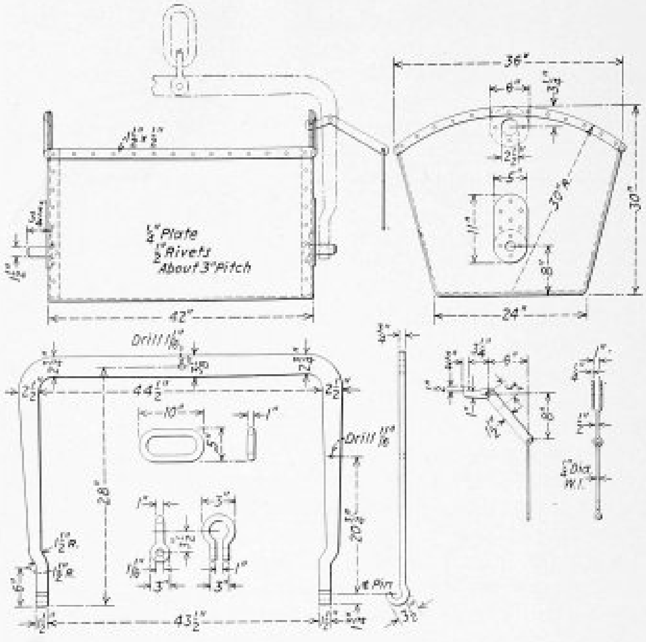
If, as is often the case, some rivets are inaccessible to the hydraulic bull and have to be driven by the pneumatic gun, it would be advisable to calk them on the inside before testing, but with hydraulic riveting this should not be necessary.

New Haven, Conn. J. Winthorpe.

Side-Dump Bucket for Removing Refuse

Removing refuse and scrap from around a car yard or boiler shop and doing it efficiently is one of the essentials of good housekeeping. The side-dump bucket shown in the drawing was designed and has been used for the past four years by one railroad for just that purpose.

It is of light construction and may be used with a crane truck if desired. The bucket is of ¼-inch plate secured with ½-inch rivets. It can be easily made in the sheet-plate mill. The other parts can be made in the forge shop.



Side-dump bucket designed for use with crane truck or traveling hoist

Trade Publications

Telltale Bolts.—A 20-page booklet, prepared by Flannery Bolt Company, Flannery Building, Pittsburgh, Pa., describes the construction and application of flexible staybolts of the telltale type. Three words tell the story—efficiency, economy and safety. These are treated at length in this bulletin.

Motors.—A 4-page leaflet, describing a new mill motor has recently been announced by the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa. The application of this motor includes heavy duty operations, such as steel mill auxiliary drives, cranes, hoists, conveyors and other similar operations.

Tap Manual.—The Morse Twist Drill & Machine Company, New Bedford, Mass., has recently published a Tap Manual, in which is compiled a considerable amount of practical information relative to the construction and methods of employment of various styles of taps. A section of the booklet devoted to lubrication is of special interest to users of taps and dies.

Welding Rod.—Joseph T. Ryerson & Son, Inc., Chicago, has issued a new bulletin on welding rod and equipment, the first pages of which contain valuable information on gas and electric welding rods. Under these two classifications, a variety of rods representing all types of welding are described. The second section is devoted to the subject of acetylene and electric welding equipment.

Combustion Steam Generator.—The Combustion Engineering Corporation, 200 Madison Avenue, New York, has just issued a catalogue describing the Combustion steam generator which is a single unit embodying in an integral design the several elements required in the production of steam. The purpose of this design is to so co-ordinate the functions of the various elements as to insure maximum efficiency with minimum operating and maintenance cost. These are available in eight standard sizes.

Associations

Bureau of Locomotive Inspection of the Interstate Commerce Commission

Chief Inspector—A. G. Pack, Washington, D. C.

Assistant Chief Inspectors—J. M. Hall, Washington, D. C.; J. A. Shirley, Washington, D. C.

Steamboat Inspection Service of the Department of Commerce

Supervising Inspector General—D. N. Hoover, Jr., Washington, D. C.

American Uniform Boiler Law Society

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Boiler Code Committee of the American Society of Mechanical Engineers

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Vice-Chairman—D. S. Jacobus, New York.

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National Board of Boiler and Pressure Vessel Inspectors

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States and Cities That Have Adopted the A.S.M.E. Boiler Code

	States	
Arkansas	Missouri	Rhode Island
California	New Jersey	Utah
Delaware	New York	Washington
Indiana	Ohio	Wisconsin
Maryland	Oklahoma	District of Columbia
Michigan	Oregon	Panama Canal Zone
Minnesota	Pennsylvania	Territory of Hawaii
	Cities	
Chicago, Ill.	St. Joseph, Mo.	Memphis, Tenn.
Detroit, Mich.	St. Louis, Mo.	Nashville, Tenn.
Erie, Pa.	Scranton, Pa.	Omaha, Neb.
Kansas City, Mo.	Seattle, Wash.	Parkersburg, W. Va.
Los Angeles, Cal.	Tampa, Fla.	Philadelphia, Pa.
	Evanston, Ill.	

States and Cities Accepting Stamp of the National Board of Boiler and Pressure Vessel Inspectors

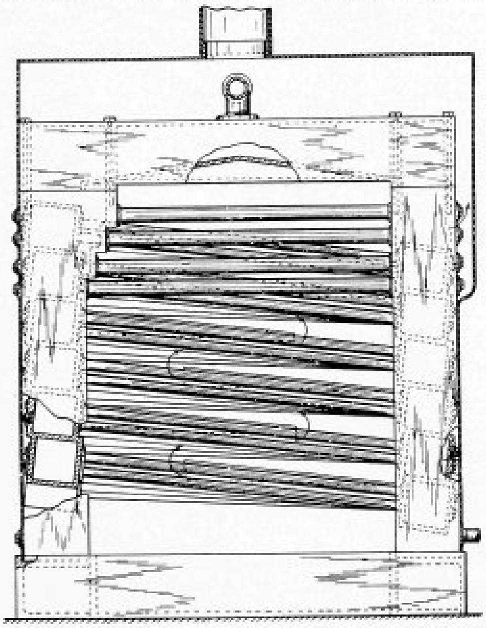
	States	
Arkansas	Missouri	Pennsylvania
California	New Jersey	Rhode Island
Delaware	New York	Utah
Indiana	Ohio	Washington
Maryland	Oklahoma	Wisconsin
Minnesota	Oregon	Michigan
	Cities	
Chicago, Ill.	St. Louis, Mo.	Nashville, Tenn.
Kansas City, Mo.	Scranton, Pa.	Omaha, Neb.
Memphis, Tenn.	Seattle, Wash.	Parkersburg, W. Va.
Erie, Pa.	Tampa, Fla.	Philadelphia, Pa.
Detroit, Mich.		

Selected Boiler Patents

Compiled by Dwight B. Galt, Patent Attorney, Washington Loan and Trust Building, Washington, D. C. Readers wishing copies of patents or any further information regarding any patent described, should correspond directly with Mr. Galt.

1,703,565. STEAM GENERATOR. SWAN ANDERSON, OF MINNEAPOLIS, MINN.

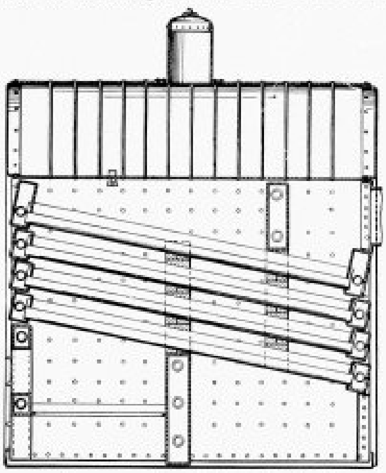
Claim.—A steam generator having in combination a chamber, means for supplying water to said chamber, a plurality of horizontally disposed ducts leading from said chamber, a pair of upstanding hollow legs spaced from said ducts and from each other, a plurality of ducts of V-shape in



longitudinal cross section extending between and connecting said legs and a plurality of sets of tubes extending between and connecting said horizontal and V-shaped ducts, each set of tubes extending upwardly from a lower horizontal duct to a higher V-shaped duct, and discharging means leading from said pair of legs. Four claims.

1,767,173. WATERTUBE BOILER. SAMUEL P. COULTER, OF MUNCIE, IND.

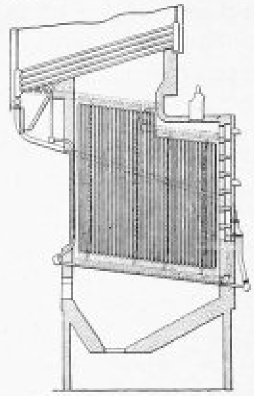
Claim.—A steam generator, comprising a drum, water legs co-extensive with the drum and disposed at opposite sides thereof, front and rear sets of headers spanning the water legs, the headers of each set being free of communication and connection with each other, nipples establishing communication between the water legs and the ends of the headers and consti-



tuting the sole means for connecting the headers to the water legs, one set of headers being disposed at a lower level than the other set and the headers of both sets being cross-sectionally angular in form and disposed at a slight angle to the perpendicular with the rear lower edge of each header below the horizontal plane of the front upper edge of the next lower header, tubes connecting the headers, a hollow cast steel front spanning the water legs below the front headers and having fire and ash door openings and connected to the water legs and free of communication and connection with the headers, a hollow back wall spanning the water legs below the tubes and communicating with the water legs, and a hollow baffle spanning the water legs above the tubes and communicating with the water legs.

1,760,140. POWDERED-FUEL-BURNING BOILER FURNACE. STANLEY A. JACQUES, OF CHICAGO, ILL., ASSIGNOR TO INTERNATIONAL COMBUSTION ENGINEERING CORPORATION, OF NEW YORK, A CORPORATION OF DELAWARE.

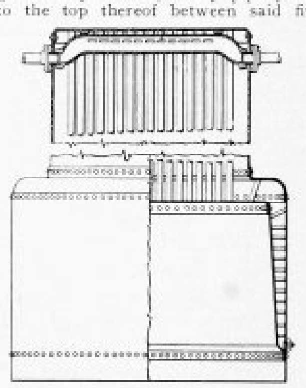
Claim.—In combination with a substantially horizontal tubular boiler, a combustion chamber therebelow having side water walls including appro-



priate headers, upcomers for said water walls connected into the circulation of the boiler and constituting a portion of a row of the tubes of the tubular boiler, and means for introducing fuel to be burned in said combustion chamber. Six claims.

1,760,829. STEAM BOILER. SIDNEY B. GORBUTT, OF PORTLAND, ORE., ASSIGNOR TO WILLAMETTE IRON AND STEEL WORKS, OF PORTLAND, ORE.

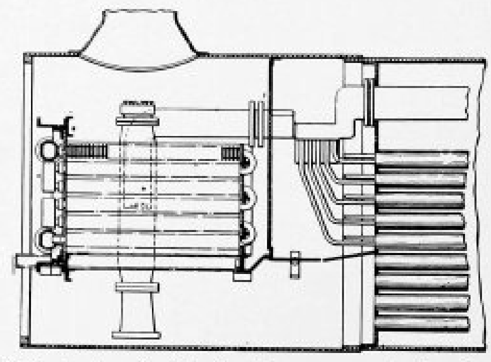
Claim.—An upright cylindrical boiler having a plurality of vertical fire tubes passing through the top thereof, a dry pipe positioned diametrically across same close to the top thereof between said fire tubes, said pipe



having downwardly offset ends, a plurality of inlet openings formed in the top side thereof, said offset ends having ferrules therein slidably mounted in the sides of the boiler, and means for preventing said pipe from rotating on its supports to prevent the contacting of said pipe with said fire tubes. Three claims.

1,764,172. LOCOMOTIVE BOILER. WALTER FRANCIS KEENAN, JR., OF PELHAM, N. Y., ASSIGNOR TO FOSTER WHEELER CORPORATION, OF NEW YORK, A CORPORATION OF NEW YORK.

Claim.—In a locomotive comprising fire tubes and a front tube sheet



into which the front ends of the fire tubes are connected, and a smoke box in front of said tube sheet, the improvement which consists in a structural frame work extending across the lower portion of the smoke box, an economizer comprising a box-like casing open at top and bottom removably supported on said frame work, tubular elements located in said casing, and baffle provisions arranged to confine the flow of the heating gases issuing from the fire tubes through said casing. Nine claims.

The Boiler Maker

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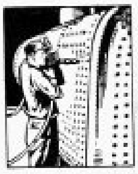

Modernizing Railroad Methods

At this time the railroads of the country are faced with problems, the correct solution of which will insure their future prosperity and will offer a measure of security to the men in their employ. The economics of the situation—namely, amalgamation of lines, rate relief and the like—are outside the scope of all but the leaders in the industry, and the thoughts and activities of the rank and file will have but little effect on the outcome in this direction. It is to be hoped that early relief will be forthcoming to the financial structure of the railroads.

Within the industry itself, however, there are evils which require correction, as well as many constructive measures to be developed that will go far towards rehabilitating the railroad transportation system. For several years past, for example, there have been signs of change in the facilities and methods of maintaining locomotives, made necessary by the modernization of power itself. Such changes, as centralizing repairs and standardizing practice on any given system or combination of roads, have resulted in economy and efficiency without which the roads involved would be in a yet more unfavorable position than now exists.

In spite of the difficulties which face practically every railroad man today, the vast majority of those who have made it their life work believes in the soundness of the railroads, and in their future place in the transportation scheme of the nation. To insure this future, regardless of other factors, it is essential that every individual, whether on the road, in the office, or in the shop, concentrate on doing his job in the most efficient manner possible and, in his small way, help in developing new methods and economies.

Discussion of Boiler Making Problems

With the publication in the September issue of the first reports prepared for the 1931 proceedings of the Master Boiler Makers' Association, the suggestion was made that readers take advantage of the opportunity presented to discuss them through the medium of our pages. In September three of the reports were published: "Cast-Steel or Cast-Iron Grate Bars," "Fusion Welding as Applied to Pressure Vessels," "Clearance between Flues and Tube Sheet Flange." In this issue appears a report on "Thermic Syphons and Maintenance Costs of Boilers."

Practically every man in the shop has definite ideas on these four subjects and how problems in connection with them may be solved. Where differences of opinion do not rise, or when the value of the device is not in question, nevertheless there are certain facts in connection with them which only develop from long experience.

There is little point in holding over information that is valuable now until an opportunity at a future convention is given for its presentation. The pages of The Boiler Maker are open to the discussion of such subjects as those mentioned, not only by members of the Master Boiler Makers' Association but, in addition, by all those individuals who are in any way connected with the trade of boiler making.

If any of our readers have opinions on the reports published, their comments will be welcomed by other members of the trade, and they are invited to submit them for publication.

Qualified Manufacturers of Welded Pressure Vessels

There has been considerable question in the past as to the proper responsibility in the case of failure of a welded pressure vessel. In this respect there has been an erroneous opinion that welding work coming into a state should be done by welders licensed by that state. The burden of proof, in the case of failure would then be placed on the welder.

It has been the intention of the Boiler Code Committee of the American Society of Mechanical Engineers to place responsibility for welding on the manufacturer of such a pressure vessel and not on the welder. This requirement is upheld in the A. S. M. E. Rules for the Fusion Process of Welding which state in part: "Each manufacturer shall be responsible for the quality of the welding done by his organization and shall conduct tests of the welders to determine their ability to produce welds which will meet the required tests."

The States of California and Oregon have enacted laws requiring all welding work coming into those states to be done by manufacturers approved by those states. In Oregon, the Safety Orders issued by the Oregon Industrial Accident Commission, for 1929, state: "That effective November 1, 1930, the State Industrial Accident Commission's Safety Standards and orders as affecting stationary boilers and unfired pressure vessels shall be such rules as are found in the 1927 edition of the American Society of Mechanical Engineers' Boiler Code, or any subsequent edition, or any provisions therein as far as they apply to the construction of boilers and other pressure vessels." Since these rules now cover fusion welding and the burden of proof is placed by the rules on the manufacturer, the question of responsibility in code states is fixed.

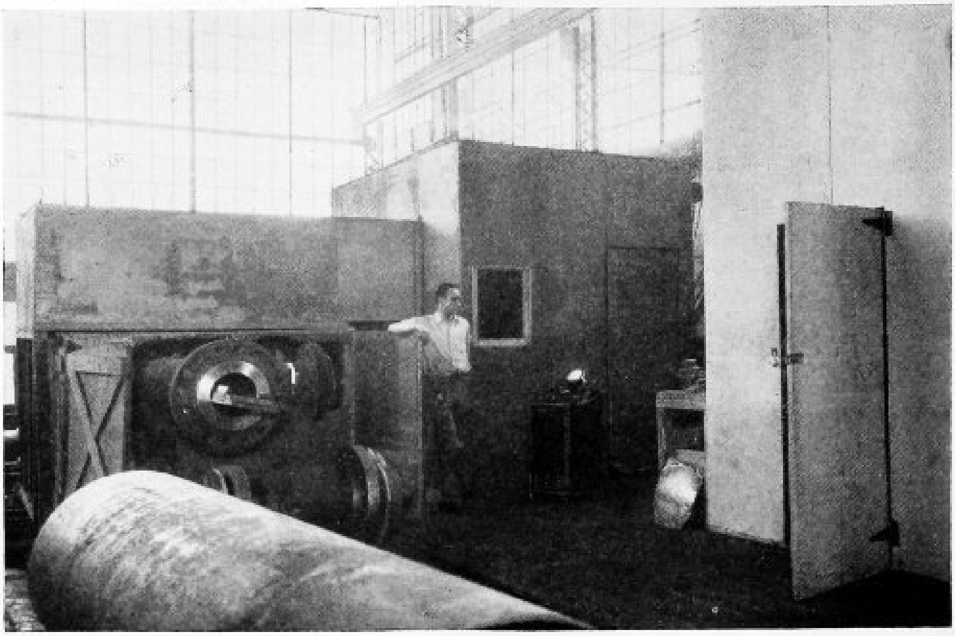

Fig. 1.—X-ray installation for the inspection of heavy steel castings

Radiographic Inspection of Welded Structures*

By Herbert R. Isenburger†

Non-destructive routine testing of structures has become of foremost industrial importance. One of the most reliable of such methods is radiographic examination, in which shadow pictures are obtained showing the interior condition of the object under investigation without destroying or in any way harming it. These pictures are made by means of a penetrating radiation of either X-rays, produced electrically by an X-ray tube, or of gamma rays, which are of shorter wave length than X-rays and are obtained from radium or its emanation. X-ray pictures are known as "exographs" as distinguished from "radiographs" made by means of gamma rays.

Fig. 1 shows an actual installation arranged for the X-ray inspection of a three-ton header for a high-pressure steam-electric power plant. The X-ray tube is placed in a lead-lined safety drum within a sheet-iron case directly over the casting. The film is placed in special cassettes on a carrier which can be seen projecting from the end of the casting. The X-rays are thus passed through the wall and make a shadow picture which shows the location and nature of any serious defects. During exposure, the casting is surrounded by a lead-covered housing to prevent the X-rays from passing out into the room. The casting and housing travel along tracks under the tube. A direct current of 230,000 volts is produced by special transformers and rectifiers within a sheet-iron room just behind the control stand. The high-potential equipment is thus completely surrounded by a grounded metal shield. On the right is the dark room for the immediate development of the films.

A diagram of the radiographic arrangement is shown in Fig. 2. The focal spot *A*, which is either the target of an X-ray tube or the bulb containing the radium, should be as small as possible in order to obtain sufficiently fine detail in the film *F*.

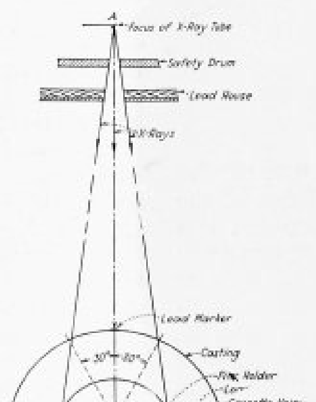

Fig. 2.—Diagram of radiographic exposure arrangement

As with ordinary photographs, darker regions on the X-ray negative or lighter regions on the print mean that more rays have passed through the object at that point, indicating that the object is more transparent at these points.

Hence cavities in the object will show up on the print as lighter spots, whereas heavy impurities or more dense metal will appear as darker spots. The absorption of the rays grows with the atomic weight of the material examined. Because of its great atomic weight, lead is used to protect the operator, since sufficient thicknesses of lead will absorb the rays completely.

There are two particular fields in the metal industry where radiography is of utmost value—foundry and welding practice. In foundry practice there are

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* Presented at a meeting of the A. S. M. E. Machine Shop Practice Division held in connection with the National Metal Congress, Boston, Mass., September 22, 1931. Published through the courtesy of *Mechanical Engineering*.

† Secretary-treasurer: St. John X-Ray Service Corporation, New York.

FIG. 3

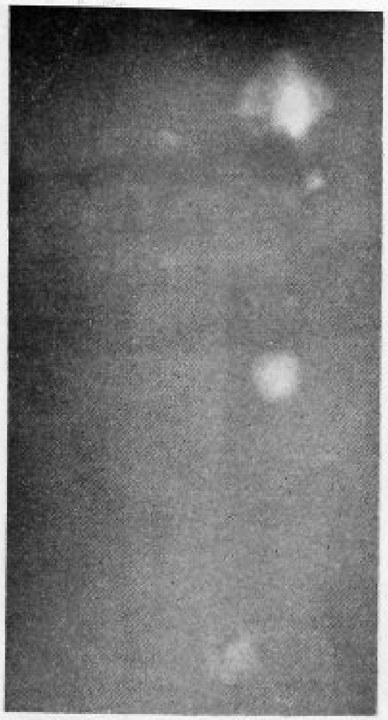


FIG. 4

FIG. 5

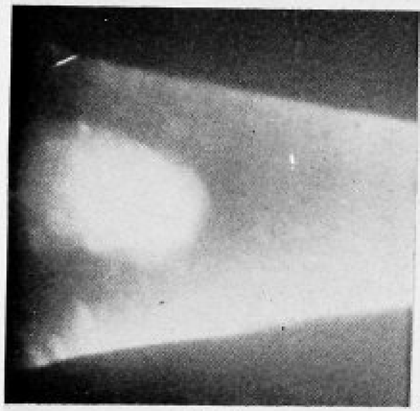


FIG. 6

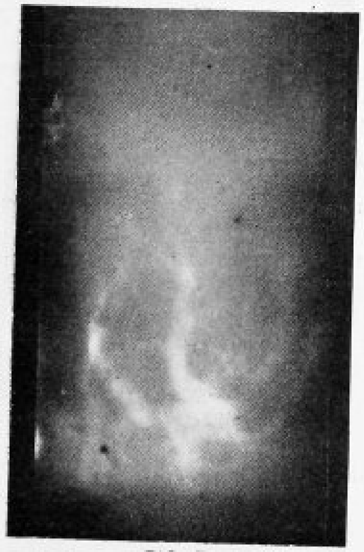


FIG. 7

FIG. 10

FIG. 8

FIG. 9

Fig. 3.—Gas pocket and sand inclusion in cast steel $1\frac{5}{8}$ inches thick. Fig. 4.—Gas pockets in steel casting. Fig. 5.—Sand pocket in $2\frac{1}{2}$-inch cast steel. Fig. 6.—Shrinkage cavity in heavy steel casting. Fig. 7.—Primary pipe in the cope side of a steel casting. Fig. 8.—Secondary pipe in the drag side of a steel casting. Fig. 9.—Spongy metal in cast steel. Fig. 10.—Hot tears in cast steel.

two important applications. One of these concerns the development of manufacturing technique, the other the final inspection of the finished product. Although the radiographic method seems expensive, there are many cases where the possible failure of a casting or forging would cause damage far in excess of the cost of the examination. Here radiographic inspection becomes a matter of insurance.

X-ray tests confirmed by cutting a section of the casting and by other means of examination indicate that the undesirable internal conditions in castings fall into relatively few classes, all of which are traceable to definite and simple causes. Most of these causes, if not all of them, can be eliminated by proper foundry practice. Experience shows that when defects have been corrected by making the required changes in foundry methods, they tend to stay corrected. It is thus possible, by the aid of radiography and the conclusions drawn from its results, to eliminate from 75 to 90 percent of the more important defects in castings produced by a given foundry.

The principal undesirable conditions in steel castings revealed by radiographic examination are the following:

1—Gas, slag, and sand pockets due to loose dirt in the mold. Fig. 3 is an exograph of a part of a steel casting, 1⅝ inches thick, showing a large gas pocket and sand inclusions around the chaplet.

2—Gas cavities due to imperfectly deoxidized metal, as shown in Fig. 4.

3—Sand inclusions due to cutting of the mold or runners. Fig. 5 shows a large sand pocket in steel 2½ inches thick. This defect was found in one of the headers shown in Fig. 1. By a double exposure of this spot it was determined that the inclusion started close under the outer surface and did not penetrate more than one-quarter of the way through the wall; hence it caused no serious trouble.

FIG. 11a

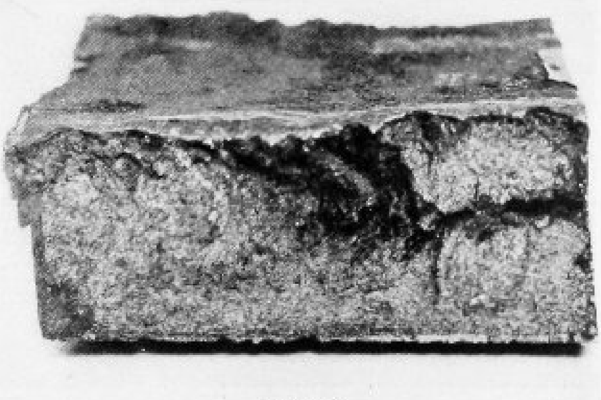


FIG. 11b

Fig. 11a—Shrinkage in cast steel 1⅛ inches thick. Fig. 11b—Photograph of cross-section of specimen in Fig. 11a

Fig. 12a—Cold crack in steel casting

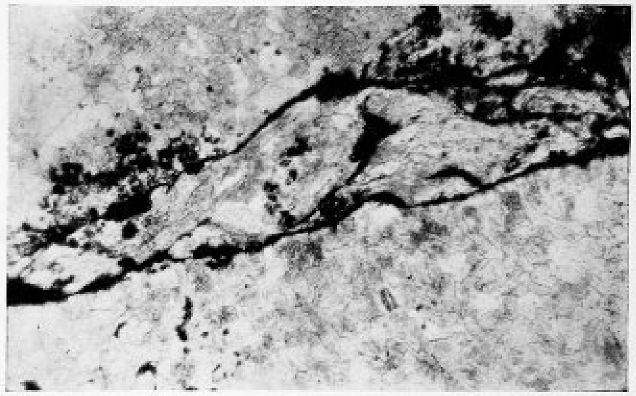


Fig. 12b—Micrograph region exographed in Fig. 12a

4—Shrinkage cavities occur sometimes because the feeding is imperfect, the molten metal being fed into the casting while it solidifies, as shown in Fig. 6.

5—Pipe or primary shrinkage caused by failure of the risers to function as indicated, as shown in Fig. 7.

6—Secondary pipes caused by the flow of viscous metal through constricted channels in the casting during the final stages of solidification, as shown in Fig. 8.

7—Spongy metal is shown in Fig. 9. Metal occupies more volume in the liquid state than in the solid. When it solidifies, a definite cavity may be formed as in Fig. 6, or there may be a region that contains many minute cavities, i.e., spongy metal.

8—Hot tears occur frequently in cast steel because of cooling stresses set up in the metal after it has solidified but while it is still tender. Usually there is not a single crack but a system of cracks as shown in Fig. 10.

9—Shrinkage cracks starting from a sinus-like cavity developed during cooling. An exograph through the wall 1⅛ inches thick and a photograph of the cross section of this area are reproduced in Figs. 11*a* and *b*.

10—Rupture developed during pressure test. Fig. 12*a* shows a portion of a steel casting which was selected by the customer's inspector as particularly good after applying ordinary inspection tests. The exograph revealed a sharply defined crack starting from a small cavity or inclusion. Its location was marked with crayon on the outside of the casting, and it was found where indicated when the piece was sectioned. Moreover, micrographic examination of the material adjacent to the crack showed that it had been cold-worked as shown in Fig. 12*b*. This casting was probably ruined in the very test that "proved it good."

The rapid development of higher-pressure and

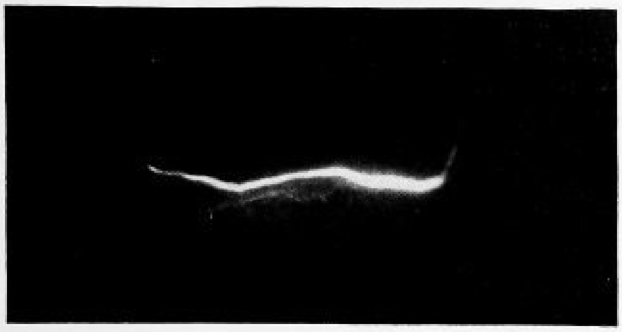


Fig. 13.—Deep crack in steel forging

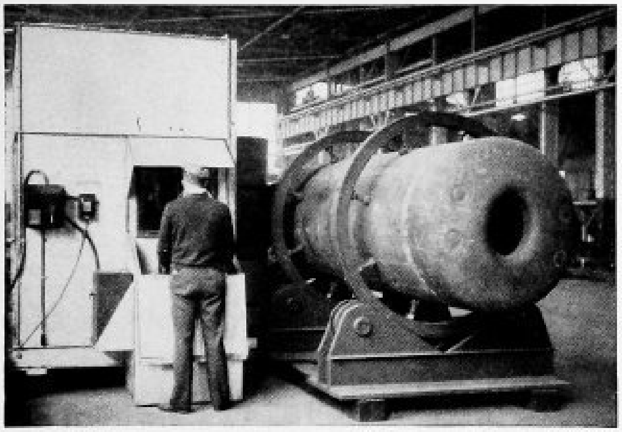


Fig. 14.—X-ray installation for the inspection of welded pressure vessels in a boiler shop

higher-temperature processes presents increasingly numerous cases where radiographic tests may be applied and where they often will be found absolutely necessary. While these conditions are perhaps more prevalent in the case of castings and welds, they also occur with forgings as well as bar or plate stock. Fig. 13 shows a deep crack in a steel forging.

The principal undesirable conditions in welding revealed by radiographic examination are the following:

1—No penetration, that is, improper fusion at scarfs between weld and parent metal.
2—Laps not fused between layers of weld metal.
3—Gas inclusions, more or less numerous throughout the weld zone.
4—Shrinkage cracks developed during or after welding.

No penetration and laps are usually characterized by slag inclusions, which may be actually slag but are mostly a fine skin of oxide. Shrinkage cracks occur very seldom.

By means of X-ray examination it was found, for instance, that a certain energy of the electric arc gave the best results for a given welding operation. If the current was greater than this, porosity in the welds began to show in the exographs; if the current was less, the X-rays revealed a lack of fusion and adhesion between the welded surfaces. In this way it was determined that a 250-ampere arc should be used for welding plate stock from ½ inch to 1 inch thick, whereas a 500-ampere arc is necessary for ¾ inch to 1½ inches. Too long an arc causes burning or oxidation of the metal. The electrode metal should have a higher melting point than the parent metal, as otherwise there is a tendency to the formation of unfused areas on the parent metal.

Welding speeds used commonly with bare metallic electrodes are too high for sound work. Of course speeds that may be used vary with the type and size of the welding rod and with the nature of the plate to be welded. X-rays determined that each welding rod has an optimum set of conditions which give substantially sound joints. By X-raying each trial the right rate of feed was determined. In similar ways, X-rays helped to select the welding rod and its size and determined the way the welder should hold the arc. The best coating and the proper amount of coating can thus be determined. Too much coating produces porous welds.

In practice, each welder should be taught to correlate his work with the X-ray evidence. He will learn more quickly in that way and remember the results and consequently use the right judgment in his future work. For each welding operation the right technique should be developed. Sample welds should be made in scrap pieces of the kind of plate to be used in construction and these should be X-rayed. Films of the preliminary welds are studied and the technique is modified accordingly. As soon as the test plates are perfect and the correct procedure is determined, production is started. While the work is in progress, test coupons should be X-rayed at intervals. Physical tests made on such X-rayed coupons have shown that internally sound welds also have desirable strength and toughness.

More important structures like welded seams in pressure equipment for severe services should be X-rayed completely. Fig. 14 shows an installation in operation in a boiler shop for the routine inspection of welded pressure vessels. A boiler drum is set up for inspection of the girth welds. The high-tension power plant is mounted on a movable platform and surrounded by a sheet-metal housing, while the safety drum containing the X-ray tube is seen in front of the housing. The tube can be rotated about its axis and raised and lowered when desired. The control cabinet is also attached to the housing. For examination of girth seams, the vessel is rotated about its axis.

A typical exograph of a longitudinal seam is shown in Fig. 15. The weld itself is not distinguishable because the weld metal was perfectly sound. The weld zone can only be located by reference markers. In Fig. 16

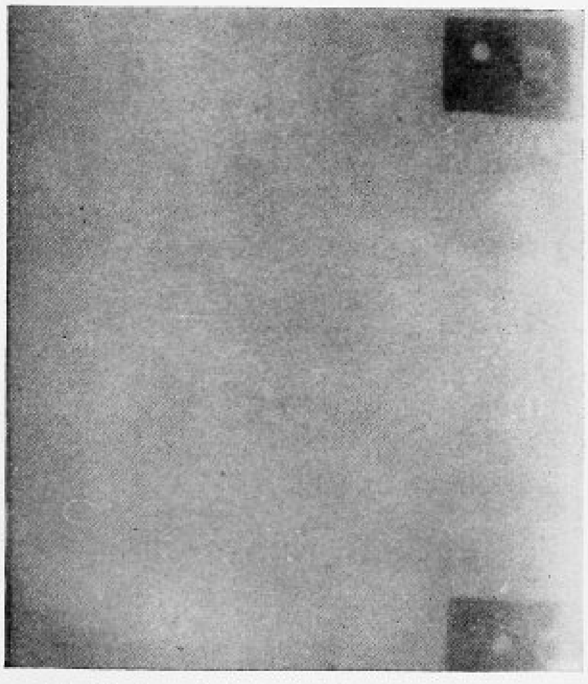


Fig. 15.—Exograph of sound weld in longitudinal seam

Fig. 16.—Exograph of weld containing slag inclusion in 2½-inch plate stock

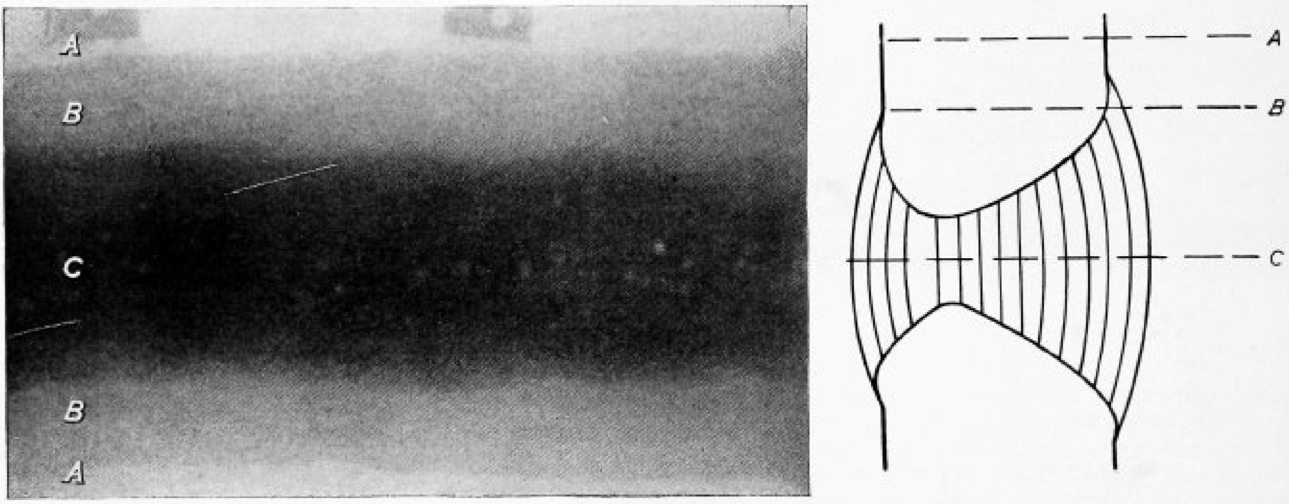


Fig. 17.—Porous weld through 1⅛-inch plate

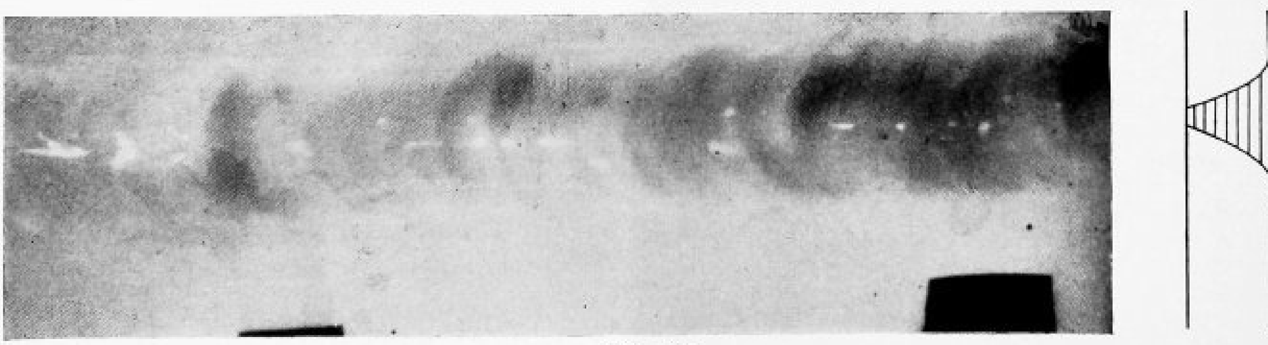


FIG. 18a

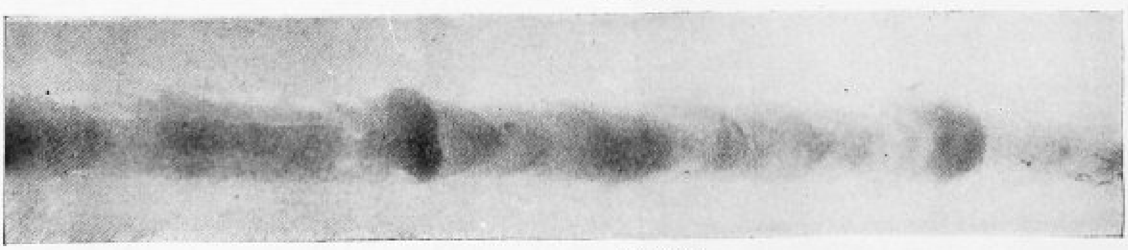


FIG. 18b

Fig. 18a—Bad weld in alloy-steel plate ⅝-inch thick.
Fig. 18b.—Improved weld similar to that of Fig. 18a made after study of X-ray evidence

slag inclusions extending along the walls of the joint are indicated as more or less cloudy elongated areas. The welded zone in this case can be readily located. Both exographs were made through 2¼ inches of steel. Gas holes, whether large or small, appear as sharply defined rounded spots as in Fig. 17, which shows a weld in 1⅛-inch stock. In the exograph three regions of different density appear: Region *A* represents the plate, region *B* the built-up metal on the surface toward the X-ray tube, and region *C*, which contains the actual weld, the excess weld metal on the side facing the film.

Although this is a porous weld, it may be considered permissible for the service intended. Here lies the danger of inexpert radiographic inspection, that the picture may show an apparently bad condition which

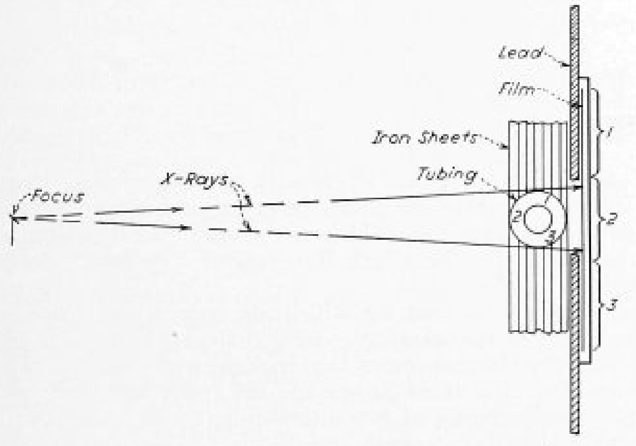


Fig. 19.—Radiographic arrangement for inspecting tubes of small diameter

actually is permissible. In this respect X-ray examination may tend to be a rigid test, calling for skill in the interpretation of the films and a thorough knowledge of the material's ultimate use. Its results, therefore, must be studied carefully and with the aid of expert advice.

Figs. 18*a* and *b* show electric arc-welded test plates of ⅝-inch stock made by the same welder. The material is an alloy steel and the weld is V-shaped, welded from one side as is the practice in welding small tubing. Exograph (*a*) shows the joint as originally submitted for X-ray test. The welder, after study of the X-ray evidence, changed his technique as previously described, and in his fifth plate was able to turn out a perfect weld as reproduced in Fig. 18*b*.

Alloy-steel tubing is now widely used in superheaters, oil crackeries, and various other severe services. On larger tubing and on welded pipes the films are placed inside, behind the welded seams. The exposure technique for routine inspection of circumferential welds in tubing of small diameter is schematically shown in Fig. 19. Fig. 20 shows the three exposures on one film showing the complete weld in a pipe 2-inch outside diameter which was thermit-welded. The dark areas in the exograph indicate the more dense and excess weld metal.

Fig. 21 is an exposure chart which has been evolved for X-raying various thicknesses of steel at the peak voltage at which present tubes will work. This curve makes it possible to visualize the exposure conditions under which all the work described in this paper was performed. The thickness of the material is plotted against the exposure time in minutes. Operation is at 230,000 volts and 4 milliamperes (18-inch spark gap)

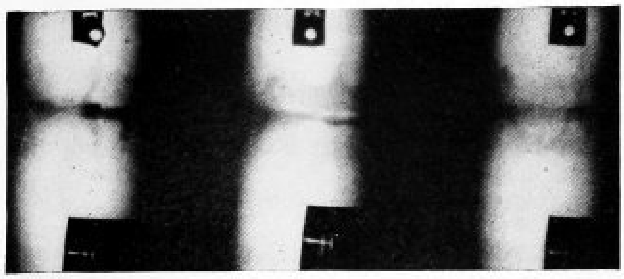


Fig. 20.—Exograph of thermit weld in a 2-inch pipe

with 24-inch focus film distance. The area of the material covered is 12 inches square. But film is used between Westex intensifying screens. It is a matter of simple arithmetic to determine the variation in the photographic effect caused by changing any of the factors involved, namely: The voltage, distance, current, and time. Since the intensity varies inversely as the square of the distance, the relation of exposure times would be directly as the square of the distance.

X-rays should be employed whenever advisable on steel castings and forgings having a thickness of 3 inches and less; whereas gamma rays should be used for examination of heavier material; 10 inches of steel has been successfully penetrated thus far. For radiographic inspection of welded seams, X-rays should be used whenever possible, since this kind of radiation gives more detail in the picture than do gamma rays. The appearance of the various defects is almost the same whether in castings or welded seams, but the precision in X-ray inspection can be raised up to 1 percent in 3-inch stock and less, but to not better than 3 percent in gamma-ray examination. This holds good for blowholes which lie in the direction of the rays.

The costs for suitable X-ray installations and for their operation depend a great deal on the material to be examined, its thickness, conditions, and mobility. A conservative estimate of operating cost is $3 to $5 per hour, depending on the way the equipment is written off. The cost of radiographic inspection by means of gamma rays is difficult to estimate. The radioactive material can be rented and in most cases the expense for such work equals the cost when X-rays are used.

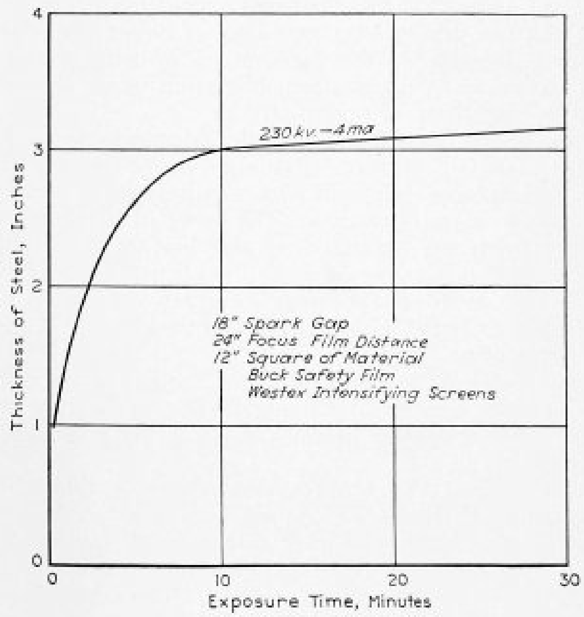
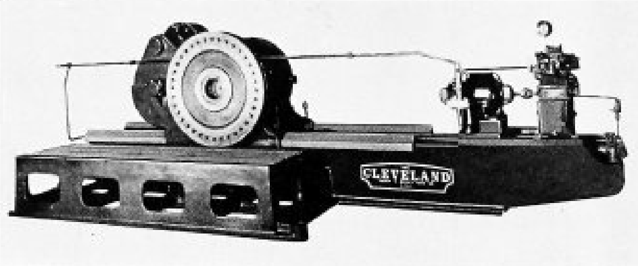


Fig. 21.—Exposure chart for X-raying steel



Cleveland hydraulic rotary planer

Hydraulic Rotary Planer

The Cleveland Punch & Shear Works Company, Cleveland, Ohio, has recently brought out a rapid-production rotary planer which is said to give a high degree of efficiency for this type of machine.

The cutter-head, which contains the high-speed tools, is mounted on anti-friction bearings. The travel of the carriage is hydraulic thereby providing an infinite number of feeds.

A feed selector, when set, makes instantly available any two feeds within the range. This is a particularly desirable feature when thick and thin material is encountered as in heavy structural members.

Other outstanding features include: Improved type of ways and the method of lubrication which results in increasing the life of the ways; all gears enclosed in oil-tight gear cases; rapid traverse both forward and backward; automatic stops at each end and entirely self-contained machine which permits mounting on a circular base, if desired.

As a test, this planer milled the end of a heavy structural girder at the rate of 12 inches a minute, which is considerably more rapid than in former types of planers.

Multiple-Circulation Watertube Boiler

The Combustion Engineering Corporation, New York, has recently developed a new type of boiler which provides a solution to the problem of insuring adequate circulation and correct steam liberation under the most severe conditions of operation.

The salient features of this development are as follows: The C-E multiple-circulation boiler departs from the conventional design in two essentials; tube arrangement and steam liberation. The tubes in the first pass of the boiler are arranged so that half of them enter the front drum and the other half enter the middle drum. The tubes in the second pass are arranged so that half the tubes enter the middle drum and the other half enter the front drum.

This boiler is available in sizes ranging from about 2000 square feet to 26,000 square feet of heating surface. It is adaptable to any type of firing and may be set double.

The unique tube arrangement effects a double circulation in the boiler. One circulation is up half the tubes in the front tube bank to the front upper drum, then down the tubes running into the middle tube bank to the lower steam and water drum. The other circulation is up the other half of the tubes in the front tube bank which run into the middle upper drum then down half the tubes in the middle tube bank to the lower steam and water drum.

This splitting of the circulation results in equalizing the steam liberation in the upper front and middle drums, thus eliminating the intense turbulence which is present in the conventional types of multi-drum bent-tube boilers, in which the greater part of the steam is liberated in the front drum.

In order to assure dry steam production, the steam circulators are increased in number over the conventional design. A further change in design consists in connecting the steam circulators from both the front drum and the middle drum directly into the rear drum. This design effects two improvements over the conventional boiler, namely, drier steam and lower steam velocities.

Tiering Truck

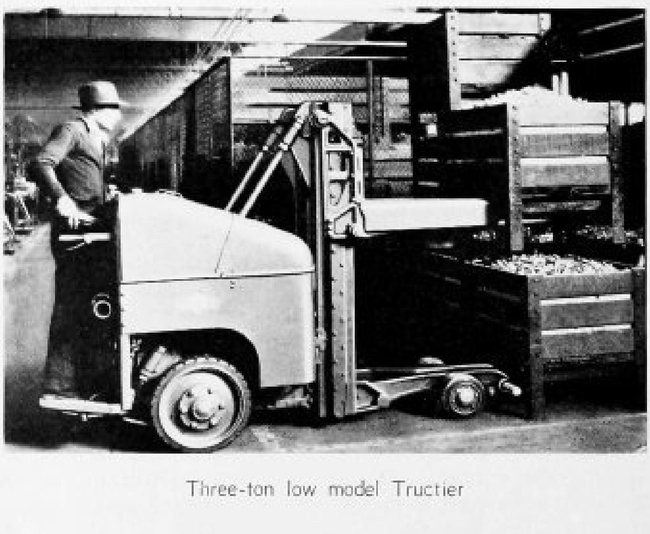
A tiering truck that steers with all four wheels, drives from the rear wheels and is powered with a tractor-type gas engine capable of 24 hours' continuous operation is announced by the Clark Tructractor Company, Battle Creek, Mich.

The new method by which all four wheels turn in response to the steering control enables the truck to get into tight places with its load and get away easily. The turning radius is 94 inches and the truck will easily negotiate the corner of two intersecting 64-inch aisles with ample clearance on each side.

The hydraulic lift applies maximum power to the point of service without drum or other complicated mechanisms. Besides utilizing all the advantages of the hydraulic lift it also cushions the descending load without shock.

Materials and equipment on skid platforms or in tote boxes are quickly moved from place to place and stacked in tiers. The Tiertop model is especially recommended for warehouse use. It tiers a 3-ton load to 6 feet in 30 seconds. Heavy dies may be positioned on presses, heavy units in process may be positioned on machine tools, material for storage is quickly and compactly tiered.

The Tiermor model tiers 3 tons to 4 feet in 18 seconds. Its flexible mobility and the construction which permits the driver to have clear vision at all times are important advantages.



Three-ton low model Tructier

A Personal History of the Arc-Welding Process*

By J. C. Lincoln†

For a process so widely used in the boiler shop as that of electric-arc welding, comparatively little of the history of its development is known to the average user of such equipment. The author of this paper has played a prominent role in the development of this modern system of welding. For this reason the Master Boiler Makers' Association and its members individually should be grateful to Mr. Lincoln for being the medium through which this interesting personal history of arc welding is made available to the industry. A similar history of the development of the oxy-acetylene process of fusion welding by one prominent in this field will appear later.

About 1880 a man named Bernardos proposed to use the carbon arc for welding. Some 10 years later a man named Slavenoff proposed to use a metallic rod as electrode instead of the carbon and this proposal was the germ of what has developed into metallic arc welding.

In 1897 The Lincoln Electric Company carried on some experiments in the puddling of cast iron. A graphite mold was developed. This mold was filled with cast-iron chips and a plating generator having a voltage of approximately 6 volts and current capacity of approximately 600 amperes, passed the current through these chips and melted the mass down so that the cast iron could be poured—the idea behind the experiment was to develop means for small repairs on defective castings. Commercially the experiment never came to anything.

In 1907 The Lincoln Electric Company built a number of welders for a concern using direct current from the street car circuit to operate what we now call an inverted rotary, taking the alternating current from this rotary, passing it through a transformer, reducing the voltage and increasing the amperage. This large alternating current of low voltage was used for brazing copper bonds to street car rails. Before this time current-carrying rails had been attached to each other by bonds riveted into holes drilled through the rail and experience has shown that such bonding cannot remain tight.

Brazed bonds, which were put on by the apparatus manufactured in 1907, have been in constant use ever since and I presume many millions of bonds have been put on by this process.

At about the same time in 1907, The Lincoln Electric Company built an alternating current transformer for filling up holes in steel castings. Before this time a large direct-current generator had been used in a few instances for building up shrink holes in steel castings and repairing castings instead of scrapping them. This transformer was an effort to replace the expensive direct current with a cheaper alternating-current machine but experience very soon showed that alternating-current was not satisfactory for this purpose. Due to the fact that when an arc is drawn between steel and a carbon electrode approximately three-quarters of the heat appears at the positive electrode and the remainder in the arc and at the negative electrode, direct current had to be used for the purpose of repairing castings. As a result of the failure of the alternating-current transformer to do the work, direct-current machines were developed in which the voltage produced on the machine was equal to the arc voltage. Direct-current machines used for repairing steel castings before this time were constant-voltage machines of about 60 or 70 volts and a resistance was used between the machine and the work. A voltage of 25 or 30 volts across the arc meant that at least as much more power was wasted in a stabilizing resistance in series withthe arc. The Lincoln Electric Company developed a machine which could be short circuited without excessive currents and which provided a voltage equal to the arc voltage and eliminated the waste in the stabilizing resistance which was common at that time.

About 1909 or 1910, the first stabilizer that I happen to know of was used in connection with one of these larger machines used for repairing steel castings. This stabilizer was not as well designed as later ones were but it answered its purpose from a commercial standpoint.

About 1910 The Lincoln Electric Company developed small machines which were used for operating moving picture machines. These machines were called "bill splitters" because the machine developed only the voltage required by the arc and saved the power which was wasted in stabilizing resistance in series with the arc in most of the moving picture theaters. The bill splitters and most larger machines for repairing steel castings were operated from direct current and consisted of a single machine designed so that the supply current came to the commutator by the regular brushes and the welding current was taken off by special brushes. A line of welders from 150 to 300 amperes was developed by The Lincoln Electric Company about 1911 and 1912,

* Paper prepared for the 1931 Proceedings of the Master Boiler Makers' Association.

† Chairman of the board, The Lincoln Electric Company, Cleveland, O.

consisting of a motor either direct current or alternating current, direct connected to a direct-current generator. This direct-current generator was developed with a winding arranged so that the generator voltage was that of the arc and no power was lost in a stabilizing resistance. In principle this welder has remained unchanged to date. Many improvements in mechanical details have been made however.

In connection with this line of welders an improved stabilizer was developed which has remained largely unchanged since its development as far as electrical features are concerned, the only change being made in recent years has been to increase the ventilation on the magnetizing coils.

In 1913 an experiment was performed showing that it was possible to weld copper with the carbon arc. Out of this experiment grew the development of a bond for street car rails which was attached to the rail by the aid of the carbon arc and from this development a fairly natural step was the development of the welded rail joint in which the carbon arc was used to weld a seam between the bottom of the fish plate and the rails and a similar seam between the top of the fish plate and the rail thereby eliminating the joint by making the rail continuous and eliminating the necessity for any bonds to carry the return current through the rail.

From the experiments with the carbon-arc welding of bonds and rail joints, the necessity for a ductile weld metal became apparent and the search for such a weld metal to be produced by the carbon arc began. Back in those days it appeared reasonable to assume that the reason that a rolled piece of steel was ductile was due to the mechanical working to which the steel was subjected. It was a matter of common knowledge that steel castings were not as ductile as the same steel after it had been rolled or mechanically worked and it was generally accepted that any steel casting would necessarily be brittle because it did not have mechanical working. On this theory a machine was developed which drew an arc and immediately behind the arc a hammer was provided which pounded the metal while it was still in its plastic state, giving it an amount of working which would be comparable to what a bar gets when it is forged under a power hammer. Experiment with this machine indicated that it was possible to get a metal which was freer of slag inclusions than the parent metal but the ductility was not greatly improved by the mechanical working.

About this time the first arc-welded boat that I happen to know anything about was built in Ashtabula. This boat was welded by one of The Lincoln Electric Company welding machines. The work was done with the metallic arc. I am told that the sheets were about 1/8 inch or 3/16 inch thick and that some 10 years after the boat was built it was still in use. Four or five years after the boat was built it encountered an ice jam and the plates were pretty badly buckled. These bottom plates were straightened without opening the welds, which at that time was an unexpectedly good performance for a welder. As far as I know this boat is still in use but I have not heard anything about it for 6 or 8 years.

Metallic arc welding began to be generally recognized as a possible process of commercial importance during the World War. In 1915, I think it was, the cylinders on the engines of some interned German vessels were dynamited to make them useless to the United States Government. The cylinders on these engines were repaired by metallic arc welding and this advertised the process to an extent that it never had been advertised before and brought it into general notice. What was called The Emergency Fleet Corporation was part of the government's activities during the war and a rather large committee of the Emergency Fleet Corporation gave a great deal of attention to metallic arc welding at that time. A large number of samples, several tons, I believe, were welded up and these samples were to be tested to determine such questions as what was the best current to use, the best size of rods, the best voltage to use, also to find the tensile strength of the joints and in general to test metallic-arc welding as applied to boat building in something the same way that the Structural Steel Welding Committee of the American Welding Society has recently tested metallic arc welding as applied to steel structures used in buildings. The Armistice caused this investigation to be dropped and as far as I know the scrap man got the several tons of samples which were about ready for testing.

It was about this time that the possibilities of developing ductile metal for the carbon arc became a matter of great interest and the writer submitted some samples which had a high ductility for the art as developed at that time to the Welding Committee of the Emergency Fleet Corporation. These welds were made under a neutral atmosphere by the carbon arc and while the ductility was very much inferior to what can be obtained now, the ductility was a distinct step in advance when compared with a weld made by other methods at that time.

About 1915 The Lincoln Electric Company first used welding in replacing castings in the machinery that they manufactured for sale. Regular production of The Lincoln Electric Company at that time was largely alternating-current motors and a starting compensator was necessary with most of these motors. A compensator made of cast iron was very expensive, the number of failures of the foundry in making castings were numerous and the difficulty was so great that an attempt was made to use sheet metal as a material to make compensator cans instead of using cast iron. Sixteen-gage sheet steel was used, the can was so designed that it was possible to make what we now know as edge welds. The edge weld was made by the carbon arc and a very satisfactory can was produced for about 15 or 20 percent of the cost of the old cast-iron can. Many thousands of these cans have been made and used for many years, so far as I know, without any failure.

From this first use of welding in an effort to replace castings, grew rather rapidly the application of welding to replace all kinds of castings so that by 1923 or 1924, most of the castings on the motors and welders manufactured by The Lincoln Electric Company had been replaced by steel parts welded.

The replacement of cast-iron end rings, for instance, on induction motors by steel-end rings made possible a very much better motor at a very considerable saving in cost. It always has been the custom to provide end plates, place the stator laminations between the end plates, rivet the end plates together thereby holding the laminations in place. When cast-iron end plates were used a pressure of 10 tons on the end plates was all that could be used without occasionally cracking the end plates. When the welded steel-end plates replaced the cast-iron end plates this pressure was raised to 70 tons thereby greatly improving the quality of the resulting structure.

This is simply an example of what was obtainable in general by the substitution of welded steel for cast iron.

Another sample I happen to think of is an all-steel welded cart for carrying welders which replaced a cart which we formerly bought outside. The cost of the welded cart was very much less than the cost of the cart which we bought outside which was made of an oak bed and cast-iron wheels. Further than that—the welded steel cart would carry twice the load without breakdown that the former cart would carry.

These two instances of improvement in quality while at the same time reducing costs, were typical of what the application of welding made possible in replacing castings.

You will probably be interested in some information which came from the Baldwin Locomotive Works with reference to the welding of locomotive parts.

Mr. Glaezner under date of July 2, 1931, gives the following information.

Tubes were first welded to the tube sheets by the electric arc in 1909 on a locomotive at the Atchison Topeka and Santa Fe Railroad.

The ends of longitudinal seams of boiler rings were welded to eliminate scarfing of butt straps by the electric arc method in 1917.

Firebox seams were electrically welded for a locomotive delivered to the Erie Railroad in 1916.

Cabs were welded by the electric-arc process on a locomotive for the Campbell Creek Coal Company in 1922 and a tender tank was welded on a locomotive for the same Campbell Creek Coal Company the same year, namely, 1922.

In 1926, the automatic carbon arc process, known as the "Electronic Tornado" had been developed to a point where it was possible to manufacture pipe commercially. The first large installation of these pipe-making machines was in California and the Mokelumna Pipe Lines supplying water to Oakland and other Bay cities around San Francisco was welded by this process. This pipe was about 65 inches in diameter with a wall thickness of ½ to ⅝ inch. The pipe line was some 90 miles long. Two longitudinal welds were made on each length of this pipe. This is the first large installation of welded pipe with which the writer is acquainted.

In 1927 The Lincoln Electric Company in co-operation with The Austin Company at Cleveland, welded the steel structure of a four-story building on Carnegie Ave., in Cleveland. Since that time many buildings have been erected by the metallic-arc process.

The latest development of The Lincoln Electric Company is in the production of a metallic electrode which will give a ductile metal. Experiments with the Electronic Tornado showed that when the atmosphere around the carbon arc was properly controlled the resulting weld metal was purified during the melting process and the resulting weld metal had a ductility approaching that of the parent metal. It was decided to produce if possible an electrode which could be used in the metallic-arc process which would give a similar ductility in the weld metal.

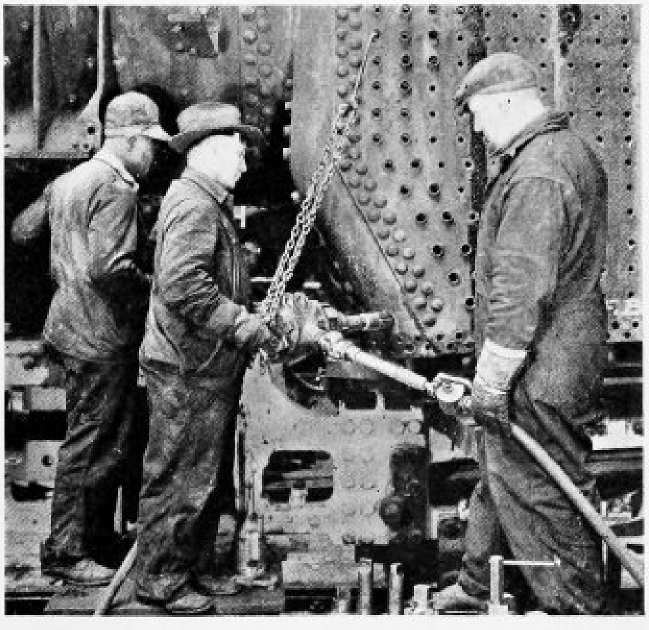
After many experiments, what we call "Fleetweld" has been developed and the physical qualities of the weld metal deposited from Fleetweld approach the ductility of the parent metal and in general it exceeds the parent metal in tensile strength and in elastic limit. The control of the atmosphere around the arc which is made possible by the character of the coating on Fleetweld rod improves the quality of the metal as it passes across the arc. Fleetweld coating provides a stronger reducing atmosphere at the arc and is another illustration of the fact that when the atmosphere is right, the metal after it has crossed the arc is very much better than the metal in the electrode before it was melted. To put it another way, the ductility and tensile strength of Fleetweld after it has crossed the arc is very much superior to what would be obtained if the steel rod composing the electrode was melted and cast. This improvement is probably due to the fact that the original electrode material contains a small amount of dissolved iron oxide. This dissolved iron oxide makes the ductility of the cast metal inferior to that of the cast metal after it is worked mechanically. When the metal passes across the arc in a strongly reducing atmosphere this small amount of iron oxide is reduced and the resulting cast metal has physical properties equal to or superior to that of the parent metal as indicated above.

Two Boiler Shop Devices

Shop devices which contribute either to safety or increased production are always welcome in the boiler shop and of general interest to boiler shop foremen and supervisors. The first of those illustrated in this article comprises a special valve inserted between the air hose and the operating handle of an air motor to permit shutting off the motor instantly, in case of necessity, while reaming and tapping mud-plug holes or blow-off cock holes. The reversible compound piston-type air motor is suspended at the proper elevation by means of a chain and hook inserted in a flexible staybolt hole, as this type of motor weighs about 54 pounds. A long dead lever is used, being held by a helper to prevent the motor getting away from the operator in case of sticking, which is always more or less of a possibility with large holes such as this 2¼-inch mud-plug hole.

The additional control valve, plainly shown in the illustration, is a spring-lever valve which remains open only while the handle is pressed down by the helper at the right, and closes instantly on release of the lever in case the large reamer or tap gives any indication of sticking. The closing of this valve shuts off the supply of air to the motor immediately and stops the motor even quicker than could be done by the use of the usual handle control valve.

With this method of operation and arrangement of the motor the boiler maker in the center is left free to devote his entire attention to lining the motor up prop-



Reaming boiler washout-plug hole with an air motor, a special quick-action shut-off valve being provided in the air line

A special lever arrangement facilitates the rapid countersinking of rivet holes in a firebox door-sheet flange

erly and making sure that the reaming or tapping operation proceeds at the proper rate for the best results.

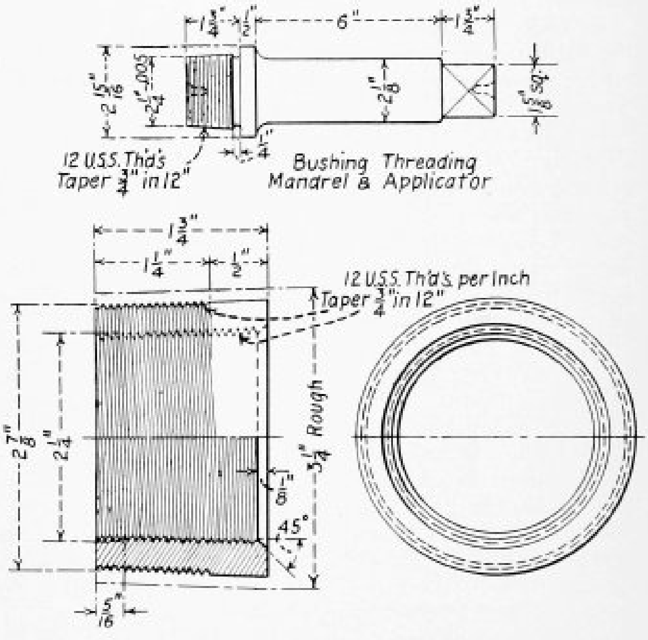
The second illustration shows the use of a close-quarter air drill in countersinking rivet holes in the flange of a fire-door sheet, using a special U-shaped hook-and-lever arrangement for feeding the drill. As illustrated, this device consists of a U-shaped forging, the two legs of which are about 24 inches apart and 10 inches long, the outer one being provided with an inward horizontally projecting end to fit in the rivet hole adjacent to the one being counterbored. By means of the long adjustable lever, pivoted in the U-forging and provided with a head bearing against the motor feed screw, sufficient pressure can readily be brought to bear on the motor to accomplish the counterboring operation quickly. The feeding device is then moved to the next hole easily and without any loss of time. By means of the bolt and four holes shown in the U-shaped forging, this device can be quickly adjusted for use with different sizes of motor or different lengths of counterboring tool.

Blow-Off Cock Application

While there is a decided tendency towards the use of flanged blow-off cocks on steam locomotives, many with threaded applications are still in service, and these threaded connections must be maintained in a safe and serviceable condition during the remaining effective life of the blow-off cocks.

The repeated removal and re-application of blow-off cocks has a tendency to produce thread wear and, moreover, boiler sheets frequently become thin inside the water leg and around the blow-off cock holes, to such an extent that the number of full holding threads is reduced and a potential hazard created. To overcome this condition, one road developed the steel bushing illustrated. This bushing is made of open-hearth steel, finished all over and machined with 12 U. S. threads per inch and a taper of ¾ inch in 12 inches, both inside and out. The smallest diameter of the bushing where it enters the boiler sheet is 2⅞ inches, and the smallest diameter which receives the threaded end of the blow-off cock is 2¼ inches. Enlargement of the blow-off cock hole in the boiler sheet to receive the bushing is usually adequate to cut away entirely the thinned portion of the sheet and provide practically the original sheet thickness in which the full number of new threads can be cut to receive the bushing. A fillet of electric-welded metal is then applied between the boiler sheet and the bushing, which greatly strengthens the construction and prevents the bushing from backing out when the blow-off cock is being removed.

The bushing illustrated is made from 3½-inch tubular open-hearth steel stock threaded on the interior diameter and cut off to the required length in a turret lathe. The mandrel illustrated in the upper right corner of the drawing is then threaded into the bushing and used to support it in an engine lathe, while the outside of the bushing is being cut to the required taper and threaded. The mandrel is provided with centers and one end cut to a square to receive the lathe dog used in the turning operation. This mandrel also proves very useful in ap-



Details of a bushing used for the improved application of screw-type blow-off cocks

plying the bushing to the boiler sheet, assuring that this will be done without damage to the bushing. The design of the mandrel is such that it can be used to turn the bushing solidly into place, a reverse movement readily releasing it, since the shoulder prevents any binding on the threads.

The Birmingham office of the Independent Pneumatic Tool Company has been moved from the Comer Building to 915 North Seventh Avenue. The new location has warehouse facilities which will enable the Birmingham office to carry a complete line of pneumatic and electric tools, as well as spare parts. H. F. Halbert is manager.

Thermic Syphons and Maintenance Costs on Boilers

While many articles have appeared on various phases of the thermic syphon and its effect on the operation and economy of the locomotive boiler, the accompanying report of a committee of the Master Boiler Makers' Association, concerning reduced maintenance costs and decreased staybolt breakage from such applications, gives the boiler maker's analysis of this important feature of the modern locomotive boiler. The report for the 1931 Proceedings of the association was prepared by a Committee composed of Lewis Nicholas, chairman, Edward Hunt, and J. P. Powers.

Thermic syphons are so designed and located in the hottest part of a boiler as to induce a definite and rapid circulation of the boiler water. For the sake of brevity, and assuming that all boiler foremen and inspectors are familiar with them, no elaboration will be made in this report on the design or description of thermic syphons.

For many years past it has been accepted that the free circulation of boiler water would have a beneficial influence on the life of the boiler structure. Probably, to many of us, the theories for anticipating benefits from circulation were somewhat vague and, in fact, many of us likely did not even stop to think of them. We might well have taken for granted that the same laws of nature would apply in connection with water contained in a boiler structure as they do in connection with more or less unconfined bodies of water. We all know, for example, that rapidly moving water, as in rivers or mountain streams, has a tendency to self-purification and that, on the contrary, the still bodies of water in marshes or ponds have a tendency to stagnation and impurity.

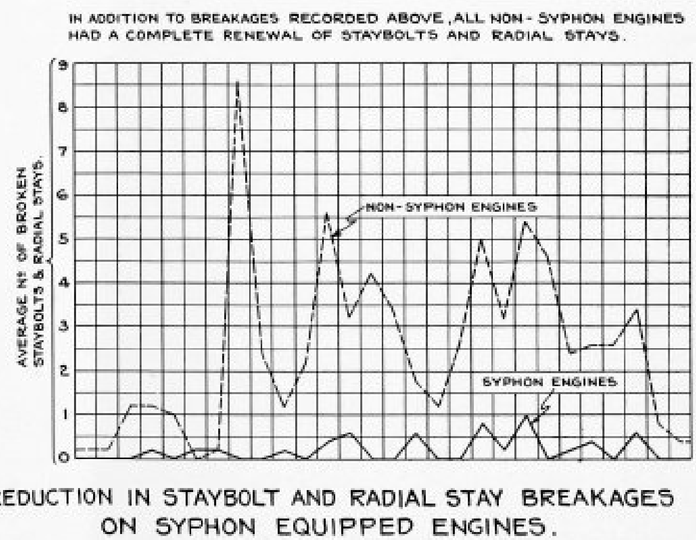
It is a matter of common knowledge that, in the conventional type of locomotive boiler, there are certain areas of the boiler in which there is very little circulation or movement of the water and these are commonly referred to as stagnant areas. This would logically be applied to the front portion of the boiler section nearest the smokebox, where the heat transfer is relatively very low and, in fact, also to the lower portions of the water legs around the firebox, notwithstanding the high firebox temperatures.

The statement is often made, "You can put your hand on the outside or wrapper sheet above the mud ring without burning it and can get cold water out of the blowoff cock even after the boiler has been fired to a full head of steam." Such expressions may be slight exaggerations, but they are, and have been, so general as to indicate a condition of fact. Wide temperature variations in different parts of the boilers bring about widely varied stresses in the boiler structure, resulting in flue and staybolt leakage and firebox fractures. Also, those boiler foremen located in bad water territories are familiar with the troubles arising from pitting and corrosion, as well as scale and mud accumulations in such stagnant areas.

With the introduction of the thermic syphon, those, who have made observations, have found every evidence, technical and practical, that a very definite and rapid

		1925 Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	1926 Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	1927 Jan	Feb	Mar	Apr	May
NON-SYPHON ENGINES	1	1	1	2	2	2	–	–	–	6	1	1	7	4	5	7	3	–	5	3	4	7	–	1	4	5	6	–	2
	2													3	–	6	–	–	–	3	3	10	15	–	3	–	3	–	–
	3					2	–	–	1	–	–	–	–	–	–	2	1	–	3	15	5	3	3	–	1	5	–	–	–
	4				4	1	–	–	–	5	5	10	20	9	9	–	1	5	1	1	4	4	2	11	5	3	5	4	–
	5			4	–	–	–	1	42	1	–	–	1	–	7	2	4	1	4	3	–	3	3	–	–	–	3	–	–
	TOTAL	1	1	6	6	5	–	1	43	12	6	11	28	16	21	17	9	6	13	25	16	27	23	12	13	13	17	4	2
	AVG.	.2	.2	1.2	1.2	1	–	.2	8.6	2.4	1.2	2.2	5.6	3.2	4.2	3.4	1.8	1.2	2.6	5	3.2	5.4	4.6	2.4	2.6	2.6	3.4	.8	.4

IN ADDITION TO BREAKAGES RECORDED ABOVE, ALL NON-SYPHON ENGINES HAD A COMPLETE RENEWAL OF STAYBOLTS AND RADIAL STAYS.



REDUCTION IN STAYBOLT AND RADIAL STAY BREAKAGES ON SYPHON EQUIPPED ENGINES.

		1925 Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	1926 Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	1927 Jan	Feb	Mar	Apr	May
SYPHON ENGINES	6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	7	–	–	–	1	–	–	1	–	–	1	–	–	–	–	–	3	–	–	–	1	–	–	–	2	–	–	–	–
	8	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–
	9	–	–	–	–	–	1	–	–	–	–	–	2	–	–	–	–	–	–	4	–	1	–	1	–	–	–	–	–
	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	–	–	–	–	–	–	–
	TOTAL	–	–	–	1	–	1	1	–	–	1	–	2	3	–	–	3	–	–	4	1	5	–	1	2	–	3	–	–
	AVG.	–	–	–	.2	–	.2	.2	–	–	.2	–	.4	.6	–	–	.6	–	–	.8	.2	1.0	–	.2	.4	–	.6	–	–

Comparison of syphon and non-syphon equipped locomotives circulation of water is induced. With the use of pyrometers practically uniform temperatures have been found throughout the boiler, even before the conclusion of the firing-up period; hence the varied and damaging stresses above referred to are eliminated. Again in the process of washing out syphon-equipped boilers, the mud accumulations are noticeably absent and scale deposits decreased to a marked extent.

In preparing this report, a questionnaire was submitted to many railroads, asking for information as to reduction in staybolt breakage on locomotives having syphons, what increased flue mileage, if any, if obtained, what increased life, if any, of firebox sheets and what effect the application of thermic syphons had in reducing the accumulation of scale on firebox sheets and flues. The answers from these railroads are almost unanimous in verifying the conclusions previously expressed. Because of lack of data it is impossible to present a tabulation but a few examples of replies are quoted.

On one railroad, for instance, the answer to the question about reduction in accumulation of scale on firebox sheets and flues is as follows: "To a very noticeable extent, our experience indicates that with our syphon-equipped boilers, there is an absence of hard accumulation of deposits and the sheets and flues are exceptionally clean. On one class of locomotives not equipped with syphons in the lower row of flues, we had to remove seven flues on account of accumulation of mud in the bottom of the boiler barrel, resulting in burned flues. Following the application of syphons, we were able to re-apply these flues and with consequent additional heating surface, and yet, at the same time, keep the barrel of the boiler and the flues clean."

On another railroad where there has been considerable difficulty because of pitting, it is stated: "Locomotives equipped with syphons are more free from scale deposits and pitting around crown stays. Our experience with syphons has not been long enough to state to what extent firebox sheet life will be increased but it is our opinion that because of the improved conditions already noted, they will definitely do so."

On one railroad an example is given of locomotives without syphons requiring renewal of six to fifteen radial stays per month after the locomotives have been in service about fifteen months. Two syphon locomotives placed in the same territory and service required no radial stay renewals after twenty and twenty-three months respectively at the time of reporting, and apparently gave every indication of continuing this record almost indefinitely. A further comparison on that same railroad shows that over a period of nearly four years, sixty-five locomotives without syphons required the renewal of 4004 broken stays and radials with average miles per bolt of 4060. On fifteen syphon-equipped locomotives in the same classes of service and territory only 327 broken stays and radials were found, with an average mileage of 17,886, an increase of nearly 350 percent in mileage per bolt.

A graphic chart shown on page 269, was submitted for another railroad covering a comparative study of staybolt breakage over a period of two and one-half years of five locomotives without syphons and five equipped with syphons in the same service and territory. Sufficient to say here that it shows a record very favorable to the syphon-equipped locomotives similar to examples heretofore quoted.

Observation was made on one railroad for comparison of flue mileage on twenty locomotives without syphons and twenty locomotives equipped with syphons on the same division and same class of service. The twenty locomotives without syphons showed mileage between flue renewals of 73,000, all of these locomotives having had flue renewals; while at the time of making this comparison only three of the syphon-equipped locomotives had had flue renewals with an average mileage of 133,000, an increase of more than 80 percent. The other seventeen locomotives still in service had had no flue renewals and were going on to even higher mileage. Another railroad showed on observation an increase from 65,000 miles maximum between flue renewals on locomotives without syphons, to over 110,000 miles on syphon-equipped locomotives, an increase of approximately 70 percent in flue mileage. One railroad reports a Consolidation locomotive equipped with syphons, operating in a bad water district and coming in for general repairs, showed only a paper thickness of scale and 50 percent less pitting than any other locomotive in the same territory in years.

Practically every railroad reporting stated the conclusion that there is considerable less accumulation of scale on firebox sheets of locomotives equipped with syphons and this should have a very beneficial effect on firebox life. The only variations from this answer to the questionnaire were on roads reporting that their water conditions were such that they had little or no trouble from scale.

The general trend of the reports is to the effect that improved results are experienced in various sections of the country, and with greatly reduced staybolt breakage and decrease in flue and firebox maintenance while away from the shop. The syphon-equipped locomotives are coming to the shop for general overhauling with flues and fireboxes in much better condition than those not equipped. The period of time and mileage between side sheet renewals has been materially lengthened.

There is difficulty in obtaining any great volume of specific data as to mileage and cost comparisons, in view of the fact that records are rarely kept in such detail as to permit ready tabulation. Locomotives are frequently moved about on various divisions of a railroad, and for these reasons your committee finds it impractical, as previously stated, to offer information in tabulated form. The result of its study, however, shows such a general conformity of observations that its conclusions must be definitely drawn to the effect that thermic syphons, because of superinduced boiler water circulation, do unmistakably result in reducing maintenance and increasing the life of the boiler structure. The extent of these effects are, of course, varied in proportion to the service and water conditions in which the locomotives are operating.

One further consideration, which may seem outside the range of this report, is the factor of safety afforded by the syphons in preventing boiler explosion in case of low water. From various sources of information, including the records and reports of the Interstate Commerce Commission, your committee makes the conclusion that thermic syphons are definitely effective in preventing boiler explosion in case of low water. The enormous item of maintenance involved in a boiler explosion needs no comment, whereas the extent of the damage to syphon-equipped locomotives in cases of low water has been practically nothing.

The Ludlow Valve Manufacturing Company, Troy, N. Y., maker of Ludlow Diamond hydrants, double-gate valves, and Ludlow multi-valves, will manufacture in Canada as The Canadian Ludlow Valve Manufacturing Company, Ltd. Offices are located at 930 Wellington Street, Montreal, Que.

Work of the A. S. M. E. Boiler Code Committee

The Boiler Code Committee of the American Society of Mechanical Engineers meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the secretary of the committee to all of the members of the committee. The interpretation, in the form of a reply, is then prepared by the committee and passed upon at a regular meeting of the committee. This interpretation is later submitted to the council of the society for approval after which it is issued to the inquirer and published.

Below are given records of the interpretations of the committee in Cases Nos. 666, 677 (Reopened), 683, 686 to 691, as formulated at the meeting on June 27, 1931, all having been approved by the council. In accordance with established practice, names of inquirers have been omitted.

Case No. 666. *Inquiry:* Do the provisions of Pars. P-195 and U-36 for increasing the thickness of heads when manhole or access openings are used, apply also to large nozzles when attached to dished heads? If it is necessary to so increase the thickness, what is the minimum diameter of nozzles to which these requirements do apply?

Reply: The provisions of Pars. P-195 and U-36 for increase of thickness of heads containing manhole or access openings do not apply in the case of openings for nozzle fittings which are attached to the head and reinforced in accordance with the requirements of Pars. P-268 and U-59.

Case No. 677 (reopened). *Inquiry:* May the longitudinal seams of tanks for the storage of air or water under pressure be made under the rules of the Code for Unfired Pressure Vessels by using the electrical resistance compression butt weld method? This process of welding involves bringing the two edges of the sheet together at one point and applying locally and continuously a current of sufficient intensity to bring the edges to the welding temperature and while the heated section is in a plastic condition, compressing the edges together so as to obtain thorough union thereof.

Reply: It is the opinion of the Committee that although this method of welding is not provided for in the Code, it may be used with safe results provided the material and construction of the tank come within the requirements of the Code, and provided:

That the plate used for tanks described and for this method of welding shall meet the requirements of Specifications S-2 for Steel Plates of Flange Quality for Forge Welding;

That this method of welding be limited to the use of plate not over 0.15 inch in thickness;

That prior to the welding operation, the edges of the plate and the electrical contact area shall be clean so as to free those surfaces from scale, oxides or grease;

That the weld be made progressively and continuously over its entire length;

That the offset of the edges due to the compressing shall not exceed 60 percent of the thickness of the plate;

That the prescribed tests for the hydrostatic pressure as specified in the Code are complied with;

That the unit stress shall not exceed 8000 pounds per square inch.

A revision of the Code to permit the above construction is under consideration.

Case No. 683. *Inquiry:* In the fabrication of A.S.M.E. Code power boilers and unfired pressure vessels, is it permissible to use seamless steel cylinders rolled to size from hollow ingots, in which the rolled cylinders are made in accordance with the specifications submitted (on file in Secretary's office), and in particular having the following minimum physical properties:

	Grade 1	Grade 2
Tensile strength, lb. per sq. in.	60,000	75,000
Yield point, lb. per sq. in.	0.5 tens. str.	0.5 tens. str.
Elongation in 2 in., percent	26	24
Reduction of area, percent	42	38

It is understood of course that these cylindrical shells will be assembled into vessels in accordance with the Code rules, by riveting, fusion welding, or other suitable means. It is noted that there is no existing specification in the Code for such material.

Reply: Pending the result of joint action of the Boiler Code Committee and the American Society for Testing Materials upon a Proposed Specification for Seamless Rolled Steel Cylinders, it is the opinion of the Committee that shells of pressure vessels and power boilers may be constructed of this material under the provisions of Sections I and VIII of the Code, provided the material conforms to the requirements of the Proposed Tentative Specifications.

Case No. 686. *Inquiry:* *a* Is it the intent of the Code to permit the omission of stress relieving of fusion-welded nozzles, when such are constructed in accordance with Fig. U-6, types A, C, D, and E and when the inside diameter in any case does not exceed that given in Fig. U-6 or by *d* in the formula in Par. U-77 where this formula applies?

b In the case of nozzles attached by fusion welding in tanks with seams of riveted construction and when the nozzles do not require stress relieving, is it the intent of the Code, as stated in the last part of Par. U-77, to allow the attachment of nozzles prior to the making up or attachment of the courses by riveting as an alternate to locating nozzles at a distance from the riveted seam equal to the diameter of the nozzle plus 4 times the shell plate thickness?

c When the inside diameter of an unreinforced fusion-welded nozzle given by *d* in the formula in Par. U-77 is greater than the largest diameter of an unreinforced circular opening, calculated by formula 1 or 2 in Par. U-59, may the latter value be disregarded in favor of the former, or shall that formula which gives the smaller value of *d* govern the size of the opening?

Reply: *a* Yes—attention is called, however, to the fact that under the proposed new rules for fusion welding, nozzles must be stress relieved on all Class 1 vessels and in some cases on Class 2 vessels.

b Yes—nozzles may be attached prior to riveting, whether stress relieving is required or not, but in no case after making up or joining the courses by riveting shall stress relieving of any nozzles be permitted, nor after such riveting shall any nozzles be attached within the minimum distance specified in Par. U-77.

c The formulas and rules in Pars. U-59*a*, U-59*b*, and U-59*c* are for plain unreinforced openings, such as tube holes and other drilled openings, and connections where the welding is applied for sealing and not for strength. The size of an unreinforced fusion-welded nozzle is governed solely by the formulas and rules in Par. U-77.

Case No. 687. *Inquiry.* Specification S-3 for Steel Plate for Brazing provides that sheets less than ¼ inch in thickness need not be stamped at the mill, but that the manufacturer must mark each vessel in some permanent manner so that the material can be identified. None of the other material specifications have provisions of this sort. May not this same provision be interpreted as being applicable to all sheets under ¼ inch in thickness when made to any of the specifications in the Code?

Reply: It is the opinion of the Committee that sheets less than ¼ inch in thickness should not be marked with a steel stamp and until such time as revisions can be made in those sections of the Code which permit the use of plates under ¼ inch in thickness, the provisions of Par. 6 of Specification S-3 should apply.

Case No. 690. *Inquiry:* In the use of a forged flange inserted from the inside of the shell and seal welded as shown in Fig. U-3A, may the material in the flange be considered as a reinforcement?

Reply: No—the welding shown in Fig. U-3A is simply seal welding and not welding for strength. It is the opinion of the Committee, however, that the material in the flange may be considered as reinforcement only if the amount of welding is sufficient to transmit to the shell the stresses capable of being developed by the flange, and provided the welding is in accordance with that required in Fig. U-6.

Case No. 691. *Inquiry:* May the thickness for a dished head with a reversed flange as shown in Fig. 27 be figured on the basis of a head concave to pressure?

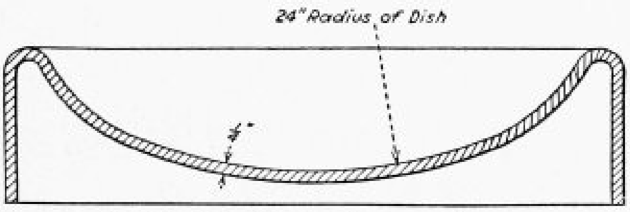


Fig. 27.—Dished head with reversed flange

This is for use in a small tank constructed for 100 pounds working pressure.

Reply: It is the opinion of the Committee that a head of this design does not meet the present requirements of the Code. If it is desired to use such construction, specific data should be submitted to the Boiler Code Committee demonstrating the safety of the construction proposed.

Hydraulic Tables and Other Data.—The Baldwin-Southwark Corporation, Philadelphia, Pa., has recently issued a bulletin devoted exclusively to the presentation of practical information and data for engineers engaged in the design or use of hydraulic equipment.

Kinks on Bending Angles

By George Gardner

In bending an internal corner in an angle iron, the standing flange should be set out somewhat as at *A*, Fig. 1, before bending, as this flange will draw in, and

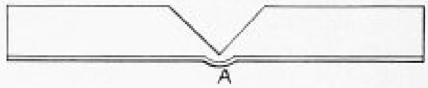


Fig. 1

if not set out, the resulting corner will not be square. It is difficult to correct for lack of squareness without thinning the material. If the corner, shown in Fig. 2, has to be welded by oxy-acetylene or electric arc, the corner is liable to alter in welding, the tendency being for the corner to draw in making the resulting angle less than 90 degrees. If this is slight it can be corrected by slightly stretching. This is done by hammering the flat flange at the corner which will open the angle.

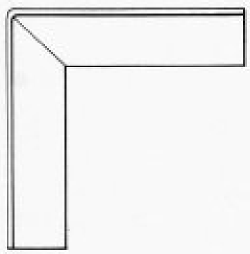


Fig. 2

In offsetting or joggling angles to fit over a plate, it helps considerably to cut a triangular piece at the point *A*, Fig. 3, before bending the angle. The material gathers at this point and cutting away the piece makes the bending easier, and helps to form the corner.

In forming a deep offset or joggled bend in an angle as at *A*, Fig. 4, it helps considerably in bending if the part *B* of the bend bears on a square corner and the

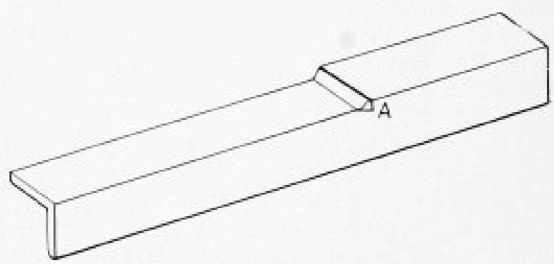


Fig. 3

joggle commenced with the tool as far away from *B* as the ultimate depth of the joggle. Then, after the two bends have been partly established, heat the joggle and "jump" the corner by hammering at *D*. This has the effect of making the two ends *B* and *C* at the same time and squaring *B* and *C*. It is surprising how deep

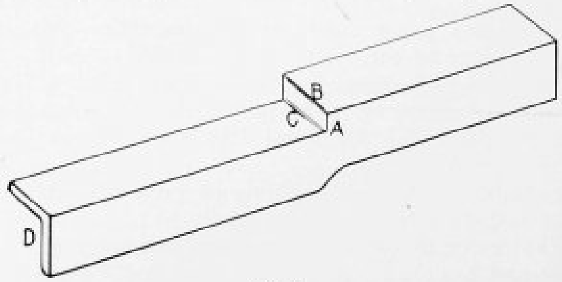


Fig. 4

a bend can be made by jumping the bar in this manner. The surplus metal which gathers in the corner at *A* can be minimized by cutting away a piece as previously explained.

In order to make a corner, as shown in Fig. 5, to fit into another angle, the distance between the joggles or

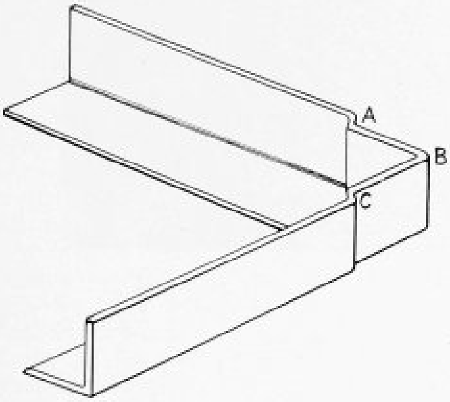


Fig. 5

offsets must be found before bending so that the finished corner will fit in the required angle. Making the distance *A-B*, Fig. 6, one and one-half times the thickness less than the added inside measurement of the angle it is to fit usually will give good results. A good plan is to check the measurements with a strip of material the same thickness as the angle. Bend this strip to fit inside the angle. Then, at a known distance from the corner of the angle on each flange, put marks and transfer the marks to the strip. Then, straighten the strip (it can be narrow so that it will bend easily) without stretching and compare the distance between the two marks and the known distance of the marks on the inside of the angle. The difference is the amount of draw, as it is sometimes called, and must be taken into account in measuring the distance *A-B*, Fig. 6. The miter should be cut out after the bar has been joggled, and the standing flange set out as previously explained.

The use of a strip is a very convenient means of checking measurements on flanged work in laying out the holes before flanging, and can be used the reverse

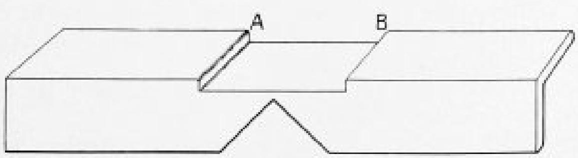


Fig. 6

way. Place two marks a known distance apart, and from the bend line on a strip before bending. Then, bend the strip in the same manner or in the same machine that the plate has to be bent. Apply a square to the outside of the strip and the difference between the added measurements from the corner of the square and the known measurements made before bending is the amount to allow the holes. The strip, however, must be the same thickness as the sheet to be used.

The Page Steel and Wire Company, Bridgeport, Conn., is opening a southeastern district sales office with headquarters at 1520 Healey Building, Atlanta, Ga. This new office will be in charge of R. J. Teeple. The Page Company is an associate of the American Chain Company, Inc., Bridgeport, Conn.

Welding Fittings

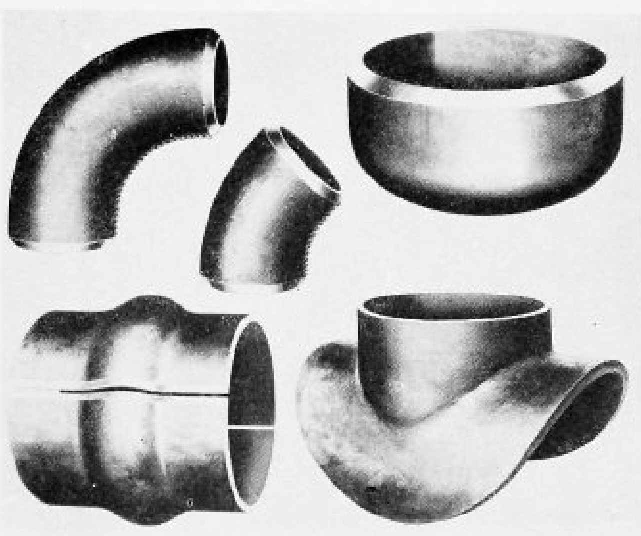
The Midwest Piping & Supply Company, Inc., 1450 S. Second Street, St. Louis, Mo., has developed a line of welding fittings for pipe work. These fittings include 90 and 45-degree ells, heads, saddles and sleeves.

Made from one piece of plate by a special process developed and patented by the Midwest Company, the ell has one welded longitudinal seam along the inner circumference. The final working of the metal is in compression at a forging heat, thus normalizing and refining the metal in the plate and the weld. It is not extruded or stretched. Every ell is subjected to a hydrostatic test pressure 25 percent greater than the mill test of the corresponding pipe. One-quarter inch of tangent is provided for each inch of pipe diameter to make the welds more accessible and remove them from the point of maximum bending stress. Sizes from 2 inches to 16 inches in diameter are available.

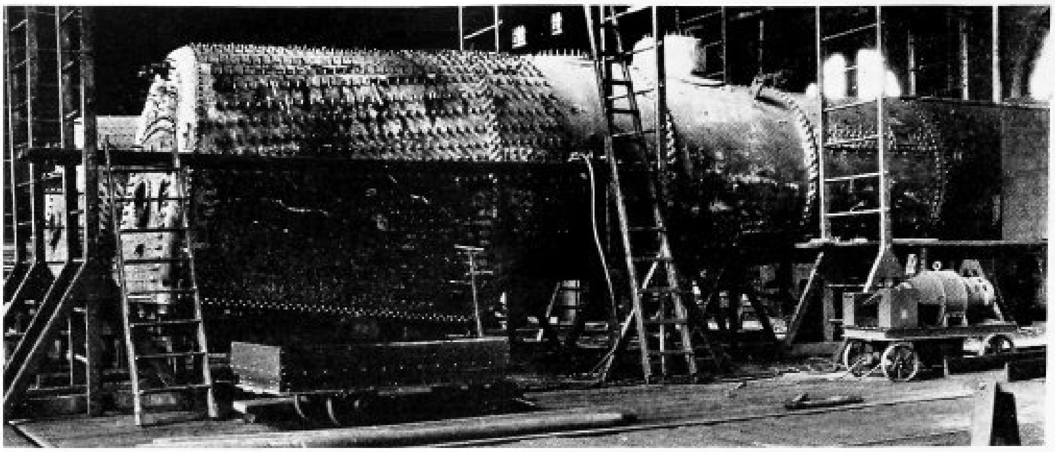
Welding heads are ellipsoidal in form to reduce the unit stress to a minimum. The circumferential weld to the pipe is in tension as the result of a long tangent. Sizes between 3 inches and 24 inches in diameter are available in stock.

The welding sleeve, used to reinforce a butt line weld between two pieces of pipe, relieves the butt weld of any bending stress and much of the tensile stress to which it would otherwise be subjected. The purpose of the butt weld then becomes principally that of keeping the joint tight. A transverse recess in the sleeve permits its application over the conventional line weld. Each half of the sleeve is slightly less than a semicircle to assure a snug fit against the pipe even when its outside diameter varies the maximum permissible amount under standard diameter. Sizes from 4 inches to 24 inches in diameter are carried in stock.

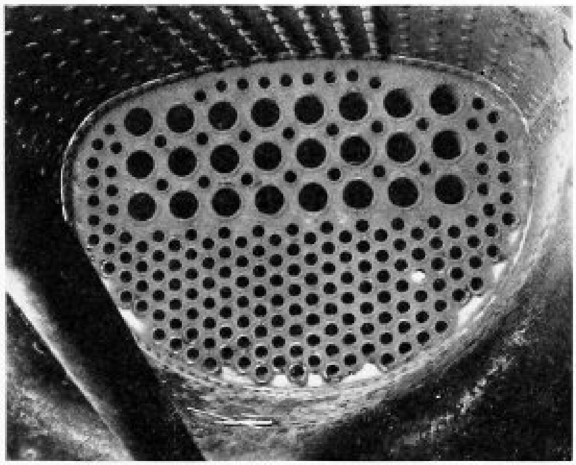
The welding saddle is a substitute for the conventional gusset plate in reinforcing the junction of the neck and body of a welded header. The saddle is slipped down the neck until it fits snugly against the body. Then it is welded into place with a heavy bead. Its purpose is not for tightness but to relieve the weld between neck and body of the greater part of the tensile, bending and shearing stresses to which it would otherwise be subjected. Sizes up to 24 inches in diameter are available.



Midwest welding ells, head, saddle and sleeve

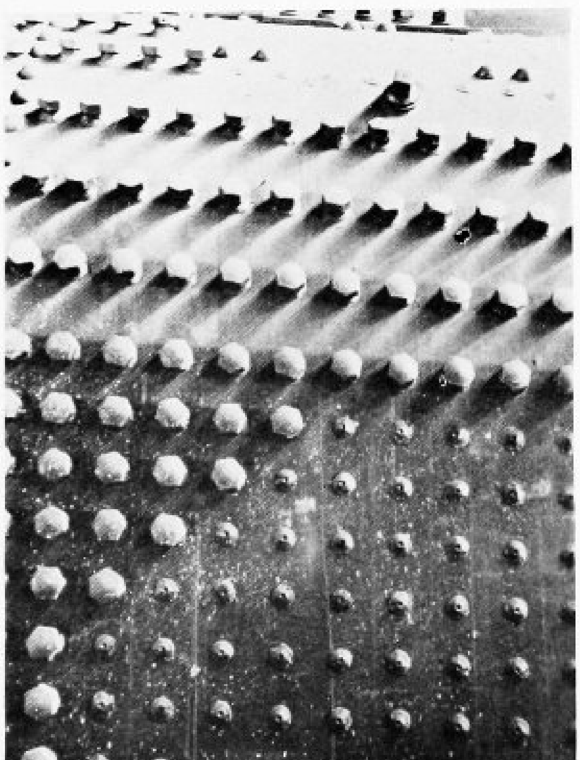


Boiler just before cutting off staybolts



After expanding, flues are welded in sheet

Welding Practice in Northern Pacific Boiler Shops



Electric welding has solved staybolt leakage problem

As in other boiler work, the application of the fusion welding processes to the construction and maintenance of locomotive boilers varies materially in method in the shops of different railroads. The following details of welding on the Northern Pacific Railroad show practice which results in a high standard of quality of boiler work. Through the courtesy of the superintendent of motive power of this railroad, the material has been made available for publication.

Only operators known to be competent will be assigned to welding of boilers.

The application of welding to locomotive boilers will be confined to stayed surfaces and smoke boxes. Welding will not be permitted on any part of the boiler that is wholly in tension under working conditions nor on arch tubes.

Crown stay heads or staybolts must not be built up or welded to sheet.

Welded seams in crown sheets will be avoided in new construction where full size sheets are obtainable, but this is not intended to prevent welding crown sheets to other firebox sheets.

Side sheet seams welded to crown sheet must not be less than 12 inches below the highest point of the crown sheet. When new crown sheets are applied this weld must be 15 inches or more below the highest point of the crown sheet to provide stock for removal of the old weld when new side sheets are applied.

Where welding is done, the parts to be welded must be properly prepared, thoroughly cleaned and kept clean during the progress of the work.

When applying patches by welding, a number of small adjacent patches will not be permitted. Instead, the defective area will be removed and repaired with one patch.

Welding of defective main air reservoirs is not permitted.

Staybolts may be removed from engines undergoing repairs by the oxy-acetylene process as shown in the diagrams on page 277. This process is not to be used unless an operator skilled in this operation is available.

Direct the flame of the cutting torch over the edge of the tell-tale hole, until the metal is heated, as shown in (a). Then apply the high-pressure oxygen gradually, at the same time moving the torch back and rotate as shown in (b).

After a depth of approximately ½ inch is reached, the flame should be directed at a 45-degree angle to the bolt as shown in (c), until the flame pierces the bolt, then rotate torch until bolt is completely out all the way around as shown in (d).

In cutting off staybolts, the head of torch is held against sheet as shown in (e); care to be taken to see that cut is made straight and about ¼ inch left outside of sheet.

The maximum oxygen pressure required for these operations is 40 pounds using a No. 2 cutting tip.

Fireboxes may be welded complete either inside or outside of the boiler. In either case the firebox is fitted up on the mud ring outside of the boiler following the method shown on page 276.

In welding tube sheet and door sheet to the crown and side sheets, the welding must be done from both fire and water sides, the beveling to be done from the fire side in all cases where butt welding is used. Where lap welding is used the lap must not be less than ¼ inch or more than ½ inch wide. When fireboxes are built up inside of the boiler, butt welds must be used in all cases.

After the sheets have been prepared if the firebox is to be welded outside of the boiler, fit same in the mud ring in the regular manner and apply necessary clamps and tack every 12 inches with tacks about 2 inches long. After the sheets have been properly tacked, remove the clamps and complete the welding.

On circumferential seams the welding should be started at the center line of the crown sheet and worked towards the mud ring on either side. Do not remove firebox from mud ring until welding is completed.

If the firebox is to be welded inside of the boiler, after the sheets have been prepared and fitted to the mud ring, the sheets will be assembled inside of the boiler.

The mud ring rivets may then be driven and the staybolts applied, but the latter are not to be driven until the welding is completed.

Butt welds of firebox sheets should be reinforced on the water side wherever possible.

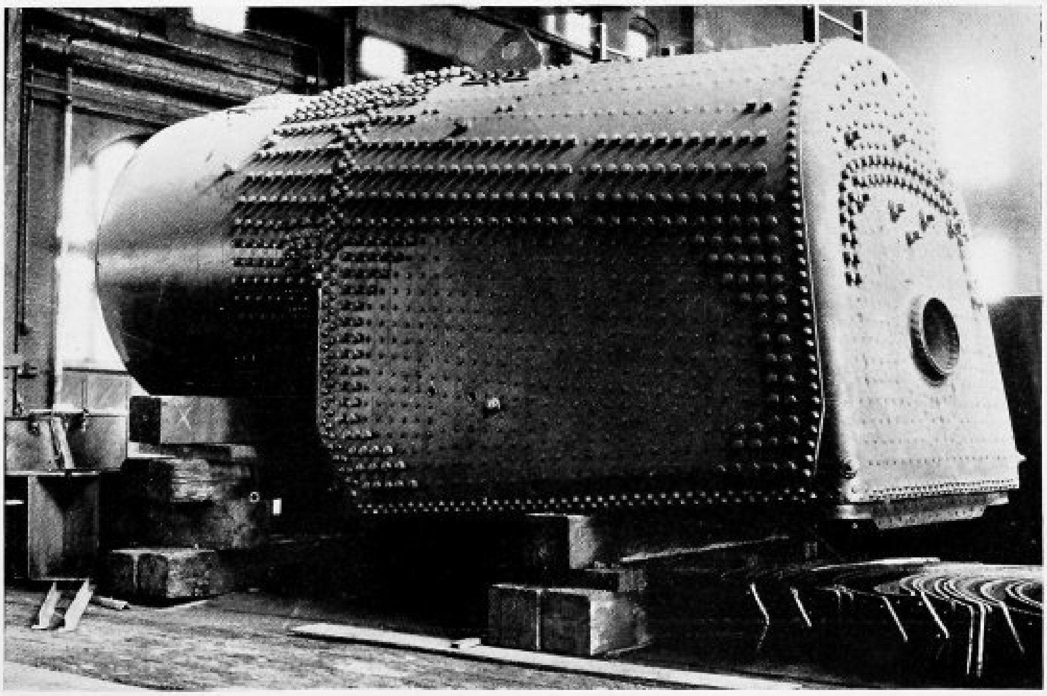
When butt welds are made by the electric process, after the vee has been filled in on the fire side the bottom of the vee should be chipped out from the water side to a sufficient depth to remove imperfections in the weld before applying the reinforcement.

Door collars should be lap welded to door sheet and riveted to the back head.

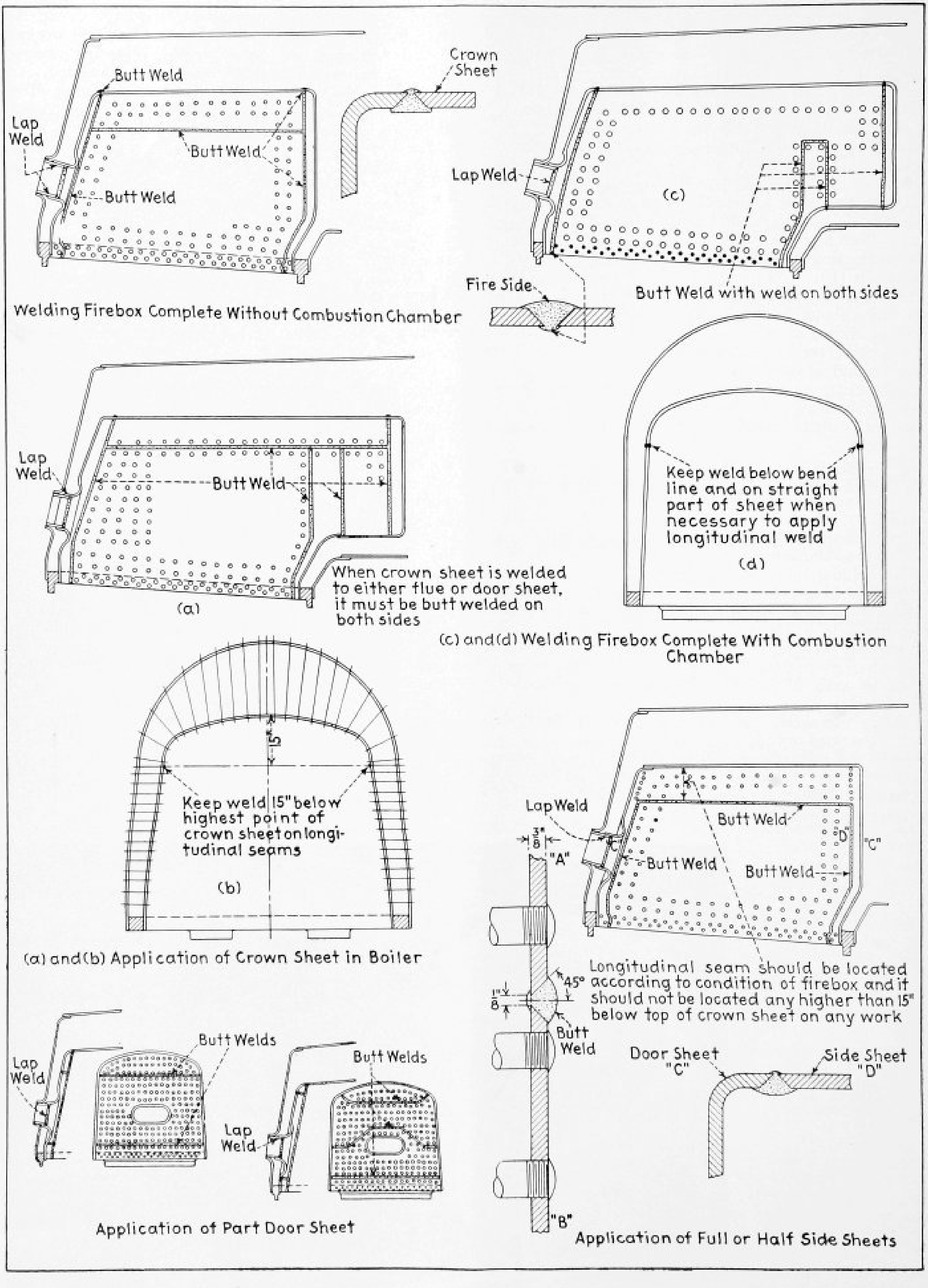
Crown sheets should be so designed that the line of weld connecting the crown sheet to the side sheets will be 15 inches or more below the highest point of the crown sheet as shown on page 276.

This will provide stock so that when the side sheets are renewed and the old weld is cut out, the new weld will not come above a line 12 inches below the highest point of the crown sheet. Crown and side sheets will be joined by butt welding from the fire side. Where a crown sheet is welded to a door sheet or back flue sheet, the weld must be made from both fire and water side, beveling from the fire side where butt welding is used. Sheets should be carefully fitted and clamped in place and tacked every 12 inches. After tacks are made, remove the clamps and complete the welding. On circumferential seams the weld should be started at the center of the crown sheet and worked towards either side.

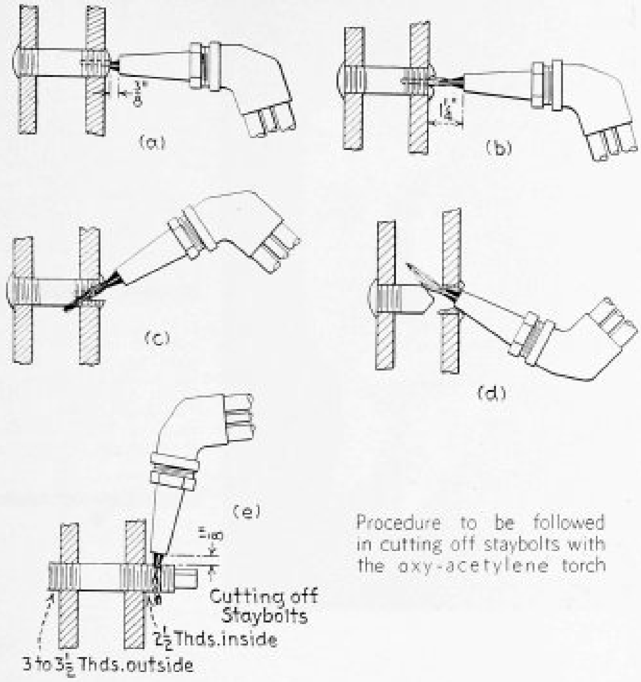
Whole or part door sheets may be renewed by the welding process as shown on the sketches. After the old portion of the sheet has been removed, which is to include all circumferential rivet seams in the area removed, the remaining edges in the firebox and those of the new sheet are fitted and beveled for butt weld. After the new portion is clamped in place it is tacked



Several complete back-end assemblies are maintained to shorten the shopping time required for modern locomotives



Methods of carrying out firebox repairs by electric-arc or oxy-acetylene welding



Procedure to be followed in cutting off staybolts with the oxy-acetylene torch

every 12 inches, after which the openings between tacks are welded from the fire side, and reinforced from the water side if possible.

If the entire sheet is being renewed, the mud ring rivets may be driven before the welding is completed.

All welding in door sheets should be completed before the staybolts are driven.

When whole or part door sheets that include the door hole are applied, the old rivet seams in the door hole should be cut out and the joint made by butt welding. At least one row of staybolts above and below the door hole should be included in part-door sheets that include the door-hole area.

When three-quarter door sheets are applied, the cut is made one or more staybolt rows above the door hole, the condition of the sheet determining the location of the cut.

When a door sheet becomes cracked or pitted at the upper flange, it may be renewed as shown in the sketch. The cut is made so the line of weld will come below the second or third row of staybolts.

The minimum height of part-door sheets applied above or below the door-hole shall be two rows of staybolts, the vertical weld falling in the side-sheet legs.

In the application of full or half side sheets the condition of the sheet will determine the location of the welds. The top weld must be at least 12 inches below the top of the crown sheet, and 15 inches where possible. The new sheet should extend to the bottom of the mud ring.

After the old sheet has been laid off it is cut out with a cutting torch and the edges beveled for butt weld. The new sheet is then fitted in, clamped and tacked every 12 inches. After the clamps are removed the welding is completed between the tacks. On the door sheet and throat sheet flanges the welding must commence at the bottom and be continued upwards. One row of staybolts should be applied in the new sheet next to the weld unless the sheet is clamped and held in place otherwise. There is no objection to applying all of the staybolts but none of them should be driven until the welding is completed. The mud ring rivets should not be driven until the welding is completed except when full side sheets are applied in which case the time of driving the mud ring is optional. Side sheets are not to be corrugated but may be applied with a slight concave roll. The minimum height of part side sheets shall be two rows of staybolts.

Either the gas or electric arc-welding processes may be used for the foregoing work, except that the oxy-acetylene process only is used for cutting out staybolts.

In the next issue further examples of the application of the welding processes to locomotive boiler maintenance and repair will be given, including firebox patches, flue sheet and other patches.

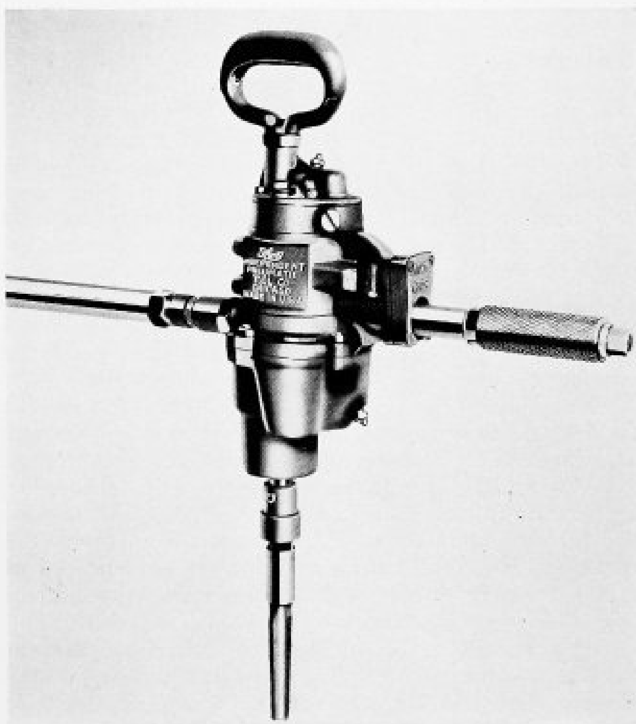
(To be continued)

Air Tool for Tapping Stud Holes

The Independent Pneumatic Tool Company, 600 West Jackson Boulevard, Chicago, has designed a new rotary pneumatic drill especially for tapping and re-tapping stud holes, etc., on locomotive boilers. This tool is constructed along the rotary air principle and is known as the Thor 254R. Stud holes on boilers were formerly tapped by hand labor and proved to be a slow, tiresome job. The new drill is capable of tapping new holes up to and including 1 inch and re-tapping holes up to and including 1⅛ inch. It can also be used for tapping new threads in cylinder head castings on locomotives.

The light weight of this tool enables one man to conveniently handle it without any assistance. While designed for tapping, it can also be used for putting on and taking off nuts, cap screws, lag screws and for many miscellaneous jobs.

It has a speed of 100 revolutions per minute, a weight of 19 pounds and a length overall of 14½ inches. The spindle is made to fit W. W. sockets only. Three sockets are included as standard equipment with each machine.



Special tool for tapping stud holes

Expansion of Seamless Steel-Tube Facilities

The Pittsburgh Steel Products Company, a division of the Pittsburgh Steel Company, the largest manufacturer of seamless steel tubes, exclusively, is taking advantage of the present depression to launch a program of expansion in its facilities for manufacturing seamless steel tubing.

As a first step in this program the company has announced the purchase from The Aetna Standard Engineering Company, Youngstown, O., of a complete new unit of the push bench type. This is a process not hitherto used in this country in the manufacture of seamless steel tubes, although it employs as a basic principle the same method as used in the manufacture of steel shell forgings during the war. This application of the forging method gives a very high quality of tubing and possesses many other advantages by giving the tubing a much better finish and a higher degree of accuracy on the diameter and the wall—also producing longer lengths. The principal feature of this method is that it will be able to produce tubes of very small diameters by the hot-rolled reducing process, which sizes formerly could only be produced by the more expensive method of cold drawing.

Champion Welding Electrodes

An announcement has been issued by The Champion Rivet Company, Cleveland, of the new Champion welding electrodes as well as rods for oxy-acetylene welding and rods to meet specific requirements.

The following details for electrodes are contained in the announcement:

Bright Bare Rod.—A fairly fast flowing rod for general welding of mild steel, producing welds of approximately 50,000 pounds, homogeneous and sound in structure.

Processed Rod.—A rod for general welding of mild steel, producing welds of approximately 50,000 pounds per square inch tensile strength and with better ductility. Has increased arc stability with easier manipulation. Suitable for flat, vertical, and overhead welding.

Type "R" Light Coated Rod (Dark Red).—This rod has all the fine qualities of its companion rod, Type "S", but is preferred by operators for overhead welding.

Type "S" Light Coated Rod (White).—A free flowing rod showing deep penetration, producing sound, clean welds of approximately 55,000 pounds tensile strength, with increased ductility, which are easily machineable. Splashing and sputtering are practically eliminated.

"Red Devil" Heavy Flux Coated Rod.—A very fast flowing electrode producing welds of unusual ductility (average 25 to 30 percent) and high tensiled strength (60,000 to 70,000 pounds per square inch). Requires higher arc voltage than ordinarily employed in metallic arc welding and reversed polarity is sometimes preferable. When the nature of the work demands strong and extremely ductile welds at increased speeds this type of rod is superior in all its characteristics.

All types of rods conform to American Welding Society specifications. They are furnished in standard lengths, but the 18-inch length is recommended for economy. Light and heavy coated rods come with center grips for easier handling.

Edward A. Simmons, born March 20, 1875; died September 30, 1931; 20 years president of the Simmons-Boardman Company.

Publisher of The Boiler Maker Dies

Colonel Edward A. Simmons, president of the Simmons-Boardman Publishing Corporation and affiliated companies, publishers of *The Boiler Maker, Railway Age,* and other business and technical periodicals, died of a cerebral hemorrhage at his home in Brooklyn, N. Y., on September 30. Colonel Simmons was in his fifty-seventh year and had been continuously associated with the *Railway Age* and its predecessor publications for forty-two years. Colonel Simmons was born in Brooklyn, March 20, 1875, and was educated in the public schools of that city. He entered the service of the *Railroad Gazette* in a subordinate capacity in September, 1889. In 1908 Colonel Simmons effected the merger of the *Railroad Gazette* with the *Railway Age* (Chicago) and served as business manager of the new company formed to take over their publication until 1911, when he assumed the presidency of the company.

In February, 1918, Colonel Simmons was commissioned a major in the construction division of the United States Army, being elevated to lieutenant colonel in the Officers Reserve Corps, Quartermasters Section, in September, 1919. In November, 1922, he was commissioned Colonel.

He was chairman of the American Marine Standards Committee; president of the American Marine Association; chairman of the Endowment Committee of the Engineering Foundation, Inc.; chairman of the United States Delegation to the International Railway Congress, Madrid, Spain (1930); associate member of the American Society of Mechanical Engineers; the American Society of Civil Engineers, Society of Naval Architects & Marine Engineers, and member of many other clubs and associations.

In addition to his activities in the publishing field, Colonel Simmons was chairman of the board of the American Saw Mill Machinery Company, president of the American Saw Works, and chairman of the board and president of the American Machine Tool Company, all of Hackettstown, N. J.

The Boiler Maker

Volume XXXI Number 10

Published Monthly by the Simmons-Boardman Publishing Company, 34 North Crystal Street, East Stroudsburg, Pa., with Executive Offices at 30 Church Street, New York City.

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Subscription Price: United States and Mexico, $2.00, Canada, $3.50, including duty. Foreign Countries, $3.00 a year. Single Copies, 35 Cents.

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Editorial Staff: H. H. Brown, Editor. L. S. Blodgett, Managing Editor. W. Lumbard, Associate Editor.

Contents

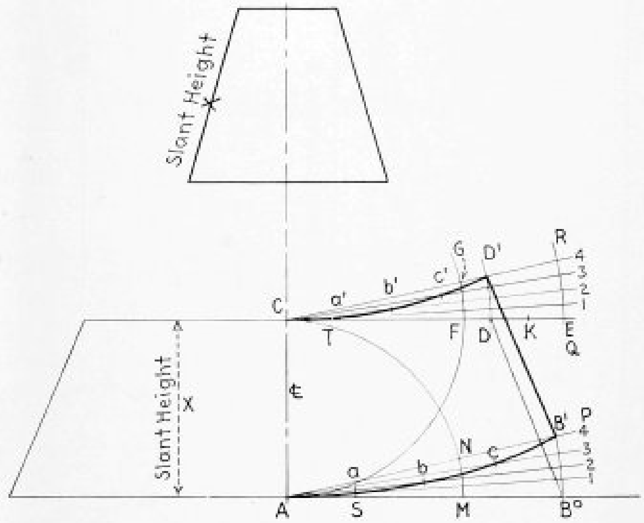
Communication

Layout of Camber Line

To the Editor:

You have shown many ways of marking the camber of cone plates, but here is an easy and good way of doing the job.

Draw parallel lines a distance apart equal to the slant height of the cone and erect *A-C* perpendicular to *A-B*. Make *A-B* equal to half the circumference of the large end and *C-D* equal to half the circumference of the small end. Make *C-E* equal to the line *A-B*. Bisect line *D-E* at *K*. With *A* as a center and *A-C* as a radius draw the arc *C-N-M*. Make line *M-N* equal to *D-K* then draw a line from *A* extending through *N*. With *C* as a center and *C-A* as a radius draw the arc *A-F-G*. Make *F-G* equal to *D-K*. Draw a line from *C* extending through *G*. Make *A-S* equal to one-quarter of *A-B* With *S* as a center and *S-B* as a radius draw an arc intersecting the line through *A-N* and in the point *B′*. Make *C-T* equal to one-quarter of *C-D*. With *T* as a center and *T-D* as a radius, draw an arc intersecting the



Method of laying out cone camber

line through *C* and *G* in the point *D′*. The line *D′-B′* is the rivet line of half the pattern.

To draw the curved lines between *A* and *B′* and *C* and *D′*, with *A* as a center draw the arc *O-P*. With the same radius and *C* as a center, draw the arc *Q-R*. Divide the arcs into four equal spaces. Draw the lines *A-1*, *A-2*, *A-3* and *A-4*; also *C-1*, *C-2*, *C-3* and *C-4*. With *A* as a center and *A-S* as a radius, draw an arc cutting *A-1* in *a*. With *A-S* as a radius and *a* as a center draw an arc cutting *A-2* in *b*. With *b* as a center and with the same radius draw an arc cutting *A-3* in *c*. With *c* as a center draw an arc cutting *A-4* in *B′*. A line drawn through *A*, *a*, *b*, *c* and *B′* will be the curved line required. In the same way, using *c-T* as a radius, the points *a′*, *b′* and *c′* may be obtained. The curve is then drawn. This completes the pattern for one-half of the development.

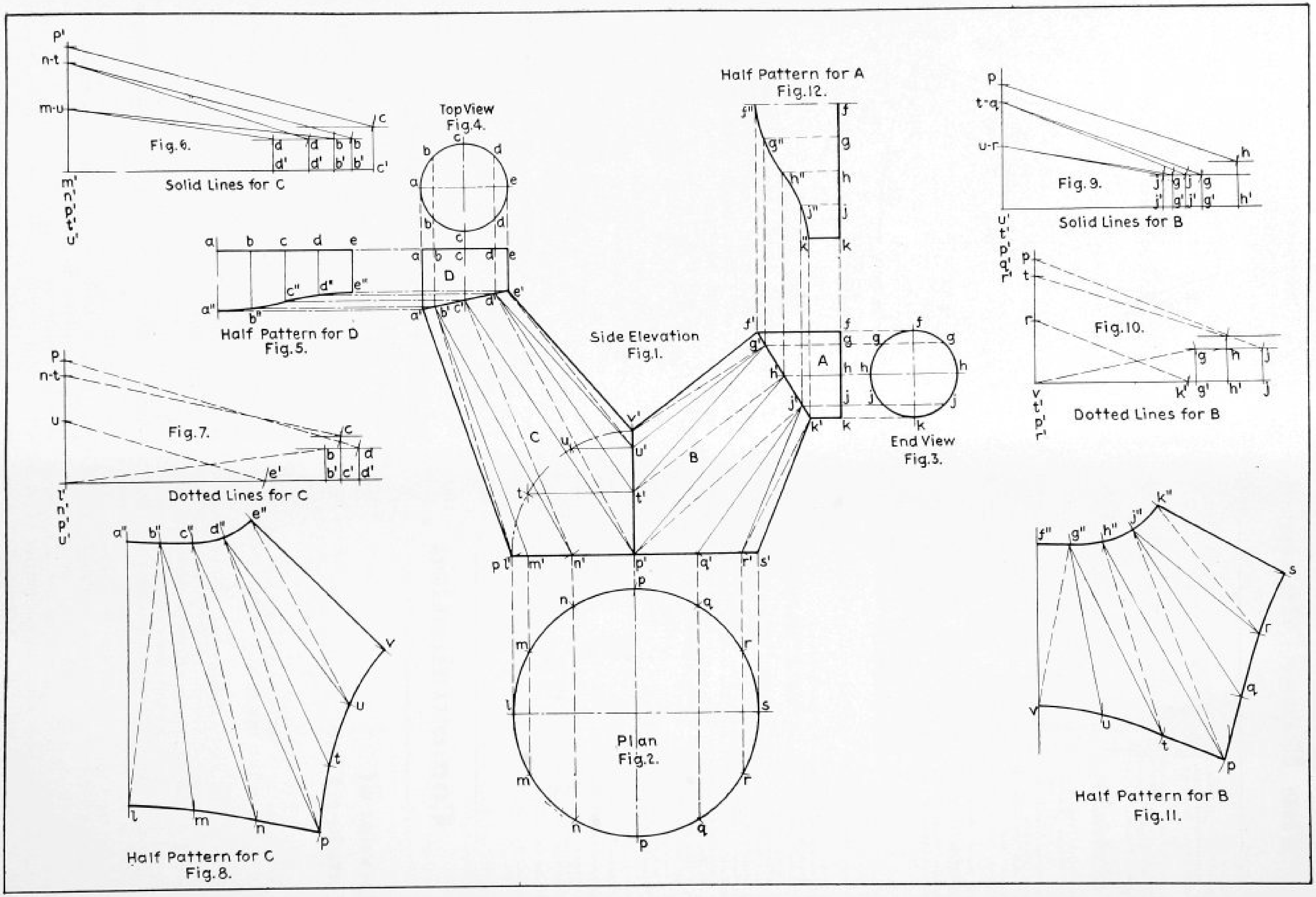
Montreal, Can. James Wilson.

Standardized Markings On Welding Rods

The Linde Air Products Company, New York, has announced a new standardized set of markings on all Oxweld welding rods. With three exceptions, all rods 1/8 inch in diameter and larger are stamped with the name Oxweld as well as the number and type of rod. On the smaller sizes of welding rod where it is not possible to stamp the name, the boxes in which the rod is shipped are plainly marked Oxweld with the number and type.

For example Oxweld No. 1 high-test patented steel rod, marked Oxweld No. 1 H. T. Patented, is for use wherever welds of uniform high strength are required in steel plate, sheets, structural shapes, pipe, etc.

Oxweld No. 2 high-carbon steel rod, marked Oxweld No. 2 Steel, is for use when welding high-carbon steel. For cold-rolled shafting, or nickel or chrome steel, Oxweld No. 3 nickel-steel rod marked, Oxweld No. 3 Steel, is the proper welding rod. For manganese-steel welding there is the Oxweld No. 4 Manganese-Steel Rod.



Method of developing a branch pipe

Questions and Answers Pertaining to Boilers

This department is maintained for the purpose of helping those who desire assistance on practical boiler shop problems. Inquiries should bear the name and address of the writer. Anonymous communications will not be considered. The identity of the writer, however, will not be disclosed unless the editor is given special permission to do so.

By George M. Davies

Bevel of Corner Angle

Q.—I would greatly appreciate your sending me a formula for obtaining the bevel of a corner angle on an irregular hopper.—C.W.E.

A.—Fig. 1 shows the corner angle of an irregular hopper when the plates are at 90 degrees to each other.

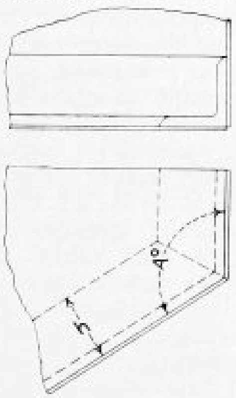


Fig. 1

The joint line of the two angles is the bisection of angle *A*.

Fig. 2 illustrates the corner angles laid out flat, the

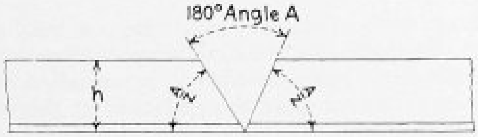


Fig. 2

bevel of each of the angles being one half *A*, where *A* is the corner angle in degrees.

Development of Branch Pipe

Q.—Please show the development of a branch pipe having a round base with round vertical and horizontal outlets. G.M.

A.—Fig. 1, page 280, shows the side elevation of a branch pipe having a round base and round outlets, one outlet running on a horizontal line, the other being vertical.

In laying out the side elevation the height of the joint line *p′-v′* was made equal to *p′-l′*, the miter lines *a′-e′* and *j′-k′* being the bisection of the angles *c-c′-p′* and *h-h′-p′* respectively.

Draw Figs. 2, 3 and 4. Fig. 2 is the plan view of the base. Fig. 3 is the end view of the horizontal outlet *A* and Fig. 4 is the top view of the vertical outlet *D*. The quarter circle *v′-l′* represents the half section of the front line *v′-p′* in the elevation Fig. 1.

To develop the pattern of the top outlet *D*, divide the top view, Fig. 4, into any number of equal parts, eight being taken in this case. Letter these parts *a, b, c, d* and *e* as shown. Erect perpendiculars to the line *a-e* through these points extending same to intersect the miter line *a′-e′* at *a′, b′, c′, d′* and *e′* as shown.

Next, extend to the left, the line *a-e*, Fig. 1, and on this line step off distances equal to *a-b, b-c, c-d* and *d-e* of the top view, Fig. 4, locating the points *a, b, c, d* and *e*, Fig. 5. Erect perpendiculars to the line *a-e* at each of these points. Parallel to the line *a-e* and passing through the point *a′* on the miter line *a′-e′*, draw a line cutting the perpendicular from the point *a*, Fig. 5, locating the point *a″*, Fig. 5. In like manner draw parallel lines through *b′, c′, d′* and *e′* of the miter line *a′-e′* cutting the perpendiculars from *b, c, d* and *e*, thus locating *b″, c″, d″* and *e″*, Fig. 5. Draw a line through these points completing the half pattern for *D*, Fig. 5.

In the same manner develop the half pattern for *A*, Fig. 12.

The next step is to develop the vertical branch connection *C*. To do this divide the plan, Fig. 2, into a number of equal parts, twelve being taken in this case. Letter these parts *l, m, n, p, q, r* and *s*, as shown. Erect perpendiculars to the line *l′-s′*, Fig. 1, passing through the points *l, m, n, p, q, r* and *s* of the plan view, Fig. 2, locating the points *l′, m′, n′, p′, q′, r′* and *s′*, Fig. 1.

In the same manner divide the quarter circle *v′-l′*, which represents the half section on the joint line *v′-p′*, into the same equal spaces. Number these points *t, u* and *v′*. Perpendicular to the line *v′-p′*, Fig. 1, draw lines through *t* and *v* locating the points *t′* and *v′*, Fig. 1.

Next, draw the solid and dotted lines representing the surface lines by connecting the points *e′-v′, d′-u′, d′-t′, d′-p′, c′-p′, c′-n′*, etc., as shown, for branch pipe *C*, Fig. 1. Note that two more spaces appear on the miter joint *v′-p′* and *l′-p′* in the elevation than occur on the miter line *a′-e′*. When a condition corresponding to this arises, simply join the points as indicated by those drawn from *m′* and *n′* to *b′*, also from *t′* and *v′* to *d′*.

Next find the true length of these surface lines.

Fig. 6 shows the method of obtaining the true lengths of the surface lines shown by the solid lines in the elevation.

To obtain the true length of the surface *d′-u′* of the elevation Fig. 1, take this distance and place it on any horizontal line as *d′-u′*, Fig. 6. Erect perpendiculars at the points *d′* and *u′* and on the perpendicular at *u′* step off the distance *u′-u* equal to distance *u-u′* of the elevation, Fig. 1, and on the perpendicular to *d′* step off the distance d'-d equal to the distance from the line a-e to the point d in Fig. 4. Connect the point d and u, Fig. 6, giving the true length of the surface line d'-u', Fig. 1.

Again to find the true length of the solid line m'-b', Fig. 1, take this distance and place it on any horizontal line as m'-b', Fig. 6. Erect perpendiculars at the points m' and b' and on the perpendicular at m step off the distance m'-m equal to the distance from the line l-s to the point m in Fig. 2. On the perpendicular at b' step off the distance b'-b equal to the distance from the line a-e to the point b in Fig. 4. Connect the points m-b, Fig. 6, giving the true length of the surface line m'-b, Fig. 1.

In the same manner determine the true length of all the solid and dotted lines as shown in Figs. 6 and 7.

The true length of the solid and dotted surface lines for branch pipe B are obtained in the same manner and are shown in Figs. 9 and 10.

The development of the half pattern for branch pipe C is shown in Fig. 8.

Draw the line a''-l, Fig. 8, equal to line a'-l', Fig. 1. With a'' as a center and with the dividers set equal to the distance a''-b'', Fig. 5, scribe an arc; and with l as a center and with dividers set equal to the distance l'-b, Fig. 7, scribe an arc cutting the arc just drawn locating the point b'', Fig. 8. Then with l as a center and with the dividers set equal to the distance l-m of Fig. 2, scribe an arc. With b'' as a center and with the dividers set equal to the distance b-m, Fig. 6, scribe an arc cutting the arc just made locating the point m, Fig. 8. Continue in this manner making b''-c'', c''-d'', and d''-e'' equal to b''-c'', c''-d'' and d''-e'', Fig. 5, and m-n, n-p equal to m-n and n-p of Fig. 2 and p-t, t-u and u-v equal to p-t, t-u and u-v, Fig. 1, using the correct length of the solid and dotted surface lines as found in Figs. 6 and 7, thus completing the half pattern for C.

The half pattern for B, Fig. 11, is developed in the same manner obtaining the true lengths of the solid and dotted surface lines from Figs. 9 and 10.

Efficiency of Butt Patch

Q.—Kindly give me the practical formula for solving the following question: What is the efficiency of a triple-riveted butt patch with double straps, using $1\frac{1}{16}$ inch rivets, 8-inch pitch and having 88,000 pounds per square inch tensile strength. I failed to answer this question in an examination and I would appreciate a solution of the problem. C.B.K.

A.—The question does not include sufficient information for determining the efficiency of a triple-riveted patch.

The efficiency of a triple-riveted and double-strap butt patch as illustrated in Fig. 1 is computed in the same manner as for a triple-riveted and double-strap butt seam and is computed as follows:

Where TS = tensile strength of plate, pounds per square inch.
t = thickness of plate, inches.
b = thickness of butt strap, inches.
P = pitch of rivets, inches, on row having greatest pitch.
d = diameter of rivet after driving, inches diameter of rivet hole.
a = cross section area of rivet after driving, square inches.
s = shearing strength of rivets in single shear, pounds per square inch.
S = shearing strength of rivets in double shear, pounds per square inch.
c = crushing strength of mild steel, pounds per square inch.

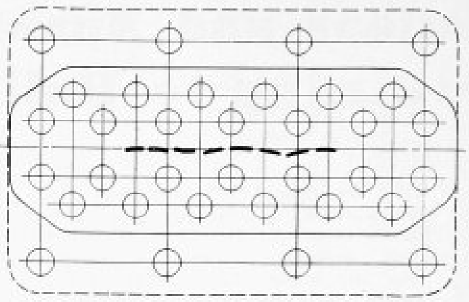


Fig. 1.—Triple-riveted patch

n = number of rivets in single shear in a unit length of joint.
N = number of rivets in double shear in a unit length of joint.

Then, A = strength of solid plate = $P \times t \times TS$
B = strength of plate between rivet holes in outer row = $(P-d)\ t \times TS$
C = shearing strength of four rivets in double shear, plus the shearing strength of one rivet in single shear $= N \times S \times a + n \times s \times a$.
D = strength of plate between rivet holes in the second row, plus the shearing strength of one rivet in single shear in the outer row $= (P-2d)\ t \times TS + n \times s \times a$.
E = strength of plate between rivet holes in the second row, plus the crushing strength of butt strap in front of one rivet in the outer row $= (P-2d)\ t \times TS + d \times b \times c$.
F = crushing strength of plate in front of four rivets, plus the crushing strength of butt strap in front of one rivet $= N \times d \times t \times c + n \times d \times b \times c$.
G = crushing strength of plate in front of four rivets, plus the shearing strength of one rivet in single shear $= N \times d \times t \times c + n \times s \times a$.

Divide B, C, D, E. F, or G (whichever is the least) by A and the quotient will be the efficiency of a butt and double strap patch, triple riveted as shown in Fig. 1.

For a correctly designed seam the weakest part of the seam is usually the strength of plate between rivet holes in the outer row. Sufficient information is given in the question to compute the efficiency at this point as follows:

$$\text{Efficiency} = \frac{B}{A} = \frac{(P-d) \times t \times TS}{P \times t \times TS} = \frac{P-d}{P} = \frac{8-1.0625}{8} = 0.868$$

Correction

Boiler patch formulas.—Through an unfortunate error in printing, two formulas appearing on page 211 of the August issue were incorrectly written. The second formula should be written:

$$\frac{\text{F. S.} \times \text{boiler radius} \times \text{pressure}}{\text{T. S.} \times \text{thickness}} = \text{Efficiency (necessary)}$$

In the example under the first table the figures 12.53 should be preceded by an equality sign instead of a minus sign.

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Vice-President—S. G. Bradford, Edge Moor Iron Company, Edge Moor, Del.
Secretary-Treasurer—A. C. Baker, 801 Rockefeller Building, Cleveland, O.
Executive Committee (three years)—Homer Adams, Fitzgibbons Boiler Company, Inc., New York; George W. Bach, Union Iron Works, Erie, Pa.; G. S. Barnum, The Bigelow Company, New Haven, Conn. (Two years)—Owsley Brown, Springfield Boiler Company, Springfield, Ill.; F. W. Chipman, International Engineering Works, Framingham, Mass.; W. C. Connelly, Foster Wheeler Company, Cleveland, O. (One year)—J. G. Eury, Henry Vogt Machine Company, Louisville, Ky.; A. C. Weigel, Combustion Engineering Corporation, New York; E. G. Wein, E. Keeler Company, Williamsport, Pa.; *Ex-officio*, H. E. Aldrich, Wickes Boiler Company, Saginaw, Mich.

States and Cities That Have Adopted the A.S.M.E. Boiler Code

States

Arkansas	Missouri	Rhode Island
California	New Jersey	Utah
Delaware	New York	Washington
Indiana	Ohio	Wisconsin
Maryland	Oklahoma	District of Columbia
Michigan	Oregon	Panama Canal Zone
Minnesota	Pennsylvania	Territory of Hawaii

Cities

Chicago, Ill.	St. Joseph, Mo.	Memphis, Tenn.
Detroit, Mich.	St. Louis, Mo.	Nashville, Tenn.
Erie, Pa.	Scranton, Pa.	Omaha, Neb.
Kansas City, Mo.	Seattle, Wash.	Parkersburg, W. Va.
Los Angeles, Cal.	Tampa, Fla.	Philadelphia, Pa.
	Evanston, Ill.	

States and Cities Accepting Stamp of the National Board of Boiler and Pressure Vessel Inspectors

States

Arkansas	Missouri	Pennsylvania
California	New Jersey	Rhode Island
Delaware	New York	Utah
Indiana	Ohio	Washington
Maryland	Oklahoma	Wisconsin
Minnesota	Oregon	Michigan

Cities

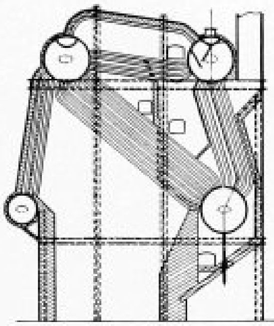
Chicago, Ill.	St. Louis, Mo.	Nashville, Tenn.
Kansas City, Mo.	Scranton, Pa.	Omaha, Neb.
Memphis, Tenn.	Seattle, Wash.	Parkersburg, W. Va.
Erie, Pa.	Tampa, Fla.	Philadelphia, Pa.
Detroit, Mich.		

Selected Boiler Patents

Compiled by Dwight B. Galt, Patent Attorney, Washington Loan and Trust Building, Washington, D. C. Readers wishing copies of patents or any further information regarding any patent described, should correspond directly with Mr. Galt.

1,767,020. STEAM BOILER. MARK E. SMITH, OF ERIE, PA., ASSIGNOR TO UNION IRON WORKS, OF ERIE, PA., A CORPORATION OF PENNSYLVANIA.

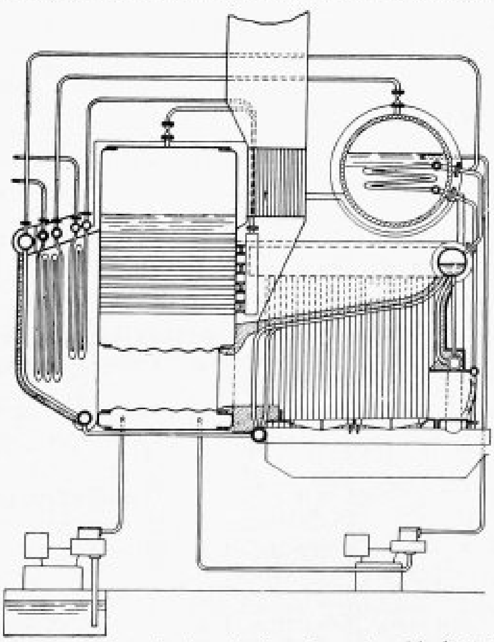
Claim.—In a steam boiler, the combination of a front steam and water drum; a rear steam and water drum; a water circulating system comprising watertubes connecting said drums; steam tubes connecting said drums entering the drums in a radial direction; a steam discharge opening leading from the upper wall of one of said drums; and a separating plate in the last-mentioned drum arranged in a plane parallel to the axis of the



drum and leading from the upper wall of the drum at the side of the discharge opening opposite the incoming steam tubes, said plate extending downwardly into the path of the steam discharged from the steam tubes and deflecting the separated steam upwardly to the discharge opening and the separated water downwardly, said separating plate being free to discharge the separated water to the drum space from its lower edge. Four claims.

1,754,167. MARINE BOILER. OTTO H. HARTMANN AND HEINRICH PEPERKORN, OF KASSEL-WILHELMSHOHE, GERMANY, ASSIGNORS TO SCHMIDT'SCHE HEISSDAMPF-G. M. B. H., OF KASSEL-WILHELMSHOHE, GERMANY, A CORPORATION OF GERMANY.

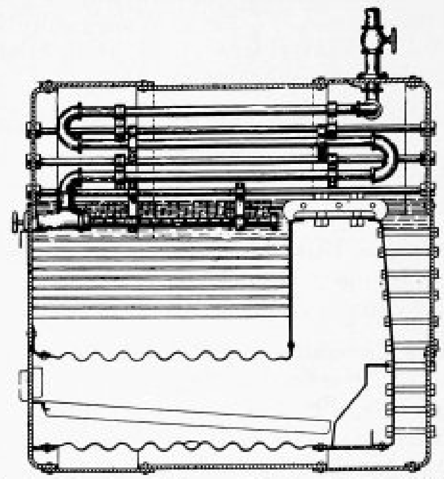
Claim.—In a marine boiler of the return-flue type which is subdivided into two steam generators of different pressure, in combination a firebox, a reversing chamber in communication with the firebox, a firetube boiler serving as the low-pressure steam generator, said firetube boiler being in communication with the exit end of said chamber and thereby heated by the gases after their change in direction, and an indirectly heated high-



pressure steam generator having heating elements with heat absorbing parts, the greater portion of said heat absorbing parts being located within the firebox and another portion thereof being located within the reversing chamber. Eight claims.

1,701,262. FEEDWATER PREHEATER. FRANCIS C. HABER, OF BROOKLYN, N. Y.

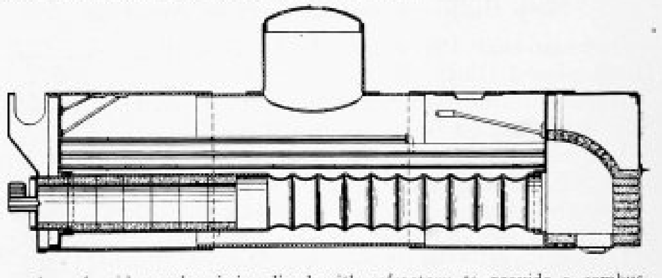
Claim.—A preheater for steam boiler feedwater comprising an upper series of imperforate pipes disposed above the water level of said boiler adapted to convey feedwater therethrough for allowing the same to be heated, a pipe extension disposed below the surface of the water in said boiler and communicatively connected with said series of pipes having per-



forations therein adapted to discharge feedwater into said boiler below the surface of the water therein, a valve casing forming the connection between said upper series of pipes and said pipe extension, said pipe extension being disposed at one end in said valve casing and screw threaded internally at said end portion, a valve in said casing having apertures therein for permitting a predetermined minimum amount of water to flow from said series of pipes to said extension and actuating mechanism operatively connected with said valve for adjusting the position of the same for regulating the flow of liquid to said pipe extension above said predetermined amount.

1,751,534. BOILER. HUSTON TAYLOR, OF PITTSBURGH, PA.

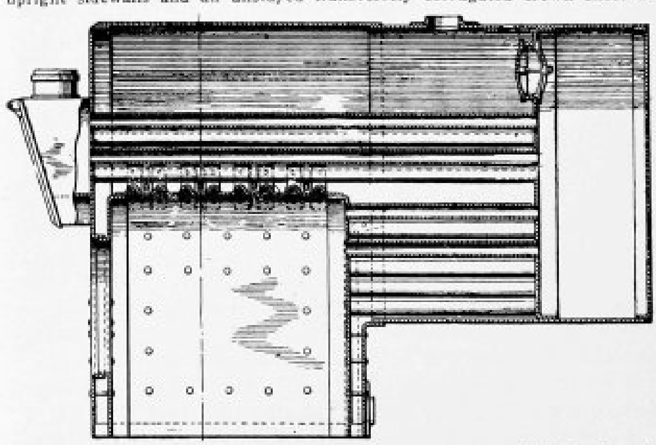
Claim.—A boiler comprising an elongated water-holding shell, a metal tubular member of flue proportions disposed in said shell below the normal water level therein and serving as a combined furnace and flue, the furnace



portion of said member being lined with refractory to provide a combustion chamber whose surface area in square feet is equal to three or more times its volume in cubic feet, and of sufficient length to cause efficient combustion of fuel within the combustion chamber when the boiler is operating within its rated capacities. Five claims.

1,702,545. BOILER. MICHAEL F. MOORE, OF KEWANEE, ILL., ASSIGNOR, BY MESNE ASSIGNMENTS, TO KEWANEE BOILER CORPORATION, OF KEWANEE, ILL., A CORPORATION OF DELAWARE.

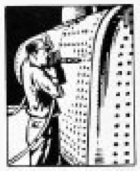
Claim.—A firetube boiler having in combination a firebox having stayed upright sidewalls and an unstayed transversely corrugated crown sheet of



sufficient strength in itself to withstand the strains to which it is subjected and of a relatively flat curvature substantially less than semicircular and a plurality of uniformly arranged firetubes equally spaced apart above said crown sheet. Two claims.

The Boiler Maker

Reg. U. S. Pat. Off.



A New Type Steam Generator

So few changes in the fundamental design of steam boilers have been made during the past twenty years, that, when a development, such as the Loeffler boiler, comes to the attention of the field, the interest of the industry is immediately aroused. Both in the power plant field and in the locomotive, the Loeffler principle of steam generation over a period of several years of development and use has proven its efficiency and practicability. Since in detail this boiler is yet in process of refinement, there will inevitably be improvements in its efficiency that time alone can effect. Its operation since the first installation has, however, been extremely successful and opens a new range of possibility in controlled steam generation, utilizing high pressures, particularly where process industries are involved, and where the available feed water is impure.

Work of the Stoker Manufacturers

The possibilities of usefulness, which the trade association may develop, are well demonstrated by the activities of the Stoker Manufacturers' Association, an organization closely allied with that of boiler manufacture. Most recently the fourteen members, producing over 95 percent of the stoker equipment used in this country, working through the association, have prepared a condensed catalogue containing detailed descriptions of the latest developments in their products.

Forty-eight different types of mechanical stokers are illustrated and described, the various stokers being grouped into the following classifications: Multiple-retort underfeed stokers, single-retort underfeed stokers, chain-grate stokers and overfeed stokers. The text is limited to engineering descriptions of the various types of machines, and a supplementary section on engineering data relating to modern stoker practice is included.

This example of an association function indicates first of all the close co-operative effort which the manufacturers of this equipment have adopted to promote sales. An impression of unity of purpose is given which must inevitably instil confidence in the minds of prospective customers. A tacit guarantee is given that fair and uniform treatment from all members of the group will characterize their business dealings. Above all, an extremely advantageous use of modern publicity methods is exemplified.

A group catalogue of this character is but an indication of the concentrated attention being given the major problem of all manufacturers, namely, sales promotion. Close contact with the work of the stoker manufacturers undoubtedly would bring to light many other efforts—all designed to the same end.

In the boiler field, the association of manufacturers may find in this work of a sister organization a suggestion for a very practical means of unifying its efforts, of compensating for a marked decline in orders, and of stimulating interest in its activities.

Safety in the Shop

Accident prevention from both the humanitarian and economic point of view is probably more important at the present than at any time in the history of the safety movement. The present period of depression with the mental attitude of future uncertainty reflects itself in the minds of employees, producing, as a result of worry, a mental hazard. Statistics over a period of years indicate that serious accidents are more prevalent at a time of mental stress. For this reason an attitude of safety consciousness must replace worry in order to eliminate loss of time and the accompanying expense due to accidents.

In this issue appears the first of a series of articles on the subject of "Safety in Boiler and Sheet Metal Fabrication" which points out the magnitude of the human factor in the safety problem. Inasmuch as only 10 to 15 percent of all accidents can be eliminated by mechanical means, it becomes necessary to direct the efforts of accident prevention against the 85 percent to 90 percent class. This effort calls for education of the individual to insure that he performs his work in the proper and safe manner. Such educational work can be accomplished best through the instruction of the foreman, because he should know the hazards of the methods of operation of the machines and equipment under his jurisdiction. By imparting that knowledge to the men and then being sure that the men are following his instructions, he can materially reduce this large percentage of accidents.

While the responsibility for educating employees rests mainly with the foreman, the individual may form his own safety habits so that, whatever his actions may be, his first thought will always be, "Is it safe to do what I am about to do?" Not only from the management point of view is safety important but from the point of view of family welfare, accident prevention is a vital factor. No man can afford to jeopardize his present and future income by carelessness nor can he dare to be thoughtless when accidents can least be afforded.

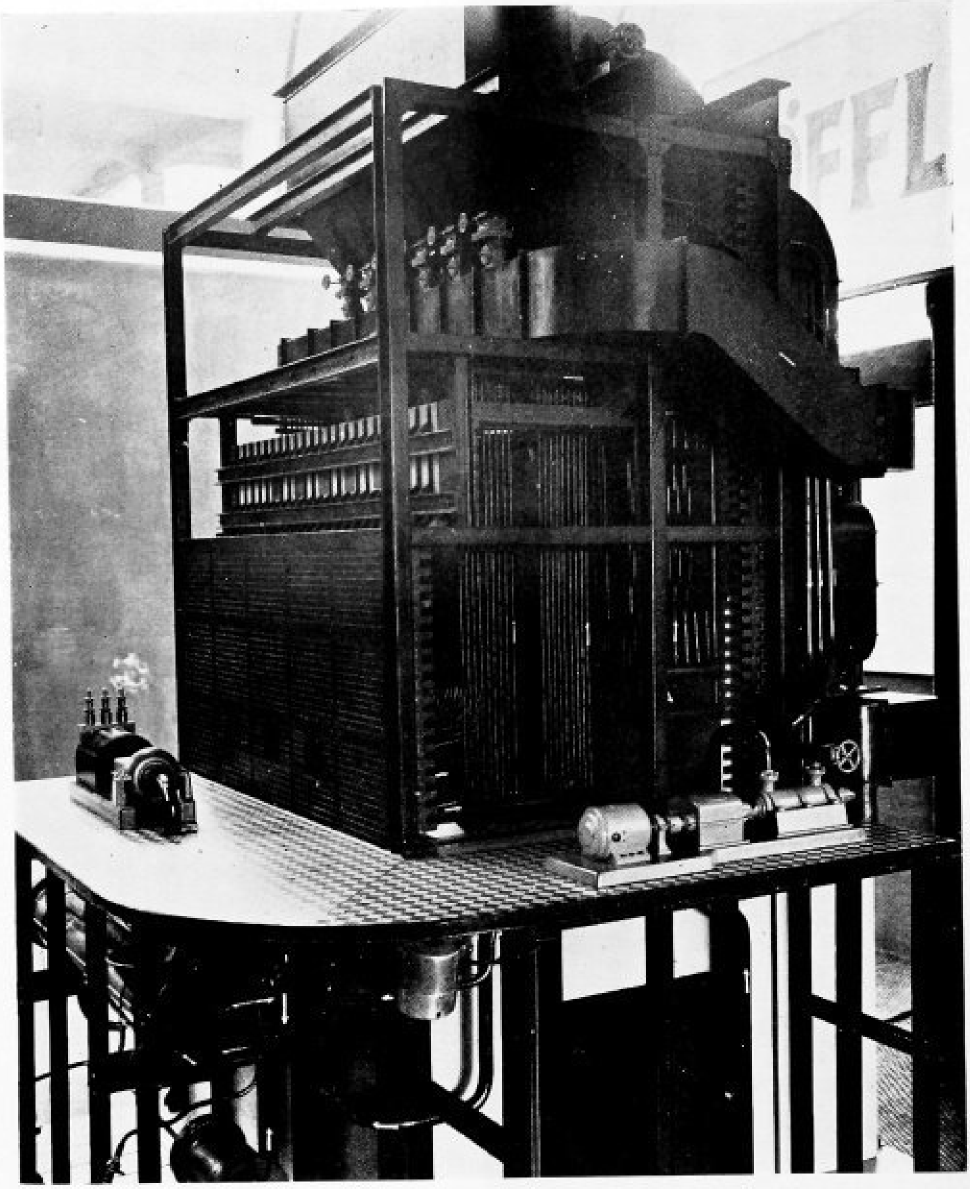


Fig. 1.—Working model of 75-ton Loeffler boiler

Loeffler Boiler Designed for 1900 Pounds Pressure

By *Arthur J. Herschmann**

The patented Loeffler high-pressure boiler, developed by the Vitkovice Works of Czechoslovakia, has created considerable interest in recent months in this country, as it employs new and novel features for the generation of steam. Numerous installations have been made abroad, similar in design to the working model of a 75 tons of steam per hour unit, shown in Fig. 1. There are five units of this size now being installed, while two 150-ton boilers are under construction. Fifty-ton units have been in successful operation since 1930.

For an understanding of the system of steam generation employed in the Loeffler boiler, the schematic diagram, Fig. 7 is given. The boiler circulates steam drawn from drums *A* by means of a pump *B* through combustion chamber screens (radiant superheater and

* Agent in the United States for the Vitkovice Works, Czechoslovakia.

convection superheater) *C* back into the drums. The flue gases give off heat to superheat steam at a working pressure of 1900 pounds per square inch to 932 degrees F. About one-third of the steam so superheated goes on the line, while the remaining two-thirds goes back into the drums where it bubbles through the water and, in giving off its superheat, raises more steam. As there is positive and very ample circulation of steam which acts as a coolant in preventing heat accumulation in the superheater, the highest desirable superheat can be obtained with the certainty that it will not be exceeded and that there will be no overheated tubes.

Since the 75-ton boiler gives 168,000 pounds of steam per hour we must circulate 532,560 pounds of steam by means of the booster pump. Let us examine this rate of steam generation as based on the surface and the steam space of the drums. We find that the boiler produces 532,560 pounds of steam within the three drums, having a combined water surface of 282 square feet. That gives about 1900 pounds of steam per square foot of surface per hour. Each drum is 43 inches inside diameter by 26 feet 4 inches long, and is 3 inches thick. For the combined free space of the three drums of 397.5 cubic feet, the limit of evaporative capacity, according to Professor Eberle of Darmstadt, would be a total of 1,590,000 cubic feet at 4000 cubic feet of steam per cubic foot of space. As saturated steam at 1850 pounds weighs 4.8 pounds per cubic foot and we vaporize 532,560 pounds in all, we produce but 110,950 cubic feet.

We could therefore vaporize 15 times more steam before generation would become violent. The above figures explain partly why Loeffler boilers give dry and clean steam even with poor quality feed water.

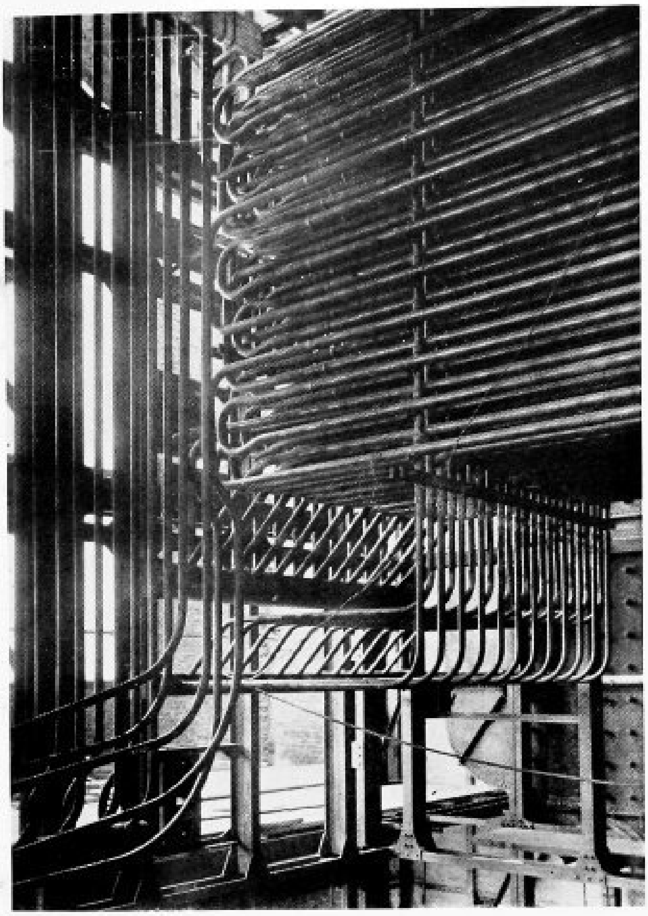


Fig. 3.—Re-superheater *C*, seen from in front

Fig. 2.—Feed-water heater *F*

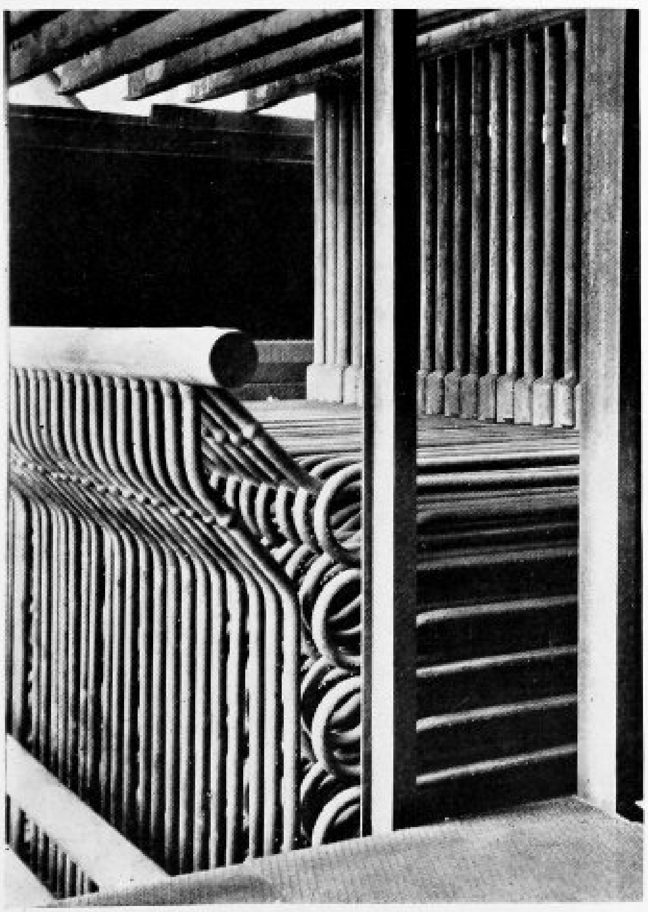
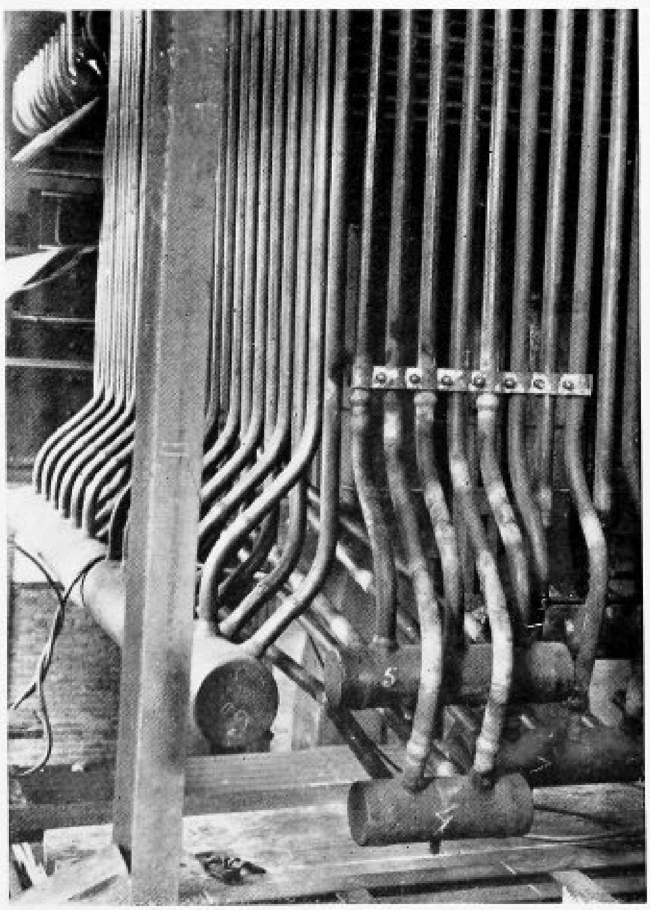


Fig. 4.—Radiation superheater *C*, from front



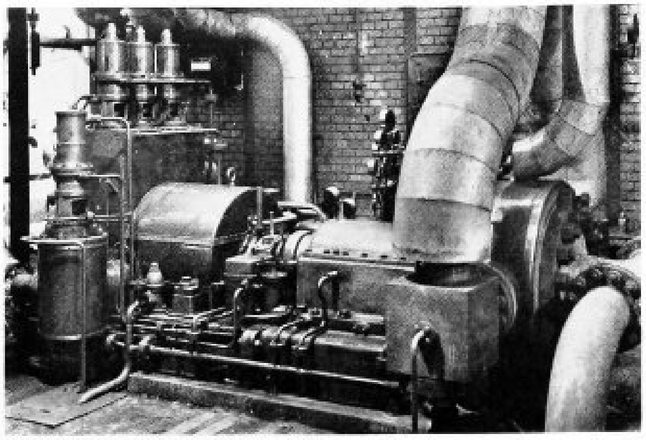


Fig. 5.—Circulating pump *B*, of Loeffler boiler

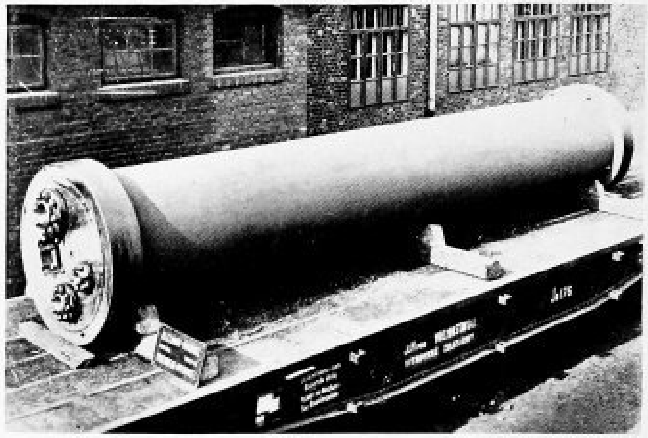


Fig. 6.—One of three vaporizing drums *A*

It is this ability of the Loeffler boiler to give clean and dry steam with feed water requiring only ordinary chemical treatment, which makes it so outstanding, where much make-up feed water is required such, for instance, as in the paper industry. For the same reason of rapid circulation and because there is no water in any part of the boiler which is touched by flames on the outside, it is entirely free from scale trouble and remarkably free from tube difficulty. After three years of continuous operation the steel drums and tubes of a smaller Loeffler boiler were examined and found perfectly clean and entirely unchanged. An ordinary boiler which was alongside and fed by the same feed water operating at 190 pounds per square inch pressure showed much scale and the valves were badly choked with deposits.

The steam circulating pump of the Loeffler boiler safeguards its operation and especially that of the superheater. Even if the load should entirely drop the temperature within the superheater tubes would not rise because the pump would continue to cool the tubes within. Only the pressure would rise and that would be quickly corrected by pump speed and fire control.

The practical boiler maker will be impressed with the ease with which this boiler can be quickly built out of relatively small stock. In the case of drums for example, instead of very heavy metal, which for such high pressure would have to go up to 5 inches in thickness with subsequent boring and reaming for so many tubes, which have to be expanded into the drums, forged drums without holes, resting on solid ground are used. The same drum is used for the 75-ton boiler, for instance, as for the 50-ton boiler. Another drum is added to increase the size of the boiler.

The first boiler at the Karolinenschacht plant at Witkowitz had a radiation superheater at the back wall of the pulverized-fuel combustion chamber, under conditions which were distinctly unfavorable. Variation in the rate of firing, and the opening of the ash doors, caused the flame to impinge on the superheater tubes. For the 40-ton boilers at this plant, the combustion chamber is completely surrounded by these tubes. The whole of the burnt products of combustion pass between the tubes at the bottom where they are spread out from each other, thereafter flowing through an after-superheater, water heater and air heater, and so to the chimney.

The method of constructing the radiation superheater is illustrated in Fig. 4. The connections for the various coils are short lengths of tube which are welded on to the superheater headers. Thus there is no welding of tubes into the wall of the header, only parts of equal thickness being welded together. The corners are formed by welding machined forgings to the distribution pipes or headers. The hanging loops of the radiation superheater are welded on, at the site, to the projecting ends shown.

A so-called heat-dam is placed in the hottest part of the radiation chamber, to assist in controlling the firing when starting up, and to give warning should the steam circulation stop for any reason, such as the failure of the supply in the case of an electrically-driven pump. It consists of an outer pressure tube, closed at one end, at which an inner tube communicates with it. A central rod attached to the closed end of the tube passes out through a stuffing box at the other end, and is con-

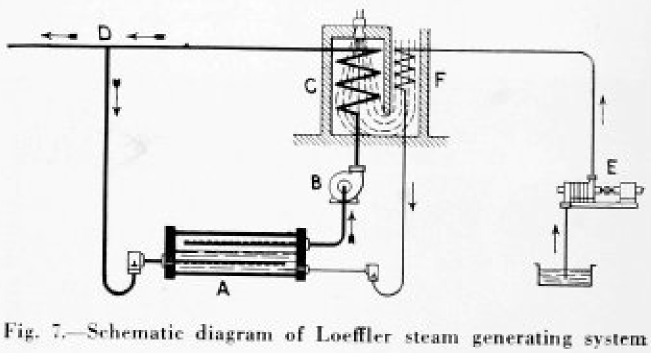


Fig. 7.—Schematic diagram of Loeffler steam generating system

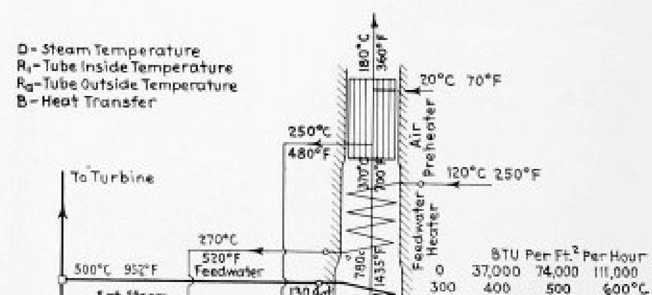


Fig. 8.—Diagram showing heat and temperature distribution

nected by a system of multiplying levers to a pointer which moves over an open scale. Steam at saturation temperature passes through the inner tube, maintaining the central rod at this temperature, and returns back through the annular space between the inner and outer tubes, cooling the latter in exactly the same manner as applies in the superheater tubes proper. The difference in expansion between the outer tube and the rod, which varies with the temperature of the tube since that of the rod is kept constant, is shown by the pointer. Should the outer tube become too hot, by reason of defective circulation or other cause, a valve opens and attention is called to the abnormal condition by a whistle.

It has already been stated that the various parts of the Loeffler boiler are joined together by fusion welding, which is an absolutely safe method of connecting tubes if carried out free from flaws and proper welding material is employed. There was formerly a certain lack of confidence in the fusion welding of high-carbon or alloy steels, which should now have disappeared, in view of the experience of recent years. Macro- and microphotographs of sections through welds show that these contain very few inclusions and that, after annealing at suitable temperatures (1562 degrees to 1688 degrees F), it is impossible to trace the actual joint between the tube and the welding material. This applies to carbon-steel tubes welded together with carbon-steel electrodes, and to molybdenum-steel tubes welded together, and to carbon-steel tubes, using electrodes containing molybdenum. Oxy-acetylene welding is used on Loeffler boilers.

The steam generating drums have flat ends, screwed and shrunk into the cylindrical barrel, which is a hollow forging. This construction was adopted to facilitate the pipe connections. One of these drums is shown in Fig. 6.

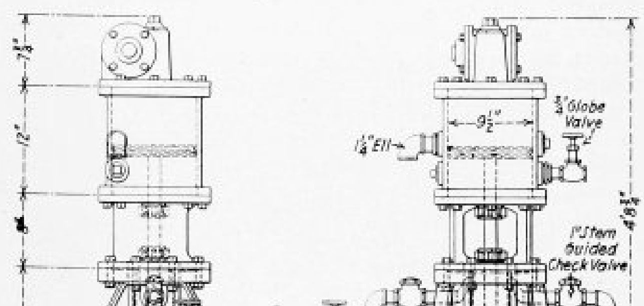
With regard to the rate of evaporation, or liberation, of steam from the water surface, it must be kept in mind that the whole water surface in the drums of the Loeffler boiler is utilized for this in a uniform manner. In a three-drum type boiler of ordinary design, only the front part of the front drum, *i.e.*, the part into which the front evaporation tubes deliver, is heavily loaded; in the remaining portion of the front drum, and in the rear drums, the surface is almost entirely undisturbed by rising steam. In vertical-tube boilers, the position is improved by allowing a number of the most heavily loaded tubes to discharge into the steam space, and not below the water level. This certainly reduces the load on the surface, but does not reduce the metastable evaporation, or the results which follow from it.

Indirect water-level indicators, operated by floats, are used in the Loeffler boiler, this being quite permissible since there is no danger, even with the drums entirely empty of water. In any case, the indicator is so simple and reliable that there is no question of failure to operate. The first boiler was run experimentally without a water-level indicator, reliance being placed on the temperature readings. It was found that the temperature in the steam space of the drum was only that of saturation, even when the water surface was only $1\frac{9}{16}$ inches above the inlets of the superheated steam. If there is enough water in the boiler, the thermometer in the steam space shows saturation temperature. If the level falls below $1\frac{9}{16}$ inches above the superheated steam inlets the temperature gradually rises, showing that feed water should be supplied. If, on the other hand, the water level becomes too high and the steam carries water into the superheater, the temperature of superheat falls at once, and the feed must be reduced or shut off.

An extension of the Karolinenschacht power station was put into operation in the spring of 1931, consisting of two Loeffler boilers, each having a maximum capacity of 75 tons of steam per hour, and a 36,000-kilowatt turbine. The design of these boilers has been considerably improved and simplified, compared with that of the earlier ones. The combustion chamber, again completely surrounded with superheater tubes, has been somewhat increased in order to improve the radiation effect from the pulverized-coal flame. At the bottom ends of the loops of the radiation superheater, collecting chambers have been welded in, to allow the condensed steam, which collects here when starting up, to be blown off. By this means it is possible to reduce the time required to start up to a minimum. In addition this makes it possible to remove any dirt which many accumulate, a condition which cannot be avoided during the erection of the loops. These collecting chambers are, of course, protected from the direct radiation of the flame. The coils of the after-superheater and of the feed heater have also been considerably simplified, facilitating manufacture and much reducing the cost. Further, the heat transmission is improved, permitting the use of less heating surface, while the number of tube bends has been reduced as far as possible. The frictional resistance of the coils and consequently the power required for the circulating pump have been diminished to an important extent. The air heater has been removed from the boiler proper, and is placed at the wall of the boiler house.

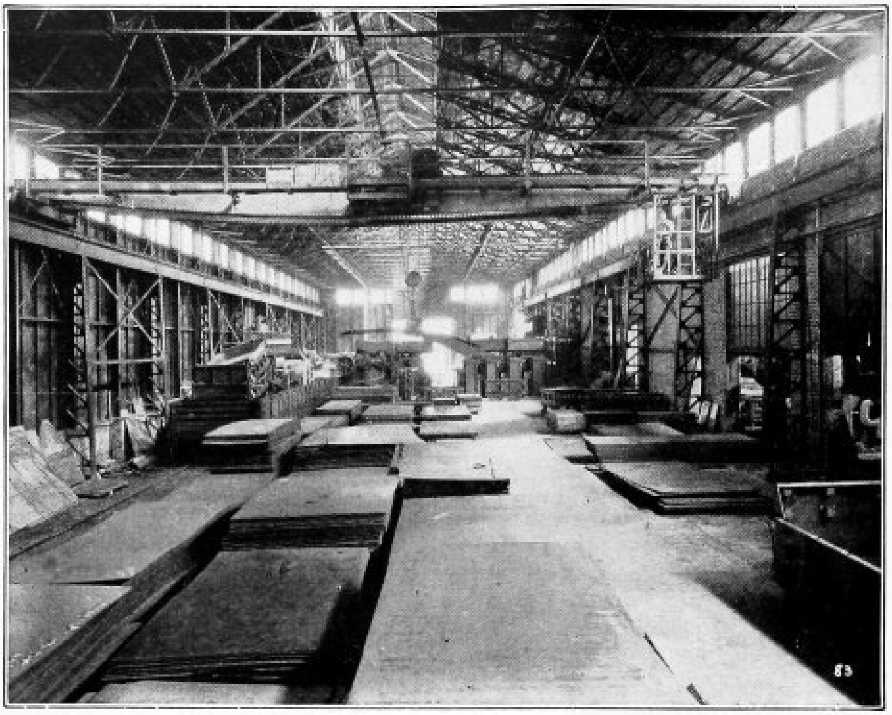
Pump for Hydrostatic Tests

The hydrostatic-test pump shown in the sketch is used by an eastern railroad as standard equipment. It is carried on a four-wheel truck of wrought iron construction. The bracing and truck parts can be forged in the blacksmith shop. The wheels are of cast iron.



Hydrostatic-test pump

The pump consists primarily of the steam portion of a Westinghouse air compressor, the piston rod of which also serves as the piston rod for the pump. The top head of the pump is W.A.B. part No. 1853, the steam cylinder complete is W.A.B. part No. 1880.



An efficient receiving stock storage and shipping department where several sheets may be handled at one time with a magnet crane

Safety in Boiler and Sheet Metal Fabrication*

The reduction of iron ore and the manufacture of wrought iron and steel plates are well understood. The modern use of steel for boilers, pressure vessels, smokestacks, bridges and buildings has developed a specialized industry which involves several trades, each of which has its own particular hazard. No effort is made here to consider the special hazards in the erection of structural steel or the installation of boilers and pressure vessels. But the hazards encountered in the shops where structural shapes, plates and sheet metal are fabricated have been considered.

Boiler shops receive steel plates of various sizes, ranging from the light gages to a thickness of two inches and upward, depending upon the kind of structure to be built. These plates are handled from the cars to storage space by various cranes. In addition to the plates, the following materials are also received: Tubes, rivets in kegs, staybolt iron, flanged heads, braces, nozzles, manhole frames, castings and other appurtenances.

As the material is required, it is brought out of storage to the layout department where the locations of rivet and tube holes and plate ends are indicated by the layerout. From the laying-out department the plates are taken to the shop and sheared to size. The edges are planed when necessary, holes are punched small and reamed to size, or drilled from the solid, depending on the kind of structure being built. The plates are rolled to form and riveted.

Machine riveting is performed where possible by hydraulic rivet bulls. It is impossible, however, to bull all rivets and a considerable amount of the work must be done by pneumatic riveters.

In boiler and tank construction many of the portions of plate must be flanged. This is accomplished by heating the plates and flanging them in one operation in large hydraulic flanging presses. In small shops and in some of the older ones, flanging is done with wooden mauls by hand. Other shops use flanging machines. Hand and machine flanging usually requires several heats to complete a job. In most shops where modern boiler work is done, plates which have been flanged are annealed in furnaces to relieve the strains set up by the flanging process.

After the boiler drums, shells and pressure vessels have been assembled and riveted, the various plate edges are calked to make them tight and the vessels tested by water pressure. If they withstand this test they are painted and sent to the shipping department; otherwise, they are reworked until satisfactory to the inspector in charge of the work.

Shipments of watertube boiler drums and horizontal tubular boilers are made when the boiler or drums are completed. Many shops which manufacture small boilers and tanks place these products in stock. Most drums, boilers and tanks are painted before being shipped from the factory.

Some manufacturers who fabricate steel for large tanks form the steel, punch the rivet holes and ship

* Published through the courtesy of the National Safety Council, Inc., Chicago.

the fabricated plates to the job where the tanks are to be erected, this riveting being done by pneumatic riveters. Other manufacturers of such tanks, after the plates are cut to size and rolled, instead of riveting the plates, weld them together in special machines. Afterward the heads are welded into the shells and the vessels placed in a large furnace and annealed. They are then subjected to test and if found satisfactory are prepared for shipment.

Some boiler shops manufacture forged parts, such as headers, and drums, etc. Forging operations are frequently of a special nature and usually involve the use of special equipment. The hazards encountered in the forge shops, however, are not increased by the connection with boiler making operations.

Drums and headers of boilers are often sandblasted to remove mill scale and dirt from the interior surfaces before protective compounds are applied. Injury to health because of improper protection against the inhalation of dusts generated in the operation is the principal hazard in sandblasting. Suitable helmets covering the head and shoulders and connected to a supply of pure air should be worn by the operators. Heavy, long gauntlet gloves should be worn to protect the hands against the abrasive action of the sand or shot and against cuts from the edges of the castings being sandblasted. The sandblasting operations should be carried on in a room or cabinet completely and tightly enclosed as a protection to other workmen.

A survey of representative industries engaged in sheet metal fabrication shows that, although many of the processes are encountered in other industries, there is a specific group of hazards in the sheet metal industry because of the size and shape of the materials handled, the use of hand tools, the use of certain special machine tools and the extensive use of autogenous welding and cutting.

Many preventable accidents are caused by particles of dust, chips, etc., entering workmen's eyes. The extensive use of hand and portable mechanical tools in chipping and dry grinding and the pouring of hot metals cause serious eye accidents, if proper attention is not paid to protection.

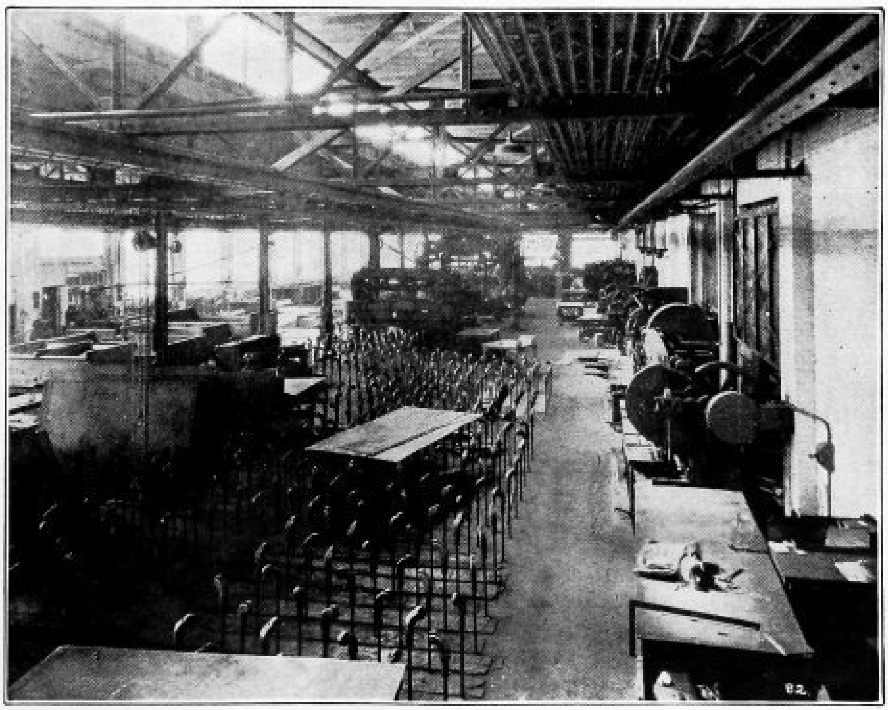
The handling of material in this industry presents a definite hazard because of the unusual shape, size and weight of the parts fabricated. The location of slings and hitches is of great importance in the safe handling of these materials and should be determined by the weight and center of gravity of the piece rather than its size or shape. Many of the materials and structures, although not quite heavy enough to necessitate the use of a crane, are still of sufficient weight to require a considerable amount of physical exertion. These materials frequently fall and cause injuries. Heavy tools are frequently dropped. Scaffolding and blocking in the assembly of large drums and tanks, the falling of parts cut away by torches, and the handling of loads by cranes or other hoisting equipment, present definite exposure in connection with the handling of materials.

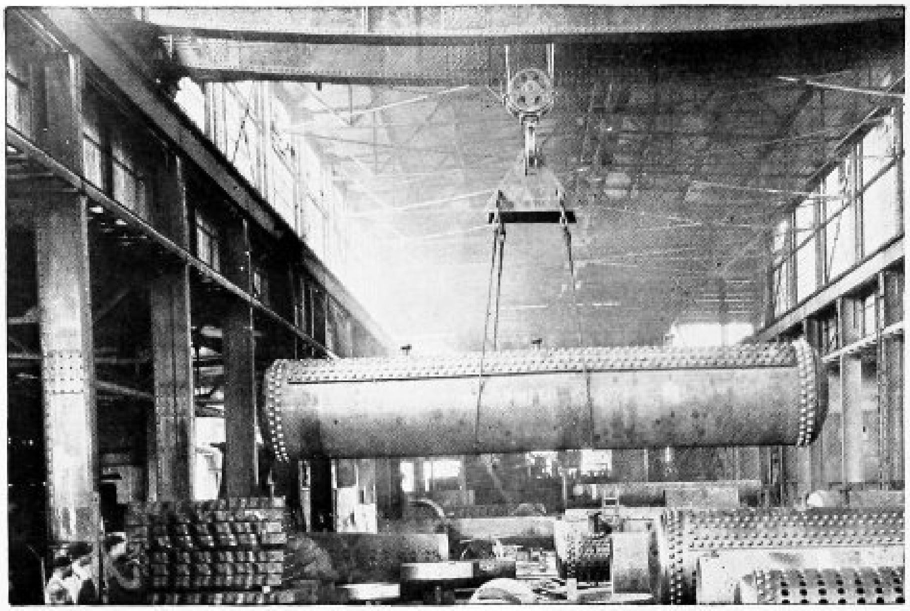
Many injuries to the feet will be prevented by the wearing of shoes with good uppers and substantial soles. The wearer of shoes with poor uppers or soles is liable to be injured by contact with or stepping on objects left carelessly on the shop floor. Objects of one kind or another falling on the toes are hazards which may be protected against by wearing shoes of a suitable hard toe type.

The handling and working of plate and structural shapes causes cuts and bruises to the hands and fingers unless heavy leather gloves or mittens are used. However, men working about machinery, drills, reamers, etc., should not wear gloves or mittens because of the danger of their catching in the work or machines with serious results to the wearer. Loose clothing, flowing neckties, or finger rings should not be worn by these men for the same reason.

Gas welders should wear goggles with suitable lenses to protect their eyes against the light rays of the welding torch and to prevent flying molten particles from entering the eyes. Goggles do not furnish the necessary protection for the neck and face against the ultra-violet rays of the electric arc. Welders performing such work should use face shields or helmets with suitable lenses. Inspectors, foremen, and others who examine welding and cutting operations should be provided with hand masks.

Sheet metal marking, shearing and punching department with pipe stand rollers for ease in sheet handling





Boiler drum moved through shop by a large traveling crane. Note perfect balance of drum, also men standing clear of load

Operators of welding and cutting equipment should wear good shoes and light fitting garments around the legs to prevent burns from sparks and dropping molten metal. Clothing of heavy, closely woven cloth should be worn to prevent burns to the skin from the rays of electric arcs.

All boiler and structural shops employ both oxy-acetylene and electric welding and cutting to a large extent. Work of this character presents definite hazards to the operators and the other men in the shop. In well organized shops these hazards are easily controlled and do not cause serious trouble, but are frequently overlooked by careless or unauthorized persons or by men not properly instructed who may attempt to do welding or cutting.

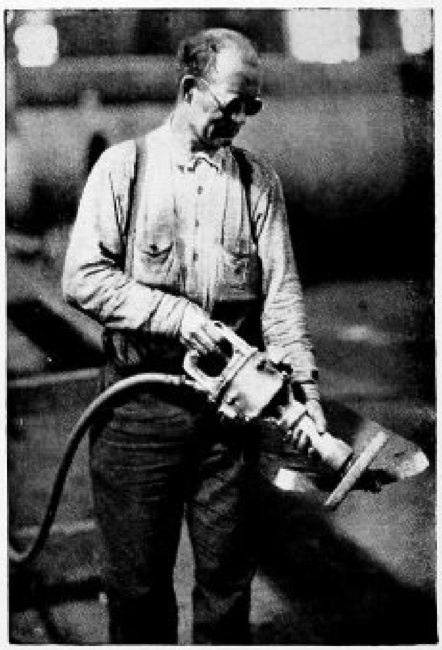
Where practicable, electric arc welding or cutting operations should be carried on in permanently enclosed rooms separate from the other shop operations. This will keep the harmful light rays of these operations away from passersby and crane operators. If permanent enclosures cannot be provided then the operations should be enclosed by suitable portable screens. All walls, screens, etc., of both permanent and portable enclosures should be painted with a flat black or preferably with dark gray paint composed of zinc oxide and lamp black. Zinc oxide has the property of absorbing all of the ultra-violet rays and reflecting only the harmless visible light. Care should be used in mixing and applying this paint to secure a flat surface as the zinc oxide will reflect the ultra-violet rays if the dried surface is glossy. A good adhesive medium to insure a flat color is glue water rather than oil. Suitable absorptive paint for walls and screens may also be obtained commercially. Surfaces painted with red lead reflect the dangerous light rays and red lead should therefore not be used to paint the sides of enclosures adjacent to the operators. Care should also be taken that the enclosures are well ventilated to carry off any fumes which may be generated in the welding or cutting operations. When it is necessary for cranes to pass over places where welding is being done and tops are not provided over the welding enclosures, the crane operators should wear goggles with suitable lenses.

All protective equipment and clothing should be maintained in first class condition. Particular attention should be paid to the handling of oxygen and acetylene cylinders. The supply of cylinders should be stored away from the job. The quantity at the job should only be sufficient for the work in hand. The hands should be free from grease and oil when handling or repairing oxygen regulating mechanism or fittings. Grease, oil, or any substance of a carbonaceous content should not be used as a lubricant for any of the valves, fittings, gages, or regulating equipment because of the danger of explosion. This hazard is so pronounced that it should be closely watched in every shop. Every employee who has occasion to use oxygen should be warned against the explosive possibilities of oil or grease when brought into contact with oxygen.

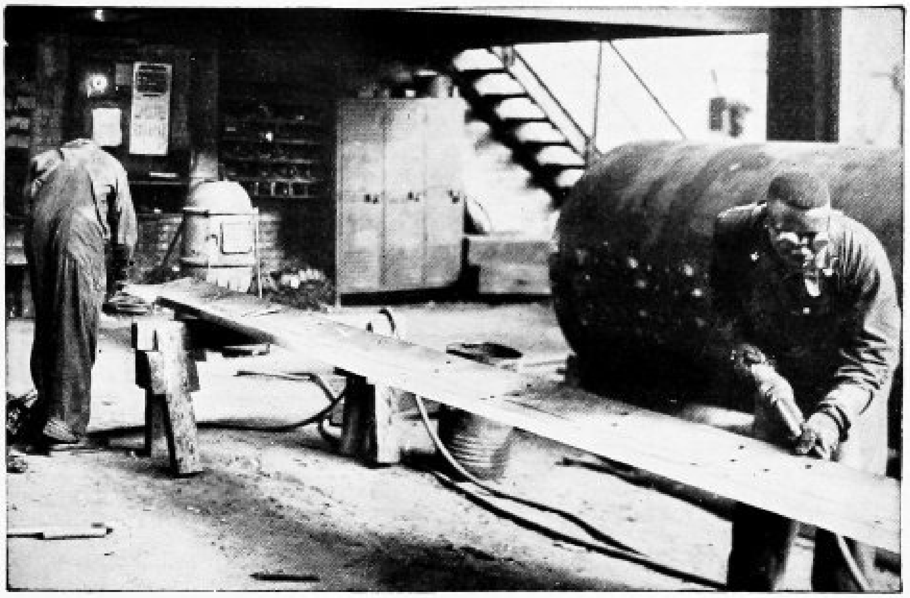
Care should be taken in handling and working with acetylene torches to avoid damage to the tips which may result in a flash back and cause a rupture in either the acetylene or oxygen hose.

When gas welding or cutting is being performed in a confined space, such as the interior of a boiler, the cylinders should always be left on the outside with an attendant and the gas led in through a hose to the point where the work is being done.

When it is necessary for an operator to work in a



The proper way to grind butt straps. Note that the goggles are in place



A safe way to chip the edges of plate. Note that the men are wearing goggles and are chipping back to back

confined, unventilated area he should, in addition to his goggles, wear a mask with hose attached through which fresh air for breathing purposes can be obtained, or he should wear a straight air hose mask equipped with lenses which provide the necessary eye protection.

Suitable receptacles or carriers should be provided in which cylinders of oxygen and acetylene can be laid during transportation. These cylinders should not be carried by cables, slings or chains. A good safety precaution is to provide a carbon tetrachloride fire extinguisher with each gas cylinder cart.

Pressure creeping up on the low-pressure side of an oxygen or acetylene regulator when the regulator adjusting screw is free indicates that the seat at the orifice is defective. The regulator should be taken out of service immediately and not used until properly repaired as there is danger of the cylinder pressure building up in the regulator causing the diaphragm to rupture.

Compressed air is used extensively in the boiler manufacturing industry. Air is compressed by motor-driven or machine-driven compressors and air lines are run throughout the various departments where connections are provided for the usual air hose.

The pneumatic tools usually encountered in the industry are air hammers, air motors for driving staybolts into the holes, and air tools for chipping, calking, cutting, reaming and drilling. The extensive use of pneumatic equipment presents the same hazards which are encountered with the use of this equipment in other industries, plus the hazards peculiar to sheet metal and structural fabrication. Various pneumatic tools fail to operate because of wear, derangement of parts, faulty lubrication, accumulations of dirt or foreign substances in the mechanism.

Operators are not always qualified to make repairs and if they do attempt it frequently render the tools dangerous for use. A tool which will not properly operate should be carefully repaired at the tool room by qualified men. All air tools should be inspected at frequent and regular intervals by competent men and necessary repairs made.

The practice of shooting tools out of an air gun, instead of removing them by hand, is dangerous and should be prohibited.

Proper ventilation is of the utmost importance in boiler shops because of smoke, gas and dust given off by the various operations. An abundance of natural light is necessary but is not always provided. The frequent cleaning of window and sky-lights will pay for itself in reduced accidents and increased production. Adequate artificial lighting is also necessary because of the nature of the structures being built. Extension cords are used extensively and should be maintained in the best possible working order.

This industry lends itself admirably to the correction and elimination of accidents through shop safety organization. Practically every shop, regardless of its type or size, consists of several distinct departments. These departments are usually in charge of foremen or superintendents. Results in the reduction of accidents and increased manufacturing efficiency can be obtained only through absolute co-operation between departments.

Practically all of the hand tools employed are made in the shop. It is important that tools should be properly tempered, made of the proper material, and periodically inspected and dressed, because the failure or chipping of hand tools may cause serious accidents. Light tools should be used on light work only. Men should not endeavor to use tools on work for which the tools are not fitted.

Set-up wrenches should be provided with jaws of sufficient strength that they will not spread or crack. Set-up wrenches with worn or spread jaws should be discarded.

Set-up bolts having worn threads or rounded nuts should be discarded because they permit wrenches to slip. The common practice of loosening the nuts on set-up bolts by striking them with a hammer or other tool batters the nuts and the threads of the bolts. The nuts should be loosened with a suitable wrench.

When pins are driven into rivet holes, they should be struck lightly until entered and seated. This manner of starting pins into holes will eliminate the tendency of the pins to fly at the first blow. Drift pins should not be oiled and should be used to secure alinement but not to enlarge holes. Care should be taken in driving out drift pins to see that all persons are in the clear in case a pin flies. To prevent drift pins flying, a piece of pipe with one end closed should be placed over the drift pin when it is struck. A handle of suitable length should be welded to the pipe so it may be held with ease and safety.

Back-stops of heavy fireproof material such as burlap or canvas should be provided to prevent rivet heads flying through the shop when they are cut off with either hand or pneumatic tools. Whenever possible, rivet heads should be cut off so they will be deflected toward the floor. Hand chisels should not be used for this purpose, side sets should be provided.

Files should be used only for the purpose for which they are intended and not as a makeshift for pins. Files without handles should under no circumstances be used because of the possibility of the tang of the file entering the hand or other part of the body. Files should not be stuck in the floor when not in use. They should be placed in a safe place where they will not create a tripping hazard.

Tools should be put in a safe place when not in use and should not be permitted to lie on window sills, ledges or other places where they may be dislodged.

Chippers should work back to back and thus avoid chipping toward other men working on the same plate. Where chippers cannot work back to back burlap screens supported on light metal frames should be placed between them.

Workmen who use air dollies should be sure that all parts of their bodies are in the clear before setting the tool. An air dolly should never be straddled as the tool may become disconnected from the extension bar and cause an accident.

When a small cold rivet is being driven with a hand hammer the rivet should never be struck until the man "bucking up" is on the rivet with the hand dolly.

Workmen using long-handled rakes, hoes or forks at flange fire furnaces, etc., should be sure that there is no one behind when the tool is withdrawn from the furnace and thrown down.

Portable electric tools and lights are extensively used in confined places such as inside and around tanks, boilers, drums, and other vessels being fabricated. There is a considerable electrical hazard in the use of such tools and lights unless proper precautions are taken.

Heavily insulated extension cords, plugs, sockets and receptacles should be used on all extension lights and portable electric tools. On account of the hard usage received in service ordinary braided extension cord, metallic or breakable sockets, plugs and receptacles are unsatisfactory and dangerous.

The use of extension lights without proper lamp guards should be prohibited. Lamp guards with hooks should be provided to allow suspension of lights.

Extension cords should be maintained in a good condition and periodically inspected. Any defects should be promptly remedied by an experienced person. Receptacles for extension cords should be located at a sufficient height from floors and working platforms to prevent contact with metallic objects and to prevent breakage by being struck by objects.

The sockets of extension lights should be provided with insulated or non-conducting handles for safety and ease of handling.

It is well to ground non-current carrying parts of portable electrically driven tools. This may be done by using as a ground wire the third wire of three conductor extension cords or cables. Some firms ground these non-current carrying parts by means of a third wire taped to the outside of the two-conductor cable or cord.

All metal non-current carrying parts of electric rivet heaters should be effectively grounded to prevent a possibility of a serious shock in case a ground should develop in any current carrying part of the heater. Rubber mats or hard maple platforms put together with wooden pegs should be placed on the floor in front of electric rivet heater stands.

Workmen operating air guns should be sure that they have secure footing. If either the workman or the tool slips, the tool may be shot across the shop, with perhaps serious injury to some one.

Pneumatic hammers should be provided with trigger guards because an unguarded trigger may be kicked or accidentally released while lying on the work or floor, which would cause the plunger to be discharged in a dangerous manner.

Air tools should be inspected at frequent and regular intervals. Handles and air hose connections should be tight and the tools in good working condition.

Portable air reamers may stick in holes with the result that the operators lose control of them. Handles of sufficient length should always be provided so that a proper leverage can be maintained. Wherever possible, the handles should be supported by pins placed in rivet or tube holes. These pins should be tested frequently to make sure they are tight in the holes and not likely to jar out of place.

To prevent tools sticking in holes, the operator should see that the drill points are ground uniformly and that bent drills, taps and reamers are not used.

Operators using pneumatic tools should avoid getting their feet or legs tangled up with the hose. This applies particularly to air motors which are difficult to handle, if the tool gets out of control or binds.

Workmen blowing scale or dirt out of tubes should wear goggles and be sure to tilt the hose nozzle downward at an angle to prevent blowing particles into the eyes of persons who may be passing.

When riveters are working plate edges in a manner that exposes the holder-on to the hazard of being struck by the die if it slips from the gun, a rivet-set retainer should be used to prevent it flying out.

Spring or safety clips should be used in connection with air guns when chipping, calking, upsetting and cutting to reduce the possibility of tools shooting out of the guns.

Soft hammers should be used for driving tools into air motor sockets.

Tap passers should not use wads of waste to catch taps coming through staybolt holes. A piece of pipe with a cap screwed on the end should be used for this purpose.

Men using air motors to chamfer tube holes (standing on tube sheet and operating reamer between their feet) should wear leggings to prevent trousers catching.

Workmen should not place hands or fingers around moving reamers, taps or drill points of pneumatic tools for any purpose. The motor should always be stopped when it is desired to remove shavings or to examine the tool or the hole being drilled or reamed.

Staybolt sets, fullers, bobbing tools, staving tools, chisels and tube beading tools at times crystallize and break in the radius of the shank. In such cases the shank remaining in the plunger of the air gun will strike the operator's hand or fingers and cause serious injury. To reduce crystallization and breakage these tools should be heat treated by qualified persons at frequent intervals.

To prevent injuries to the eyes from flying chips, rivet buckers and operators of air guns and portable grinders should wear goggles.

Only extra heavy nipples and fittings should be used in connection between a pneumatic tool and an air hose. So-called standard fittings and nipples frequently break and cause injuries to the operators.

(To be continued)

Development of the Oxy-Acetylene Fusion Welding Process ▲ ▲ ▲

By Frank C. Hasse*

In the October issue a history of the electric-arc process of fusion welding was outlined by J. C. Lincoln. This paper and the present one were prepared for the information of members of the Master Boiler Makers' Association, and for use in the 1931 proceedings of this organization. Mr. Hasse in discussing the beginnings and growth of the oxy-acetylene process draws on the historical background of the discovery and commercial application of the gases oxygen and acetylene in conjunction with the modern welding torch. Cutting and brazing are also discussed. Space does not permit the completion of this paper in the present issue, but a final instalment covering applications of this important tool to railroad work will appear in December.

Early history records the era during which prehistoric man learned to fashion crude implements from metal, as so significant that it is referred to as the "Bronze Age." At first the only metals known were those that occurred naturally in lumps or nuggets large enough to be recognized and that were also soft enough to be shaped by heating or pounding. Most important were copper and gold. In the course of time, it was found that these could be melted over a hot fire and formed into various useful or ornamental shapes by casting in crude molds.

Unlike copper and gold, iron deposits do not occur naturally in metallic form. Iron was therefore unknown until it was observed that a metallic substance was formed when a very hot fire was built on certain colored earths. These were in reality iron ores and heating in the presence of charcoal from the wood fire was precisely the condition necessary to liberate the iron from the ore. When it became known that the implements made from the new metal were superior in many respects to those previously used, attempts were made to obtain more of it.

Throughout this and subsequent developments, the craftsman and worker in metals have bent their energies toward the problem of shaping these materials into articles that would satisfy some utilitarian or artistic demand. Particularly important has been the question of how best to join together pieces of metal. This is a constantly recurring problem in every industry.

Obviously, the ideal way would be to place the pieces in contact and then merge them together along this line of contact to form a single, uniform, continuous piece. Until quite recently, however, the high temperatures necessary for the practical application of this principle were not obtainable. It is true that for many years it has been possible to melt iron, steel and other metals in furnaces,—but that is quite different from melting the abutting edges of two pieces of metal without affecting the rest of the piece. To accomplish this requires a comparatively small, easily manipulated source of intense heat.

The use of a blowpipe in the arts, especially in metal working, was no new thing. History records the fact that the ancient Egyptians, Greeks and Romans used some crude form of blowpipe in working lead and similar metals of low melting point; and down through the ages the blowpipe has been one of the instruments of workers of precious metals, for applying a hot flame derived from alcohol, etc., to a given point. But it was not until the discovering of gases that would yield high temperatures that the blowpipe process became capable of development to the point of general utility for the cutting and welding of metals.

With the increasing use of metals in every form of human activity, the problem of joining metal parts securely together had become most urgent. Its solution came with the discovery of the oxy-acetylene process.

The oxy-acetylene blowpipe is an outgrowth of the blowpipe in common use which are supplied with coal, gas and air. Attempts to increase the temperature of the flame led to the use of combustible gases having higher thermal values per unit of volume, and to the use of pure oxygen. In this way, a given number of heat units produced by the combustion were confined to the smallest possible volume of gas. The use of pure oxygen eliminated the nitrogen present in the air, which served only to dilute the gases and to lower their temperature in a corresponding degree. The result of these changes was to bring into use the oxy-hydric blowpipe which is extensively used in Europe for the welding of steel and for other work.

Acetylene, as a substitute for hydrogen offered theoretic advantages, as its thermal value per cubic foot is over six times the thermal value of hydrogen. Attempts to use acetylene, however, resulted in serious explosions.

The first successful oxy-acetylene blowpipe was devised by E. Fouche, a French investigator, who experimentally determined the rate of propagation of explosion in tubes of varying cross sections, when they were filled with an explosive mixture containing acetylene. He then perfected a blowpipe in which the acetylene is supplied through small tubes at a rate greater than that of the propagation of the explosion back toward the acetylene reservoir. While this precaution would apparently be unnecessary if the tubes contained only pure acetylene, there is always some danger that, on account of imperfect operation, the oxygen which is under higher pressure than the acetylene will be forced into the acetylene passages or even into the reservoir itself.

In order that use may be made of the acetylene gas under the pressure at which it is usually generated

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(about 20 inches of water or less—one inch of water being equal to a pressure of 0.57 ounce) the Fouche blowpipe used the oxygen under pressure to draw the acetylene into the blowpipe on the injector principle. This avoids the necessity for an expensive compressor for the latter gas.

Fouche invented his blowpipe probably about 1901 or 1902 but the process was not introduced into this country until 1904 when the Fore River Shipbuilding Company of Quincy, Mass., installed oxy-acetylene blowpipes for welding light steel plate which had formerly been riveted.

As mentioned, the oxy-hydrogen flame had been previously used, and we find that the first blowpipe of this kind was suggested by Robert Hare of Philadelphia about 1805. In 1820 Broke in Germany designed an arrangement by which a mixture of oxygen and hydrogen previously compressed by means of a force pump into a strong plate vessel escaped by a capillary tube.

Next Pins Sainte-Claire Deville obtained a blowpipe using oxygen and hydrogen compressed in two separate vessels. He succeeded in melting iron, silver and platinum. However, the oxygen-hydrogen blowpipe remained a laboratory instrument until such time as the gases could be produced at a low price and arrangements devised for their safe storage, and was not introduced for industrial welding until 1901.

The term oxy-gas is given to the flame produced by the combustion of a mixture of oxygen and illuminating gas.

In 1838 Debasayus de Richemont replaced the hydrogen and air by oil-gas. They thus obtained joints by using more fusible alloys (brazing) and obtained autogenous welds on lead. The process was tempting, because it allowed a cheap and easy installation for autogenous welding in all shops supplied with illuminating gas. However, it was found impracticable, owing to the composition of the gas which is not constant. Further, because of the fact that a cubic foot produced only about 600 British thermal units, and the necessity of preheating the gas, which required the tubes through which the gas is conveyed to the tip to be made in spiral shape, the resulting blowpipe was very bulky.

The welds made by oxy-gas blowpipes are of low tensile strength and have no ductility. Therefore, acetylene offers considerable advantages over all other combustible gases utilized for welding flames, in that it facilitates work, produces a weld of quality at less cost. Moreover, it is the only process with which welds from the smallest to the largest thickness can be obtained of the required tensile strength, ductility and elongation characteristics.

Oxygen is the most abundant and important of the elements, being found in the air to the extent by weight of 23 percent, in water by weight of 89 percent, as well as in minerals, acids, salts and as a constituent of all animal and vegetable matter.

The characteristic property of oxygen is its power of supporting combustion; a glowing candle will instantly burst into flame if plunged into a jar of oxygen, as will a piece of iron heated to redness burn or decompose when plunged into pure oxygen. The combustion is a chemical reaction between the oxygen and the body which burns in it. The product of the combustion is termed oxide.

Oxygen was first isolated by Priestley, in England and Schele, in Sweden. Lavoisier studied its properties and gave it the name of oxygen. Up to 1877, oxygen was regarded as a body not capable of existing in the liquid state. However, liquefaction was brought about by M. Caillet and Pictet, by compressing it to 320 atmospheres (4704 pounds) and lowering its temperature to 140 degrees C. below zero (—284 degrees F.). Under these conditions the density of the gas approaches that of water.

Oxygen in the laboratory is usually prepared by heating manganese dioxide to a bright red heat, when it gives up one-third of its oxygen; or by heating potassium chlorate, which likewise gives up its oxygen. If the potassium chlorate is mixed with about one-eighth by weight of manganese dioxide, the action is more regular.

These processes are not now considered practical for industrial purposes. The latter method was at one time the only source of supply for blowpipe welding and cutting.

The inability to obtain oxygen on a more elaborate basis, retarded the use of oxy-acetylene apparatus until the final conclusion of experiments in May, 1895, on the extraction of oxygen from liquid air, as conducted by Professor Linde. By the aid of this process, oxygen could be produced in such quantities as to make it commercially economical.

In this process, the air is drawn through carefully prepared dryers and purifiers and is then compressed to about 3000 pounds per square inch and cooled. It is then expanded through a needle valve, the rapid expansion absorbing heat until the temperature is sufficiently lowered to become a liquid. This liquid (liquid air) is evaporated fractionally and the vapors then passed through a rectification tower.

In this way due to different temperatures of evaporation, the oxygen is separated from the nitrogen, the nitrogen passing off as a gas, and the oxygen remaining as a liquid. The oxygen is then collected in a gas holder, from which it is drawn into compressors, and compressed in steel cylinders at a pressure of 2000 pounds per square inch. This pressure has been adopted as a standard by all producers. Oxygen extracted from liquid air is now the standard of producing manufacturers.

Water is a compound of hydrogen and oxygen, which can be split into its elements, and the two gases collected separately.

This separation is brought about by adding to a given quantity of water a proportional amount of sulphuric acid or potash, through which mixture an electric current is passed, the oxygen being liberated at the negative and the hydrogen at the positive pole. This is termed the electrolytic process, and while a reasonably pure oxygen can be obtained by this process, it has many disadvantages.

Oxygen is compressed in cylinders to a pressure of 2000 pounds per square inch and is furnished in three different sized cylinders, 110, 220, and 275 cubic feet, the 220-cubic foot cylinder being that most generally used.

Since all gases expand when heated and contract when cooled, the pressure of oxygen in the closed cylinder will go up or down as the temperature changes. If, for example, a full cylinder of oxygen is allowed to stand outdoors for several hours when the temperature is, say, 30 degrees F., or just below freezing, the pressure of the oxygen will register 1800 pounds per square inch. This does not mean the oxygen has been lost; cooling has merely reduced its pressure. Placing the cylinder in a warm room at 70 degrees F. will again bring the pressure back to 2000 pounds. Here no oxygen has been gained; warmth has merely increased the pressure. The accompanying table shows how the pressure of a full cylinder will vary as the temperature changes:

Temperature of Oxygen Deg. F.	Gage Reading Lb. per sq. in.	Temperature of Oxygen Deg. F.	Gage Reading Lb. per sq. in.
70	2000	30	1804
60	1951	20	1755
50	1902	10	1706
40	1853	0	1657

Acetylene is known as C_2H_2 having the composition by weight of twenty-four parts of carbon and two of hydrogen, or 92.3 percent carbon and 7.7 percent hydrogen. Carbon, known in many forms as a fuel for combustion, with a view either to producing heat or furnishing light, is a constituent of all fuels from whatever source and wherever employed. Pure carbon—100 percent—as well as in other forms, such as anthracite coke, charcoal, etc., does not even melt under such heat as can be attained, much less pass into the form of vapor or gas. It is, therefore, interesting to note that acetylene, containing only 7.7 percent of material other than carbon, is the nearest approach to gaseous carbon at common temperatures known to science.

It is a colorless and tasteless gas, but has a peculiarly penetrating odor, its presence in the air to the extent of only one part in ten thousand is distinctly perceptible. However, when properly burning, there is absolutely no odor and if an odor of acetylene is detected about an apparatus in operation, it is on account of leakage, and should be traced to its source and remedied, as a mixture of 30 to 35 percent of acetylene will cause an explosion. Acetylene in a free state cannot be compressed or utilized at a pressure above 15 pounds per square inch; above this point it is explosive, except when dissolved. This will be covered in a subsequent paragraph. Acetylene will ignite at about 900 degrees F., the lowest known ignition point for any gas, and will light from the glow of a cigar.

In 1836, Humphry Davy, an English chemist, observed that a by-product which he had secured incidentally to the production of metallic potassium, was capable of decomposing water. With the evolution of a gas which contained acetylene in 1862 Woehler, the most famous chemist of the day, announced the discovery of the preparation of acetylene from calcium carbide, which he had made by heating to a very high temperature a mixture of zinc and calcium. The product could decompose water like Davy's compound, and yield a gas containing acetylene. Thus the phenomenon which had been observed, but not understood by Davy was explained and published by Woehler.

Then for thirty years, these two substances seem to have been practically forgotten, and up to the year 1892, it is safe to say that few, even professional chemists of the world, ever saw an acetylene flame, much less dreamed of it as a commercial possibility.

With the advent of the electric furnace, the possibility of calcium carbide as a commercial product was revealed to Thos. L. Willson, an electrical engineer at Spray, North Carolina; and in May, 1892, while conducting experiments for the purpose of preparing metallic calcium from a mixture of lime, and coal tar, he secured a melted mass, which on cooling became solid and brittle, and, not containing the metallic calcium desired, it was thrown from a window into a stream. It was noticed that there was a gas liberated when in contact with water, and on investigation this was found to be acetylene gas, and that the original mass, instead of being the desired metallic calcium, was calcium carbide. The manufacture of calcium carbide is now given as a mixture of 56 pounds of lime and 34 pounds of coke, which makes 64 pounds of carbide. For each pound of carbide produced, there is consumed approximately a pound and a half of the mixture, which is something like 7/12 lime and 5/12 coke.

Carbide is furnished in drums, which are hermetically sealed, and should always be stored in a dry place, and under no circumstances should a partly filled can be allowed to stand without the covering being properly screwed in place.

Volume requirements of acetylene suggests the use of acetylene generators located in a separate building and the gas distributed through pipe lines with outlets at convenient locations. Generators for such use may be classified in two general types, depending on whether the carbide is dropped into the water or the water is dropped into the carbide. The latter is not used in the United States, as the heat generated by the chemical reaction is undesirable, and affects the purity of the acetylene.

In the carbide-to-water type generator, which is used almost exclusively in this country, small lumps of carbide are fed from a hopper into a comparatively large volume of water. The heat given off during the reaction is readily absorbed by the surrounding water and the acetylene formed bubbles up through the water, being cooled and purified in this way.

While all carbide-to-water generators operate according to the general method outlined above, there is of course, considerable variation in mechanical details. Modern acetylene generators for use in welding and cutting are designed to be automatic in operation and as nearly fool-proof as possible. When installing and operating acetylene generators, the manufacturer's instructions should be followed exactly.

Acetylene is widely distributed in cylinders. These are quite different in construction from oxygen cylinders for, as already noted, free acetylene should not be stored at above 15 pounds per square inch pressure. After much study, the problem of combining safety with capacity was solved by packing the cylinders with a porous material, the fine pores being then filled with acetone, a liquid chemical having the property of dissolving or absorbing many times its own volume of acetylene. In such cylinders, acetylene is perfectly safe. The acetylene dissolved in acetone will not change its nature and cannot be exploded.

The cylinder itself is a strong steel container packed completely full of a porous substance which in turn is saturated with acetone. Acetylene is drawn off through a valve, which, in some types of cylinders is located in a recessed top, where it is protected from breakage. The valve is much simpler than an oxygen valve, not having to withstand the high pressure. It should be opened only 1½ turns. Safety fuse plugs are provided to meet any fire emergencies and the entire construction must satisfy the requirements of the Interstate Commerce Commission.

Dissolved acetylene is sold in cylinders containing either 100 or 300 cubic feet of gas. Average shipping weights are: for the 100-cubic foot cylinders, 89 pounds full, 83 pounds empty; for the 300-cubic foot cylinders, 227 pounds full, 205 pounds empty. A pressure gage placed on a full cylinder containing dissolved acetylene would register 225 pounds.

Acetylene cylinders should never be charged or recharged except by the manufacturer, who can conduct this operation under careful control. The acetylene is made in large stationary generators, purified very carefully and then dissolved into the cylinders.

Development of apparatus has changed little, if any, in basic principle of operation with a few exceptions of departures from original pressures and change in design. Refinements and improvements in efficient operation indicate that the welding industry has grown from a slight youngster to a husky and early manhood.

Engineers and designers have met every demand of the different industries by furnishing equipment to suit each individual need. The blowpipe of considerable weight and unstable flame, used mainly for rugged repair work has been replaced with a tool of precision, of variable sizes and a range of welding tips for every type of manufacturing and repair work.

Semi-automatic and automatic cutting and welding blowpipes manually and power driven are available to simplify and speed production of repetition work.

Portable and stationary automatic shape-cutting machines, unlimited in scope, can be had for cutting of metals up to 24 inches in thickness, and to close tolerance, reducing to a minimum machine work, when a finished surface is required. Many different parts cut on machines now available, are used without machining.

Tips for welding blowpipes and nozzles for cutting blowpipes have been refined and improved to a point where performance of equipment is no longer considered a factor or questionable quantity in the successful accomplishment of oxy-acetylene welding. Oxygen and acetylene regulators equipped with suitable gages have developed from crude inaccurate unreliable instruments, to devices that actually reduce, regulate and deliver a given uniform volume. Gages are now equipped with non-corrosive Bourdon tubes adjustable to precise pressures. Safety features as release openings and several types of self-releasing or safety backs to prevent destruction of the case in the event of tube rupture.

The use of oxy-acetylene apparatus is now quite general; however, there is some question if all users have considered the value of the apparatus when scientifically applied in the maintenance and repair of equipment of every description, marine, railroad, industrial, mining and manufacturing of all forms.

First cost of welding rods and fluxes when purchased is too often the governing factor. In the infancy of oxy-acetylene welding many costly failures were experienced due to lack of sufficient engineering experience to direct the manufacture of rods of proper analysis. Many instances can be related of using strips taken from similar material to accomplish a weld. In so doing no thought was given to the effect of the intense heat of the oxy-acetylene flame on the materials welded.

Laboratories have since, as a result of extensive investigations, demonstrated the importance of what may be termed a balanced mixture of ingredients, in rods for specific operations.

Proportional amounts of carbon, silicon, phosphorus or such other component parts as may be required for special rods, must be in direct and exact ratio to accomplish the perfect weld, and this at all times must remain to the dictates of metallurgists and engineers.

Therefore, welding rods and fluxes should not be purchased or used on a price basis alone but should be selected on a basis of definite engineering data. Then the materials recommended for the particular type of metals to be welded should be used.

The metallurgist and chemist are faithfully serving the industry both in the laboratory and in the field and in co-operation with the engineer and practical welder have made possible extended applications of welding in every industry. This will continue only so long as there is a close co-ordination of effort between the engineer and the welder.

Selection of students for training as welders is frequently considered unimportant, and is done in an indifferent haphazard way, resulting in the assignment of men utterly incapable of acquiring the art.

(To be continued)

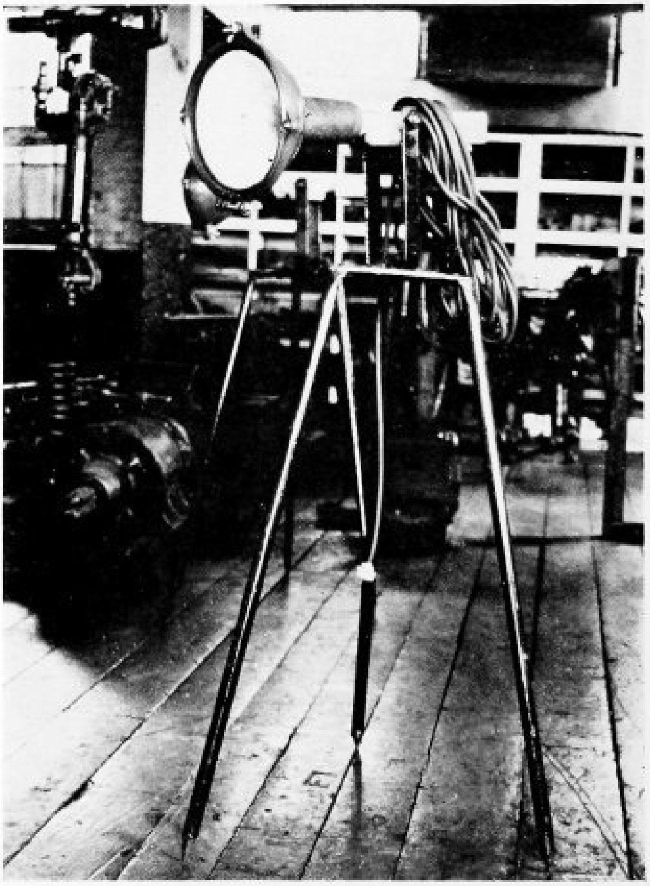
Portable Electric Lights For Boiler Shops

In many boiler shops it is practically impossible to arrange the lighting facilities in such a manner as to afford sufficient light for workmen on the night shifts. In many instances extension cords are used by the men, but at their best they are not satisfactory.

The portable electric light shown in the illustration can be used effectively for this purpose and can also be used for emergency jobs about the shop or enginehouse. While it can be made adjustable by the use of different size pipe in the legs, this is not essential for the reason that the tension bracket which holds the reflector can be adjusted to any angle desired.

The base is 4 feet 6 inches high and is made from one-inch pipe which is welded or riveted to a ¼-inch plate cut in triangular form and measuring 12 inches on a side. The bracket is 2 inches wide and ¼ inch thick and is secured to the base plate by one ⅝-inch bolt equipped with a wing nut to permit ready adjustment of the bracket. The size of the reflector can be either 12 inches or 18 inches as desired. It is secured to the top of the bracket by one ⅝-inch bolt which is also equipped with a wing nut to permit ready adjustment of the lamp.

The length of the extension cord is governed by the location of electric-light receptacles. A 75-foot cord is best suited for general use so as to enable the repairmen to move the light to any position that will require better lighting without necessitating changing the plug at the receptacle.



A light of this type can be used for many purposes around the shop

S. O. Dunn, chairman of the board

Henry Lee, president

New Officers Head Simmons-Boardman Company

R. V. Wright, vice-president

George Slate, vice-president

The election of Samuel O. Dunn as chairman of the board and of Henry Lee as president of the Simmons-Boardman Publishing Company, to succeed Colonel E. A. Simmons, deceased, places in executive charge of its management two men who have been associated with it for a quarter century. The association of Mr. Lee with the Simmons-Boardman Publishing Company and its predecessor organization dates from 1905, when only one paper was published; that of Mr. Dunn, from 1907. Each has participated to a major degree in the development of this company and its affiliates to their present position as publishers of nine leading business papers. At the same time Mr. Lee was elected chairman and Mr. Dunn president of the affiliated American Builder Publishing Corporation; Mr. Lee was also elected president of the House Furnishing Review Company.

The history of the Simmons-Boardman company during the past quarter century has been one of sound and steady progress. During most of this time Mr. Dunn was head of the editorial department and Mr. Lee of the business department. Both of the new Simmons-Boardman executives joined the organization prior to the beginning of its period of expansion. Both were connected with the old Railway Age, which on June 1, 1908, was consolidated by W. H. Boardman with the Railroad Gazette to form the Railroad Age Gazette (subsequently to become the Railway Age-Gazette, and still later, the Railway Age). In addition to the consolidated publication, the company also published the magazine now known as Railway Signaling. Expanding its activities to meet the need for additional papers in the railway field, the company acquired or established the publications now known as Railway Mechanical Engineer, Railway Engineering and Maintenance, and Railway Electrical Engineer. In 1920, through the acquisition of the Aldrich Publishing Company, Marine Engineering and Shipping Age and THE BOILER MAKER were added to the list of Simmons-Boardman publications. The Railway Review was purchased in 1926 and at that time was consolidated with Railway Age.

Samuel O. Dunn was born on March 8, 1877, at Bloomfield, Iowa. When 12 years of age, he began to learn the printer's trade, and at 18 was editor and publisher of a newspaper at Quitman, Mo. After four years as associate editor of the Maryville (Mo.) Tribune, he joined the staff of the Kansas City Journal in 1900, and was promoted to editorial writer two years later. Beginning in 1904, he was for three years an editorial writer on the Chicago Tribune, during which time he began to specialize on transportation matters.

Mr. Dunn became an associate editor of the old Railway Age in January, 1907. A few months later he was made managing editor. On June 1, 1908, when the old Railway Age and the Railroad Gazette were consolidated to form the Railroad Age Gazette, he was appointed western editor. Mr. Dunn was appointed editorial director in 1910, and on October 1, 1911, succeeded W. H. Boardman as editor. At almost the same time, he completed the study of law to which he had devoted much of his spare time, and was admitted to the bar. Expansion of the company brought parallel expansion in his duties, as he became editor-in-chief of all papers acquired and established.

Mr. Dunn has been a frequent contributor to magazines and speaker on transportation subjects. He is the author of "The American Transportation Question," published in 1911; "Government Ownership of Railroads," published in 1913; and "Regulation of Railways," published in 1918, as well as numerous articles published in Scribner's, the Atlantic Monthly, the Review of Reviews, World's Work, Nation's Business, etc. He has lectured on transportation subjects at Harvard University, the University of Illinois, Northwestern University, the University of Wisconsin, the University of Missouri, the University of California, the University of Indiana, Purdue University, the University of Texas, and Iowa State College, and has spoken on transportation problems before such organizations as the Investment Bankers Association, the Chamber of Commerce of the United States, the Railway Business Association, the National Metal Trades Association, the National Association of Manufacturers, the National Industrial Conference Board, the Rivers and Harbors Congress, and the Associated Traffic Clubs of America. He was a delegate of the American Railway Association to the International Railway Congresses at Rome in 1922, and at London in 1925.

In addition to his duties as chairman of the board of the Simmons-Boardman Publishing Company, Mr. Dunn will continue as editor of the Railway Age.

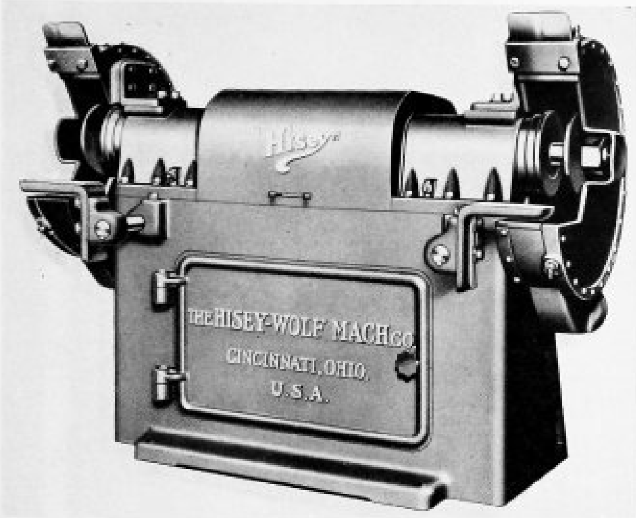
Henry Lee was born at Hamlet, Ill., on May 25, 1884, and received his education at the Aledo, Ill., high school and at the Metropolitan Business College at Chicago. He joined the old Railway Age at Chicago in 1905, and was assigned to the news staff in 1906. A year later he was appointed associate editor and transferred to New York. Upon the consolidation of the Railway Age and the Railroad Gazette in 1908, Mr. Lee was transferred back to Chicago, and a year later was placed in charge of the make-up department at New York. Later in 1909, Mr. Lee was placed in charge of the copy service department, shortly after which he was made a sales representative of the company. He was elected secretary in 1910 and was elected secretary-treasurer in 1911. Mr. Lee was elected a director of the Simmons-Boardman Publishing Company in 1912, and became vice-president and treasurer in 1916, at which time he was placed in active charge of the business department. He relinquished his duties as treasurer in 1929, continuing as vice-president in charge of the business department.

Mr. Lee has been active in various organizations, including the Federation of Trade Press Associations (now the Associated Business Papers, Inc.) of which he was secretary-treasurer in 1910-11. He was successively secretary, vice-president and president of the New York Business Publishers Association during the years from 1916 to 1919, and was a director of the Technical Publicity Association in 1918. During the war he served as chairman of the Business Press division for the several government loans, and following the war served for two years as a member of the Surplus Property committee of the War Department. In 1929, he was elected vice-president, director and member of the executive committee of the Simmons-Boardman Publishing Corporation, and in the same year was elected vice-president and a director of the American Builder Publishing Corporation.

As a sequel to the election of Samuel O. Dunn and Henry Lee, to the chairmanship and presidency, respectively, of the Simmons-Boardman Publishing Company, other elections and appointments have been made as follows: Roy V. Wright, secretary of the company, has been elected vice-president and secretary; George Slate, business manager of Marine Engineering and Shipping Age and THE BOILER MAKER and a director of the company, has been elected also vice-president; Elmer T. Howson, western editor of Railway Age and editor of Railway Engineering and Maintenance, has been elected vice-president and a director; Frederick H. Thompson, vice-president, in charge of the Cleveland office, has been named to the directorate, and Frederick C. Koch, manager of advertising sales of the railway publications division of the company, has been elected vice-president. The headquarters of each will continue as heretofore, i.e., Messrs. Wright, Slate and Koch at New York, Mr. Thompson at Cleveland, and Mr. Howson at Chicago.

Roy V. Wright was born at Red Wing, Minn., on October 8, 1876, and was educated at the University of Minnesota, from which he was graduated in 1898 with the degree of M.E. He entered railway service in the same year as a machinist's apprentice on the Chicago, Milwaukee & St. Paul at South Minneapolis, Minn. Two years later he joined the staff of the Chicago Great Western as a draftsman and was later made chief draftsman. In 1901 he was appointed mechanical engineer of the Pittsburgh & Lake Erie, which office he resigned in 1904 to become associate editor of the American Engineer and Railroad Journal (now the Railway Mechanical Engineer). In the following year he became editor of that publication and continued as such until 1910 when he became mechanical department editor of the Railway Age-Gazette (now Railway Age). In the following year he was appointed managing editor and has since continued in that capacity. Since 1912 he has also been editor of the Railway Mechanical Engineer and of the Car Builders' Cyclopedia and the Locomotive Cyclopedia. He was elected a director of the Simmons-Boardman Publishing Company in 1915 and secretary in 1919. He is a member of the Transportation Committee and the Industrial Committee and chairman of the Board of Publications of the National Council of the Y.M.C.A. He served two terms as president of the United Engineering Society, New York, and is at the present time president of the American Society of Mechanical Engineers, in the work of which association he has long taken a prominent part. Last June the degree of Doctor of Engineering, *honoris causa,* was bestowed upon him by Stevens Institute of Technology.

George Slate was born on September 27, 1874, at Oxford, Mich. He was educated in the public schools of Alma and Grand Rapids, Mich., and started his business career in the classified advertising department of the Philadelphia Press, later removing to New York where he served the New York Journal in a similar capacity. His association with Marine Engineering and Shipping Age dates back over 30 years, having joined the staff of that publication as an advertising salesman on October 14, 1901. He was later elected a vice-president of the Aldrich Publishing Company, which at that time published this periodical. That company in 1905 acquired THE BOILER MAKER and Mr. Slate's jurisdiction was extended to include that journal as well as Marine Engineering. In 1920 the Aldrich Publishing Company, with its two publications, was acquired by the Simmons-Boardman Publishing Company, and shortly thereafter Mr. Slate was elected a director of the latter company, on which board he has since served continuously. He is an associate member of the Society of Naval Architects and Marine Engineers. He was for 15 years secretary and treasurer of the Boiler Maker Supply Men's Association and has long interested himself in the affairs of that organization and the Master Boiler Makers' Association. He has also been active in the work of the Associated Business Papers, Inc., and in the business paper division of the Audit Bureau of Circulations.



Variable-speed snagging grinder

Heavy Duty Snagging Grinder

The new Hisey heavy duty snagging grinder, a radically new machine in that it affords independent speed control for each wheel, has been developed by the Hisey-Wolf Machine Company, Cincinnati, O. The new machine permits the operation of both wheels at the most efficient and economic speed. It eliminates the necessity of running the wheels on both ends of the split spindle at the same speed, thereby causing the smaller wheel to run at a lower linear speed than the larger. This grinder is manufactured for 20, 24 and 30-inch grinding wheels, of either the high speed or vitrified type with spindle speeds to correspond. Ball bearings or Timken roller bearings are optional. The drive is through V belts. Any stock power motor can be used.

Another feature is automatic belt tension adjustment, which eliminates the necessity of adjusting the motor. Steel riveted plate guards with exhaust connection and bayonet-type doors are standard equipment. A steel spark arrester is firmly held in a box-type of head and is easily adjusted to the wear of the wheel. The spindle is made of chrome nickel steel which is heat treated before machining and accurately ground. The wiring is encased in flex-steel conduit and fittings and meets all requirements of the underwriters.

Fleetweld Rod for Shielded-Arc Welding

The Lincoln Electric Company, Cleveland, announces the introduction of an improved, heavily coated electrode for welding within the shielded arc on mild steel. Like its predecessor this electrode will be known commercially as Fleetweld.

Research and experiment have brought many improvements in Fleetweld. The new electrode, as compared with the old, insures a higher ductility of weld metal, 20 percent to 30 percent elongation in 2 inches. The tensile strength of coupons will be increased about 10 percent with this electrode, to averages between 65,000 and 80,000 pounds per square inch. Resistance to corrosion, greater than mild steel, is also noted. There is little spattering with the new electrode.

The shielded-arc process utilizes a heavy coating on the outside of an electrode of mild steel of proper specifications. This coating, burning in the arc less rapidly than the electrode melts, forms in effect a crucible around the arc, protecting it for almost its entire length. As the coating burns it gives off the oxidizing gas which prevents oxygen and nitrogen in the ambient atmosphere from reacting with the molten metal. The shielded-arc process, eliminating oxides and nitrides in this manner, gives improved ductility, tensile strength and resistance to corrosion. With the shielded-arc process porosity is avoided and the layer of easily removable slag, the residue of the burning coating, forms a protection for the hot metal while cooling.

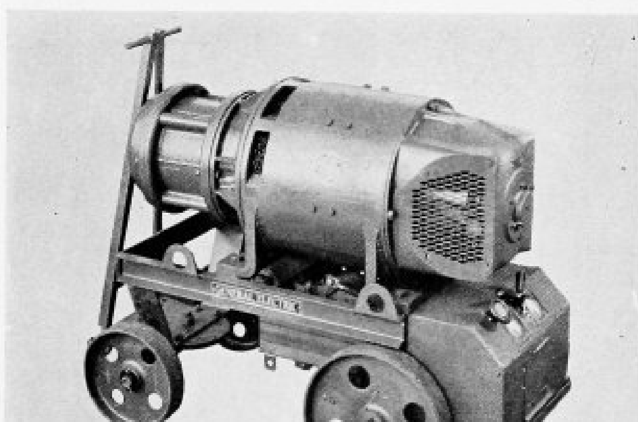
The new Fleetweld, a shielded-arc electrode, requires high welding current and allows welding speeds, which are 2 to 4 times greater than that secured by bare or lightly coated electrodes.

Fleetweld was first introduced, after years of research, in 1929. The new Fleetweld merely increases the widely known efficiencies of the shielded-arc process. The heavy coating is of special composition material, the metal core is drawn to rigid specifications and carefully selected and tested. This electrode will be produced in diameters from ⅛ inch to ⅜ inch and in two lengths, the standard 14-inch, and the special 18-inch, popular on pipe lines and wherever extremely high speed is desirable. As with all other Lincoln electrodes Fleetweld comes packed in square metal protective containers.

New Welding Sets Have Many Improvements

The General Electric Company, Schenectady, N. Y., announces a new line of single-operator welding sets in which are incorporated many improvements over past designs. This has been designated the WD-20 line as the types are numbered WD-21, 22, 23, 24 and 26, covering the 100-, 200-, 300-, 400- and 600-ampere ratings respectively.

It includes both portable and stationary sets the basic form being stationary with but a slight change needed to make it portable. Types include those for operation on either alternating or direct current at all standard voltages and, in the case of alternating cur-



New portable arc-welding set

rent, standard frequencies and 2- and 3-phase gasoline-engine-driven sets will also be available.

Among the principal advantages of the line are the use of two-bearing construction on the alternating current types up to 600 amperes; compactness and light weight; and greatly improved welding characteristics. The sets are self-excited with a tapped series field for major current adjustments and a shunt field rheostat giving duplex voltage control.

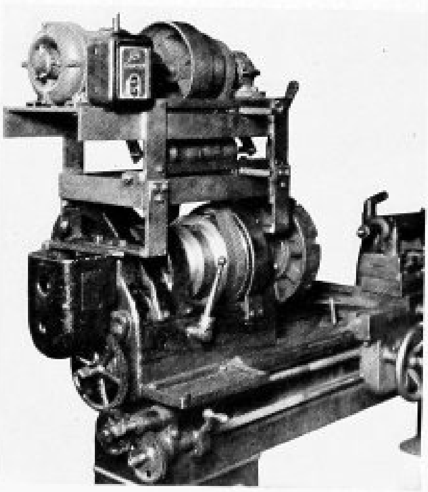
The latest design of standard alternating current motor has been specially adapted for use in the alternating-current sets. Generators are of a distinctive new design while retaining all the good features of the past equipment. The direct current motors are of the latest standard design.

A typical alternating current set consists of a generator with an over-hung driving motor mounted on a simple base to which is attached a strong sheet-metal control cabinet enclosing the generator control devices, meters and motor-starting equipment. A specially designed transformer-reactor is mounted in the base under the generator. Base supports are arranged to be bolted to the floor or to have axles and wheels readily attached. The whole assembly occupies a minimum of space, a typical 300-ampere, alternating current set standing 36 inches high, 50 inches long and 23 inches wide. The weight of such a set is 1865 pounds.

Motorized Unit for Machine Tools

The Production Equipment Company, Cleveland, Ohio, has recently developed a motorized unit drive for machine tools which makes it economically possible to change belt-driven machines to motor drive. This is accomplished by the application of a specially designed unit-type drive which performs the functions of line shaft and countershaft.

The complete motorized unit consists of the base and the drive unit. Two styles of bases are regularly used—the box type and the overhung type—depending upon the type of machine tool to which the application is made. The box-type base provides support at all bearing points and assures accurate alinement under all operating conditions. It permits the ready mounting of an idler pulley and belt shifter, thus giving a complete unit which will meet practically any engineering or safety requirement. The box-type base is usually supplied with two U-shaped supporting members which are mounted directly over the spindle-bearing caps. The belt is entirely inside the box construction and, to comply with the safety codes, a mechanical belt shifter can be built in and wire mesh covers furnished for the box. The box-type mounting also permits the use of an idler pulley which makes possible heavier cuts than can be made when a machine is driven from a line shaft.



A motorized unit with box-type base and idler pulley applied to a lathe

The overhung type of drive utilizes a base mounting on a welded steel base supported from a structural-steel column which is bolted to the side or rear of the machine. The countershaft base is hinged at the upper end of the column and the belt tension is adjusted by means of a simple cam operated by an adjusting lever. The overhung type of base is usually used without the mechanical belt shifter or the idler pulley, although these auxiliaries may be used if desired.

The drive unit consists of a speed reducer with an extended shaft to which the drive pulley is keyed. The shaft has an outboard bearing. The speed of the extended shaft is designed to duplicate the normal speed of a countershaft. The unit is supplied in ratings from ½ to 20 horsepower, in single-, or multi-speed designs, reversible if desired. This type of drive may be used with either single-pulley or cone-type machines. The electrical equipment is fitted with pushbutton control.

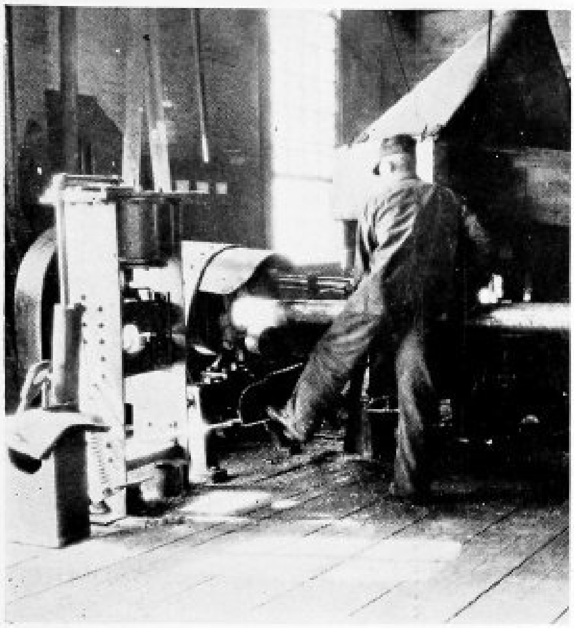
Give a Man a Chance to Look Ahead

Why is it that in these days, when one might think that anyone who is steadily employed would be content merely because of that fact, so many applications for work are received from men who have steady jobs? The reason, in nine cases out of ten, seems to be that the man who desires to make a change feels that there is no chance for advancement with his present employer. This is a bad state of affairs, both for the man and for the employer. The man may leave a job, which, had he stayed, would soon have led to a promotion; the employer may lose a good man at the very time when his training has placed him in line for promotion.

I believe that the cause of this trouble lies largely, on the one hand, with the employer who promises more than can be fulfilled, and on the other, with the employer who is too cautious in stating the prospects for advancement. The first one arouses hopes, which, when not fulfilled in a reasonable time, make the employe doubt his chances of promotion; the second, in trying not to make promises that he cannot live up to, is over-cautious and gives the employe an idea that there is practically no hope of advancement.

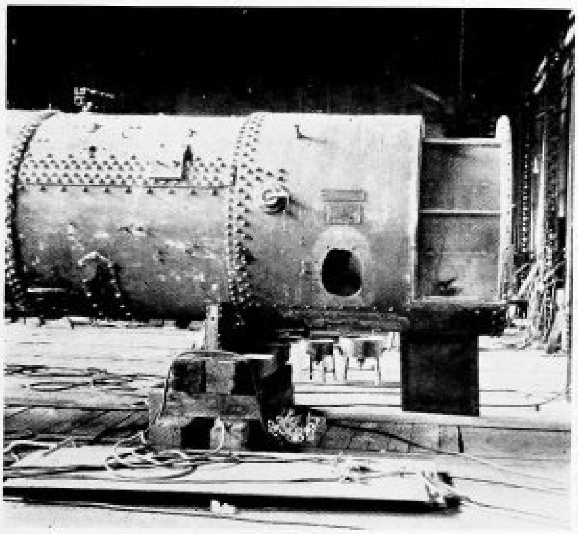
Frank discussions with men who are in line for promotion should be encouraged. Promotions that have been made in the past should be pointed out to the newcomers, so they will realize that if they make good and stay with the firm they will have their chance when an opportunity presents itself. There are some large firms making use of this plan which have demonstrated conclusively that it operates very successfully. The strongest organizations are those who promise only what can be kept, and who regularly promote men from within the organization.—*Machinery.*

Welding Equipment.—The Torchweld Equipment Company, Chicago, has prepared a 32-page pocket-sized catalogue describing the variety and characteristics of the non-flash Torchweld line of welding and cutting torches, units and gas-pressure regulators.



Reclaiming superheater flues

Welding Practice in Northern Pacific Boiler Shops*



Welded recess for feedwater heater

When necessary to apply patches to firebox sheets the shape of the patch will be governed by the defective area to be replaced. In general the shape should approximate that of a circle or an ellipse, all sharp corners being avoided.

Patches should be butt welded from the fire side. Sufficient stock should be allowed in the patch to allow for dishing as shown in Fig. 1. The patch must be bolted firmly in place and tacked in the regular manner. As the welding of the intermediate spaces progresses, the supporting bolts must be removed, in order to relieve the stresses while the weld is cooling. Staybolts must not be applied until after the weld is cooled.

The usual and most practical point to start the weld with gas is at the top center working downward both ways to equalize strain and keep the patch in the center of the cut.

With electric welding the weld should start at the bottom center and work upwards.

* First instalment of welding instructions appeared on page 274 of the October issue.

Patches should not be dished to excess as it is desired to have the sheets as straight as possible when welding is completed.

When trouble is experienced from leaky crown sheet seams, door collars, flanges or old patches, on which rivets or patch bolts are bad, remove the rivets or patch bolts and cut the outer portion of the seam away on a line with the center of the holes. Bevel the edge of the sheet slightly, clean rust and scale from rivet holes and weld as in lap welding, filling the holes.

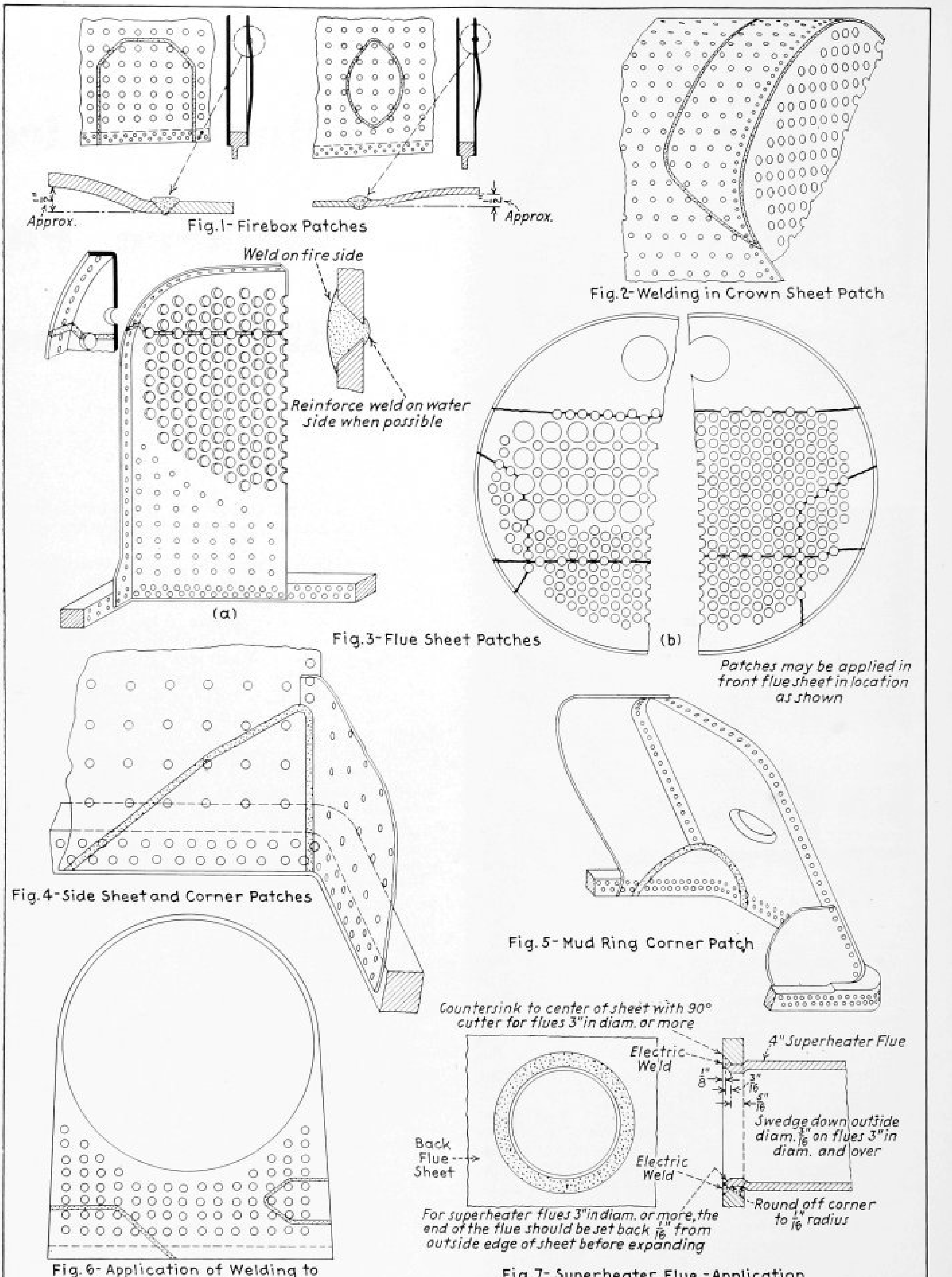
In fitting door collars the door flange should first be fitted and the seam clamped in place. Then tack on opposite sides until there are enough tacks to leave a space of about 12 inches between each tack. The width of each tack should be 2 inches. After the patch is tacked, all supporting bolts and clamps should be removed and welding performed. The order of welding the sections may have to be varied to suit conditions. If a door sleeve is used the sleeve must be lap welded to the door collar on both sides before applying.

Boilers without sleeves with the back head and door sheet flanged to the water side should be butt welded in making repairs.

Patches applied to the front end of the crown sheet should be shaped at the ends as shown in Fig. 2, the end seams widening out toward the side of the firebox. This patch must be securely held in place and tacked every 12 inches. Welding should start at the top center space and continue downward one space at a time, alternating from side to side. Welding is to be done from both sides. When butt welds are made by the electric process, after the vee has been filled in on the fire side, the bottom of the vee should be chipped out from the water side to a sufficient depth to remove imperfections in the weld before applying the reinforcement.

Where stoker tubes are to be applied, the holes in the door sheet and back head are first marked off and then cut out with a gas cutting torch.

If the tubes are to be welded in with the gas process the sheets are cut on a bevel of 45 degrees. If the electric process is used, the sheet is cut at right angles and finished to fit the outside diameter of the tube. The tubes are made of firebox steel rolled to the correct size and butt welded with the gas process, the weld



Typical boiler patching methods employed by the Northern Pacific being finished on both sides. In applying the tube, the weld must be located at the bottom. Tack in four places and weld from the bottom up, alternating from side to side if necessary to hold the tube in alinement.

Patches on flue sheets may be welded, the line of the weld depending on the condition of the sheets. In patching through flue holes, the cut should be made straight across, and the cut through the flange should be on a 45-degree angle instead of straight through. Patches should be fitted up with all flue holes in, with standard bevel and opening, and clamped every 8 inches. The center bridge should be welded first, then the bridge on each side, and continue alternating until welding has been completed, welding the flanges last. Welding is to be done on the fire side, and reinforced on the water side where possible.

In renewing portions of flue sheets, care must be taken to see that the line of weld clears all braces and does not fall through arch tube holes.

Cracked flue sheet bridges may be welded after the flues have been removed from that area. After welding each bridge, the sheet should be allowed to cool before starting another. Gas welding is preferred on bridges.

The standard method of repairing cracks in flue sheet knuckles is by application of a patch. In emergency cases, where cracks are few and small and the condition of the surrounding area of the sheet is good, they may be repaired by welding from the water side and reinforcing from the fire side. Good judgment must be exercised in determining whether to repair by this method or by the application of a patch.

When butt welds are made by the electric process, after the vee has been filled in on the fire side, the bottom of the vee should be chipped out from the water side to a sufficient depth to remove imperfections in the weld before applying the reinforcement. Typical flue sheet patches are shown in Figs. 3 (a) and (b).

Side sheet corner patches may be welded to the flue sheet or door sheet as the case may require, the shape and size of the patch to be governed by the defective area necessary to remove. This patch is shown in Fig. 4. The line of weld should be as centrally located between the staybolt holes as possible and may be laid out to run vertically or on an angle, making the patch wider at the mud ring. The method of preparation and welding in of patch should be the same as for mud ring corner patches.

Mud ring corner patches are usually applied as shown in Fig. 5. The patch should be prepared in the regular manner and securely bolted to the mud ring. In bolting the patch to the mud ring (gas weld) it should be applied about $\frac{1}{16}$-inch low to allow for drawing up in welding. When the electric process is used on this operation, the weld must be started at the mud ring, proceed 6 inches up the outside edge; then go to the other edge of the patch, welding it 6 inches; returning to the part which was first started, weld upward 6 inches farther, alternating from side to side until the weld is completed. When gas is used for this operation start welding in the corner at the top of the weld, and proceed toward the mud ring. The patch should be made the thickness of the door sheet or flue sheet.

When necessary to weld a broken mud ring, a sufficient amount of the firebox sheet should be removed to permit of operating the welding tools. The mud ring should be beveled from the top. The weld should be reinforced on the top and bottom after which the portion of the sheet which was removed should be welded into place.

It is considered a good practice to reinforce the mud ring corners inside and outside as the engines go through the shop for classified repairs. Before welding, the sheet should be chipped clean and free from oil, dirt or other foreign substances.

Corners should be calked before welding is commenced. Metal applied should extend at least 6 inches beyond the corner of the ring and up about 8 inches inside and outside according to conditions.

When welding patches on the throat sheet of the boiler, the joints will be made by butt welding. Whenever possible the weld should be reinforced on the water side. Vertical welds in the throat sheet are not permissible. Welds should be either horizontal or slope not more than 45 degrees from horizontal.

When renewing the bottom of the throat sheet the weld should be above the bottom row of staybolts. When renewing the upper part of the throat sheet the weld should be below the top row of staybolts and above the bottom row of staybolts.

Patches may be applied in the throat sheet, the ends of which should be diamond shaped, the points of the diamond being at least two rows of staybolts from the knuckle, otherwise it should extend around the knuckle and be riveted to the wrapper sheet.

Cracks in the throat sheet knuckle are to be repaired by applying a patch as in Fig. 6, and under no consideration should repairs be attempted by placing a patch over the crack and lap welding it to the throat sheet. Exclusive of corner patches, not more than one patch shall be applied to the throat sheet, the minimum height and length of which shall be three rows of staybolts.

In applying superheater flues to the back flue sheet without the use of copper ferrules, the flue holes are countersunk to the center of the sheet with a 90-degree cutter. The sharp corners in the holes are then rounded off as shown in Fig. 7, to a $\frac{1}{16}$-inch radius. The flue is set back $\frac{1}{16}$-inch from the outside edge of the sheet and expanded in the usual manner with a special expander made up for this purpose.

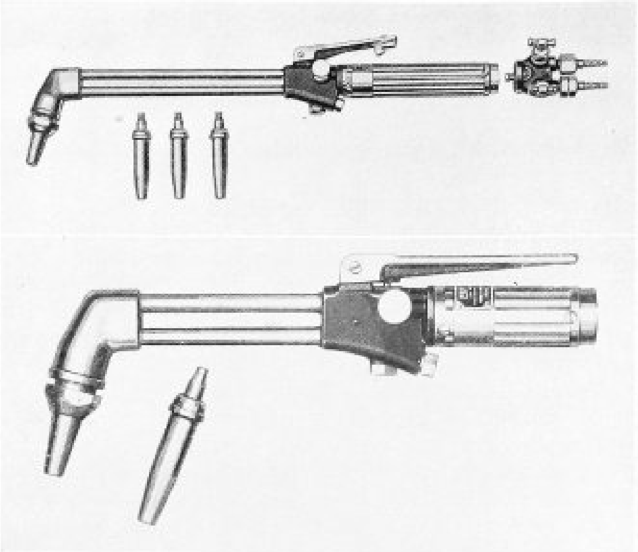
When the flue is expanded, the shoulder on the swedged end must be held firmly against the flue sheet to prevent the flue from working back in the flue hole. The weld should be made flush with the sheet and slightly overlap the end of the flue on the inside as shown. Weld to be by the electric process only.

New Cutting Blowpipe

The Linde Air Products Company, 30 East 42nd Street, New York, N. Y., has recently added a cutting blowpipe and cutting attachment to its new line of Prest-O-Weld medium-pressure apparatus of the detachable valve body design. The new cutting apparatus includes the type C-105 cutting blowpipe and type CW-105 cutting attachment.

These two types of cutting apparatus together with the types W-105 and W-106 welding blowpipes, can all be used interchangeably with the same detachable valve body. By means of the detachable valve body, the operator can change easily and quickly from a full size welding blowpipe to a smaller welding blowpipe, to a full size cutting blowpipe, or to a cutting attachment without detaching the hose or hose connections and without the use of a wrench.

The locking device for connecting the detachable



Above—Type C-105 cutting blowpipe and (below) CW-105 cutting attachment

valve body to any one of these blowpipe handles consists of a locking bolt and wedge-shaped locking screw. The locking screw is operated by turning a ring and draws the detachable valve body and blowpipe handle together making a gas-tight joint. The ring can also be used for hanging up the blowpipe when not in use.

Pressure forgings are used in the construction of the blowpipe head, cutting valve body and lever. The cutting oxygen tube is made of Ambrac, a special hard brass, to afford the necessary stiffness. The cutting nozzles have conical seats so designed that they will not become nicked or damaged if the nozzles should be accidentally dropped.

The blowpipe is light and well balanced and of sturdy construction to withstand the hard usage to which cutting blowpipes may be subjected. It is furnished as standard with four cutting nozzles and a 75-degree angle head. If required, a 90-degree angle head can be furnished. Steel and wrought iron up to 12 inches in thickness may be easily cut with this blowpipe and metal of greater thickness can be cut by experienced operators.

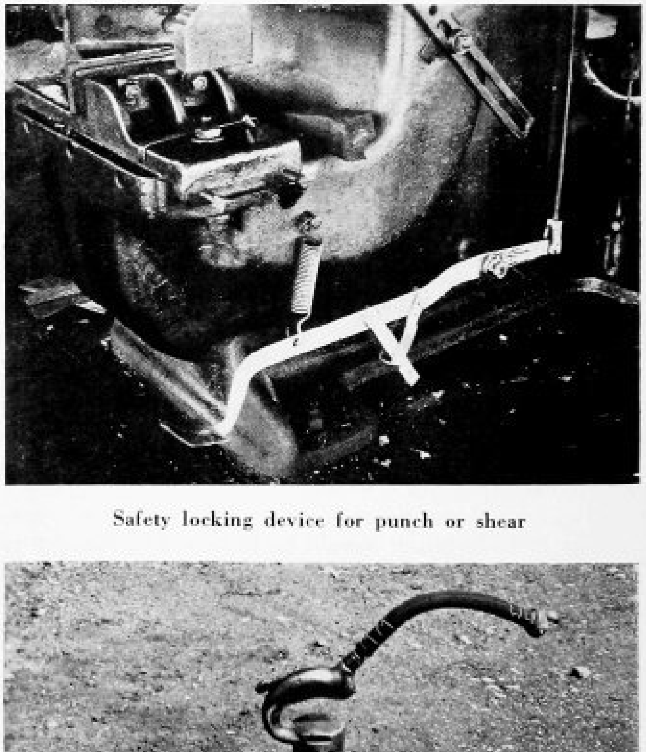
The type CW-105 cutting attachment is of the single joint design and attaches directly to the valve body. It will readily cut metal up to 2 inches in thickness. Because of its small size, only 11 inches overall, it can be carried in the pocket of the operator.

Two Shop Safety Devices

The two shop devices illustrated are designed to contribute either to safety or economy in shop practice, or both. The punch-and-shear safety locking device consists simply of a steel strap or bar bolted to the operating foot treadle at the point illustrated and long enough to reach to the floor when the treadle is in its upper position and the machine not in operation. This safety bar, therefore, prevents any accidental starting of the punch or shear by some one stepping, or a weight falling, on the foot treadle. When desirable to operate the machine, the safety lever is simply swung up out of the way, being held by a U-strap, also clearly illustrated. This device was developed at the Milwaukee shops of the Chicago, Milwaukee, St. Paul & Pacific Railroad, and the illustration is furnished by the courtesy of the Milwaukee magazine.

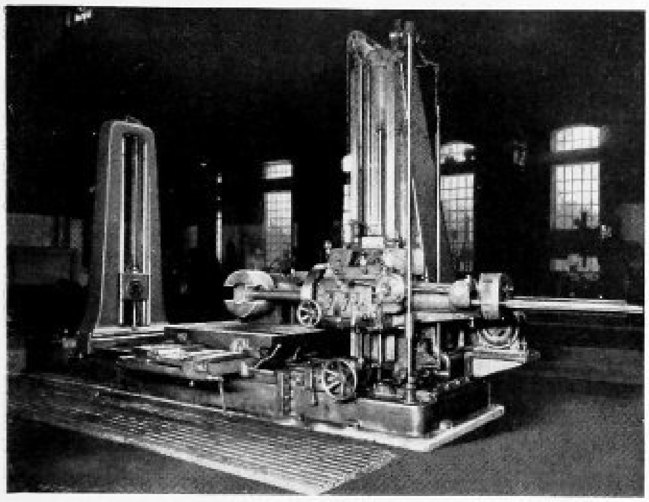
Another illustration, also provided through the courtesy of the Milwaukee magazine, shows a rivet-hammer receptacle which is both a convenience and a safety feature. The device consists simply of a short piece of steel tubing of the proper diameter welded to a circular base plate and easily moved to any point about the shop where riveting operations may be performed. When for any cause, it is necessary to stop riveting, the hammer is simply placed vertically in the receptacle instead of being laid on the floor or scaffolding where there is danger of accidental discharge of the rivet set, as well as of the collection of dirt in the hammer. Moreover, the hammer may fall and hit some worker underneath when riveting is being done on a scaffolding. The provision of this rivet-hammer receptacle within convenient reach is an important labor saver and safety device.

These two simple devices are the result of ingenuity and thought on someone's part and indicate a realization of safety principles. As a general rule, the promotion of safety also leads to increased efficiency and convenience. In every shop there are suitable materials and facilities for putting together safety devices of all kinds. THE BOILER MAKER will welcome descriptions for publication of similar shop kinks as those described.



Safety locking device for punch or shear

Rivet-hammer receptacle which contributes to convenience and safety



Special boring, drilling, and milling machine

Horizontal Boring, Drilling and Milling Machine

Joseph T. Ryerson & Son, Inc., Chicago, in conjunction with the Ohio Machine Tool Company, Kenton, Ohio, has developed a special horizontal boring, drilling and milling machine, which is one of the largest of its kind. The weight of this machine is 60,000 pounds.

A better conception of its size is indicated in the following list of specifications: Diameter of spindle, 5 inches; continuous feed to spindle, 36 inches; reset to spindle, 40 inches; working surface of table, 60 inches by 96 inches with a cross feed of 94 inches; maximum distance from top of table to center line of spindle, 85½ inches, and maximum distance from face plate to bar support, 168 inches. Eighteen speeds, all reversible, are obtainable. Eight boring and drilling feeds and 16 milling feeds to the head, table and table saddle, also reversible, are furnished. Feeds are not affected by the drive back gears as they secure their primary drive from the spindle. Centralized oiling systems are furnished to all units. All gearing and shafting is of high carbon alloy steel, heat treated. No loose keys are used on the shafts. Gears operate on multiple splined shafts or squared sections. Helical tooth bevel gears and herringbone gears are used wherever possible. The back gears to spindle, located at the face plate, are herringbone.

In addition to its size and capacity for handling large work, several unusual features have been incorporated. It is equipped with a 60-inch power and hand-driven revolving table which receives its power feed and rapid traverse from the feed shaft in the bed.

It is also equipped with a novel thread chasing attachment which operates directly from the spindle through a minimum number of gears and shafts to the feed pinion operating on the spindle sleeve. The mechanism is interlocked so that the feeding and threading operation cannot be thrown in at the same time. The attachment is of such a design that any number of threads per inch can be cut, requiring only the changing of a few gears to accomplish this work.

The head of this machine contains the feeding and driving mechanism for the spindle. All controls may be operated from this head with the exception of the directional control levers to the table and table saddle. Controls for the motor, which is reversible, are operated from the head and also from the floor. Rapid traverse of the selective type is furnished to all units and can be set to traverse in any direction desired, exclusive of the direction of the feed or spindle. Feed directional levers located in the feed selection box in the bed are automatic in operation and interlocked.

One of the most important features of this design is the method of guiding the various sliding members. All guides are of the square lock type with steel taper gibs fitted their entire length for resisting wear. All feed screws are of large diameter, centrally located between the guiding surfaces. The guide for the table is on the side of the saddle nearest to the spindle head with the screw located between the guides. The table and saddle are of unusually deep box section and at no time does the table have less than 60 percent bearing on its saddle. The saddle is guided on the unusually wide bed, 54 inches overall, by a narrow guide located in the center of the bed with the feed screw directly under the center of the spindle at all times.

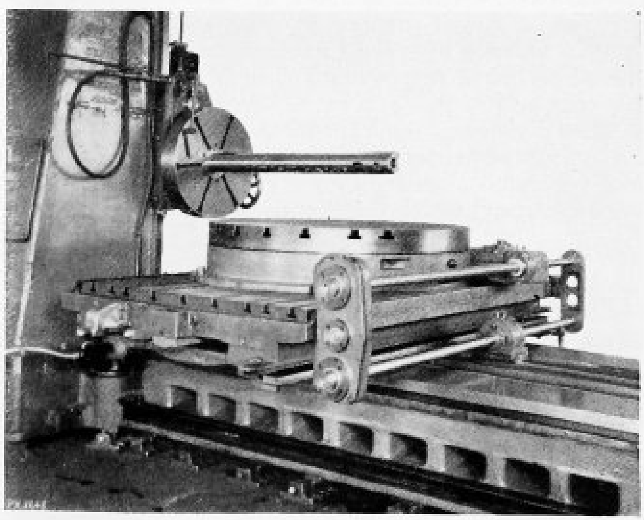
The bed is a heavy box-shape casting with three ways. It contains chip chutes and the cutting compound lubricating system with pump. It is keyed, dowelled and bolted to the main post support casting.

The boring bar support is of the closed type with an adjustment to the feeding nut. The outboard bearing travels in conjunction with the main head as it is driven through special cut bevel gears and helical tooth spur gears so that there is very little lost motion between the two units. This unit can be removed from its base. It is traversed on the bed by a gear reduction operating on racks bolted to the bed on each side.

The main post is a heavy box-shaped internally-braced casting with two straight and two tapered sides. In its base is a speed box containing three speeds of the driving mechanism which are operated from the head. The counterweight for the head is suspended by two cables running on roller bearing pulleys and is entirely enclosed in the post.

Power is furnished from a 20-horsepower constant-speed reversible-type motor, arranged for quick stopping and reversing the spindle. Its drive is by a silent chain to the primary drive shaft.

The size of the machine, together with its rugged construction, enables it to be used for large machining operations. With the number of speeds available, boring, drilling and milling operations may be performed at the most economical speed consistent with the type of work.



Head of boring, drilling and milling machine

Obituary

George Wagstaff, first president of the Master Boiler Makers' Association and at one time chairman of its executive committee, died on October 11 at his home in West New York, N. J. He was born on March 29, 1858, at Shropshire, England. Since 1879 he served in various positions in the United States with the Lehigh Valley Railroad, the Rome Locomotive Works, the Delaware, Lackawanna and Western Railroad, the Grant Locomotive Works, the Chicago and Northwestern Railroad and the New York Central Lines. In 1903 he was appointed assistant master mechanic of the Collinwood Shops of the Lake Shore and Michigan Southern Railroad, now part of the New York Central Lines. He subsequently served as supervisor of boilers on the New York Central Lines from 1905 to 1908 and then with the American Locomotive Equipment Company until 1910 when he entered the service of the American Arch Company. He was traveling engineer for the latter company until his retirement from active service, about three years ago.

George Wagstaff

C. B. Woodworth, manager of the railroad division of the Vanadium Corporation of America, with headquarters at Chicago, died at his home on October 24. Mr. Woodworth was graduated in mechanical engineering from Purdue University in 1907 and from then until 1916 he served with the mechanical departments of the Wabash and the Baltimore & Ohio Railroads. He then entered the employ of the American Arch Company, serving until 1918, when he received a commission as captain of engineers in the United States Army. After a service of 15 months with the A. E. F. on railroad work in France, he returned to this country and joined the foreign sales department of the American Locomotive Company, spending six years in the Argentine and in Brazil engaged in sales and service work. In 1926 he went with the Premier Staybolt Company as special technical representative; in May of the following year he left that service to become manager of the western division of the Vanadium Corporation of America, with headquarters at Chicago, and in August, 1930, was appointed manager of the railroad division of the same company, which position he held until his death.

Arc Welding Prize Competition Has Many Entries

The second Lincoln Arc Welding Prize Competition which will award $17,500 for the best papers on redesign for arc-welded construction closed October 1, 1931, with four times as many papers entered as in the former contest sponsored by The Lincoln Electric Company of Cleveland, Ohio.

Reading and judging of the papers by a jury of award headed by Dr. E. E. Dreese, chairman of the electrical engineering department of Ohio State University, was begun November 1. Interest in this contest has been international in scope with 16 foreign countries represented, Germany, France, England and Australia submitting a remarkable number of papers.

Welding Conference

The Engineering Extension Department of Purdue University announces its Seventh Annual Conference on Welding to be held at Lafayette, Ind., on December 10-11, 1931. The meeting will consist of lectures, demonstrations, and exhibits. Two hundred and seventy-five representatives from the industries of Indiana and neighboring states were in attendance at the conference last year. Requests for programs and other information should be made to Engineering Extension Department, Purdue University, Lafayette, Ind.

Trade Publications

Economizers.—Return Bend Economizers is the subject of a new bulletin issued by The Babcock & Wilcox Company, 85 Liberty Street, New York. This publication describes a forged steel return bend type economizer in which all the latest features of design have been incorporated and which, the Company states, provides a high rate of heat transfer with a remarkable freedom from expansion strains. All the details of the economizer, such as the return bends, headers, tubes, casing, etc., are fully described and illustrated by photographs and drawings.

Stokers.—Chain Grate Stokers is the subject of a new bulletin issued by The Babcock & Wilcox Company, 85 Liberty Street, New York. This publication describes a line of chain grate stokers, which, the company states, are built with all the precision of fine machine tools. The booklet contains full descriptions of the various types of stokers with suitable photographs and line drawings to illustrate each type. Typical setting views are shown, demonstrating the adaptability of the stokers to various types of boilers.

Boiler.—Combustion Engineering Corporation, 200 Madison Avenue, New York, has just issued a pamphlet describing the C-E multiple circulation boiler. This boiler is designed to provide the positive and unrestricted circulation which is so important in modern boiler practice with its high steam pressures, high temperatures and high rates of evaporation. It is a departure from the conventional design of bent tube boilers in two essentials—tube arrangement and steam liberation. This boiler is available in sizes ranging from 2000 square feet to 26,000 square feet of heating surface. It is adaptable to any type of firing and may be set double.

A. A. Probeck, for many years active in the arc-welding field, was appointed sales manager of The Federal Machine and Welder Company, manufacturers of welding equipment, Warren, O., on October 1. Mr. Probeck started in the welding game in 1910 with the C. & C. Company, one of the first manufacturers of arc welders. He joined the Federal force in 1912 and in 1917 he returned to the arc-welding field.

The Boiler Maker

VOLUME XXXI NUMBER 11

PUBLISHED Monthly by the Simmons-Boardman Publishing Company, 34 North Crystal Street, East Stroudsburg, Pa., with Executive Offices at 30 Church Street, New York City.

Samuel O. Dunn, Chairman of Board. Henry Lee, President. C. R. Mills, Vice-President. L. B. Sherman, Vice-President. Roy V. Wright, Vice-President and Secretary. F. H. Thompson, Vice-President. E. T. Howson, Vice-President. F. C. Koch, Vice-President. John T. DeMott, Treasurer. George Slate, Vice-President and Business Manager.

Chicago: 105 W. Adams Street. Washington, D. C.: 17th and H Streets, N. W. Cleveland: Terminal Tower. San Francisco, Cal.: 215 Market Street.

Subscription Price: United States and Mexico, $2.00. Canada, $3.50, including duty. Foreign Countries, $3.00 a year. Single Copies, 35 Cents.

Request for change of address should reach us on or before the 15th of the month preceding the issue with which it is to go into effect. It is difficult, and often impossible, to supply back numbers to replace those undelivered through failure to send advance notice. In sending us change of address, please be sure to send us your old address as well as the new one.

THE BOILER MAKER is a member of the Associated Business Papers, Inc. (A. B. P.), and the Audit Bureau of Circulations, (A. B. C.)

EDITORIAL STAFF: H. H. Brown, Editor. L. S. Blodgett, Managing Editor. W. Lumbard, Associate Editor.

Contents

Communications

Length of Arc of a Circle

TO THE EDITOR:

Here are two good rules for finding the length of an arc of a circle which should be of interest to the readers of THE BOILER MAKER:

RULE.—As 360 degrees is to the number of degrees of the arc so is the length of the circumference to the length of the arc.

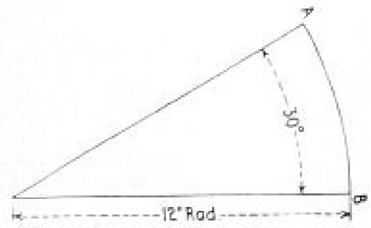
EXAMPLE.—If the circumference of a circle is 12 feet, what is the length of a 30-degree arc?

Let x = length of the arc.

Solving for x, $360 : 30 = 12 : x$.

$$x = \frac{30 \times 12}{360} = \frac{360}{360} = 1 \text{ foot}$$

Another good rule which should interest the reader is as follows: To find the length of an arc when only the angle or degrees and radius are known, multiply the number of degrees by .01745 and the product by the radius. Following the above rule for solving the problem illustrated, we have 30 degrees x .01745 = 0.52350.



Arc of 30-degree angle

Then, $0.52350 \times 12 = 6.28$ inches, the length of the arc *A-B*. This is a very good rule to use in locating the corner washout plugs on horizontal boilers, as they are generally shown on the drawing in degrees.

Schenectady, N. Y. WILLIAM MORRISON.

Scientific Pressure Testing for Boilers

TO THE EDITOR:

About 20 years ago, in an article in THE BOILER MAKER, I predicted the "rivetless boiler." A critic in a following issue ridiculed the idea and as much as said that I should have my head examined. The rivetless boiler has been with us for some time.

I now have another prediction to make: Boilers in the future will be tested under high pressure, at operating temperature, without the least danger to human attendants in the event of an explosion or rupture.

The old cold water method is not satisfactory and never has been. It should be eliminated as soon as possible. Boilers should be tested under actual operating pressures and temperatures. For instance, not so many years ago I was sent to witness some tests on pressure vessels which had been entirely welded. No rivets had been used in them at all. The vessels were about 3½ feet in diameter and 30 feet long. In actual operation they were subjected to a pressure of about 200 pounds per square inch alternating with a vacuum. When under pressure the vessels were hot and when under vacuum they were cool.

During the pressure tests these vessels were filled with ordinary cold water out of the water mains which was pumped into them until a pressure of about 500 pounds per square inch was reached. There was no leakage. Then a strong young man was told to do some pounding with a sledge hammer here and there on the vessel. This pounding, I presume, was supposed to duplicate the effect of heat. The man didn't strike very hard but he did make considerable noise. The vessels didn't leak. The tests were pronounced "successful."

To me the performance bore a semblance of child's play, and I said so; but I was assured by this manufacturer that all pressure vessels which they made were tested in this way and that everybody else tested them in this same way. So far as I know, according to "specifications" which I see now and then, they are still being tested in this same old orthodox way.

Here is a constructive and practicable suggestion: Use a salt solution instead of water—a salt which has a

(*Continued on page 312*)

Questions and Answers Pertaining to Boilers

This department is maintained for the purpose of helping those who desire assistance on practical boiler shop problems. Inquiries should bear the name and address of the writer. Anonymous communications will not be considered. The identity of the writer, however, will not be disclosed unless the editor is given special permission to do so.

By George M. Davies

Thickness of Furnace Plate

Q.—I would appreciate an answer to the following question: What would be the required thickness necessary for a plain hammer-welded furnace (not corrugated) 25 inches outside diameter, 60 inches long, to operate at 175 pounds working pressure, using Lloyd's Register of Shipping formula? The part of the formula I do not understand is $(t - 1)^2$. How can you subtract 1 from the thickness when the thickness is unknown? W. J. L.

A.—The formula referred to in the question as found in Lloyd's Register of Shipping is as follows:

$$WP = \frac{c(t-1)^2}{(L+24) \times D}$$

Where WP = the working pressure in pounds per square inch.

D = the external diameter of the furnace or combustion chamber in inches.

t = the thickness of the furnace plate in 32nds of an inch.

L = the length of furnace or of combustion chamber bottom or the length between points of substantial support, in inches, measured from the centers of rivet rows or from the commencement of flange curvature, whichever, is applicable.

c = 1450 where the longitudinal seams are welded and 1300 where they are riveted.

Solve the formula for t as follows:

$$WP = \frac{c(t-1)^2}{(L+24) \times D}$$

Multiply each side of the equation by $(L + 24) \times D$ and we have

$$WP \times (L+24) \times D = \frac{c(t-1)^2 \times (L+24) \times D}{(L+24) \times D}$$

Canceling, we then have

$$WP \times (L+24) \times D = c(t-1)^2.$$

Divide each side of the above equation by c, then

$$\frac{WP \times (L+24) \times D}{c} = \frac{c(t-1)^2}{c}.$$

Canceling, we then have

$$\frac{WP \times (L+24) \times D}{c} = (t-1)^2.$$

Take the square root of each side of the above equation and we then have

$$\sqrt{\frac{WP \times (L+24) \times D}{c}} = t - 1.$$

Add 1 to each side of the equation, then

$$\sqrt{\frac{WP \times (L+24) \times D}{c}} + 1 = t - 1 + 1.$$

Canceling, we then have

$$\sqrt{\frac{WP \times (L+24) \times D}{c}} + 1 = t.$$

Substituting the values in the question in the formula, we have

$$t = \sqrt{\frac{WP \times (L+24) \times D}{c}} + 1$$

$$t = \sqrt{\frac{175 \times (60+24) \times 25}{1450}} + 1$$

$$t = \sqrt{\frac{367{,}500}{1450}} + 1$$

$$t = \sqrt{253.4} + 1$$

$$t = 15.9 + 1$$

$$t = 16.9$$

$t = \frac{17}{32}$ inch, thickness of shell plate.

Development of Gusset Piece

Q.—Please show how to develop a gusset piece between an oblique elliptical pipe and a horizontal round pipe. G. M.

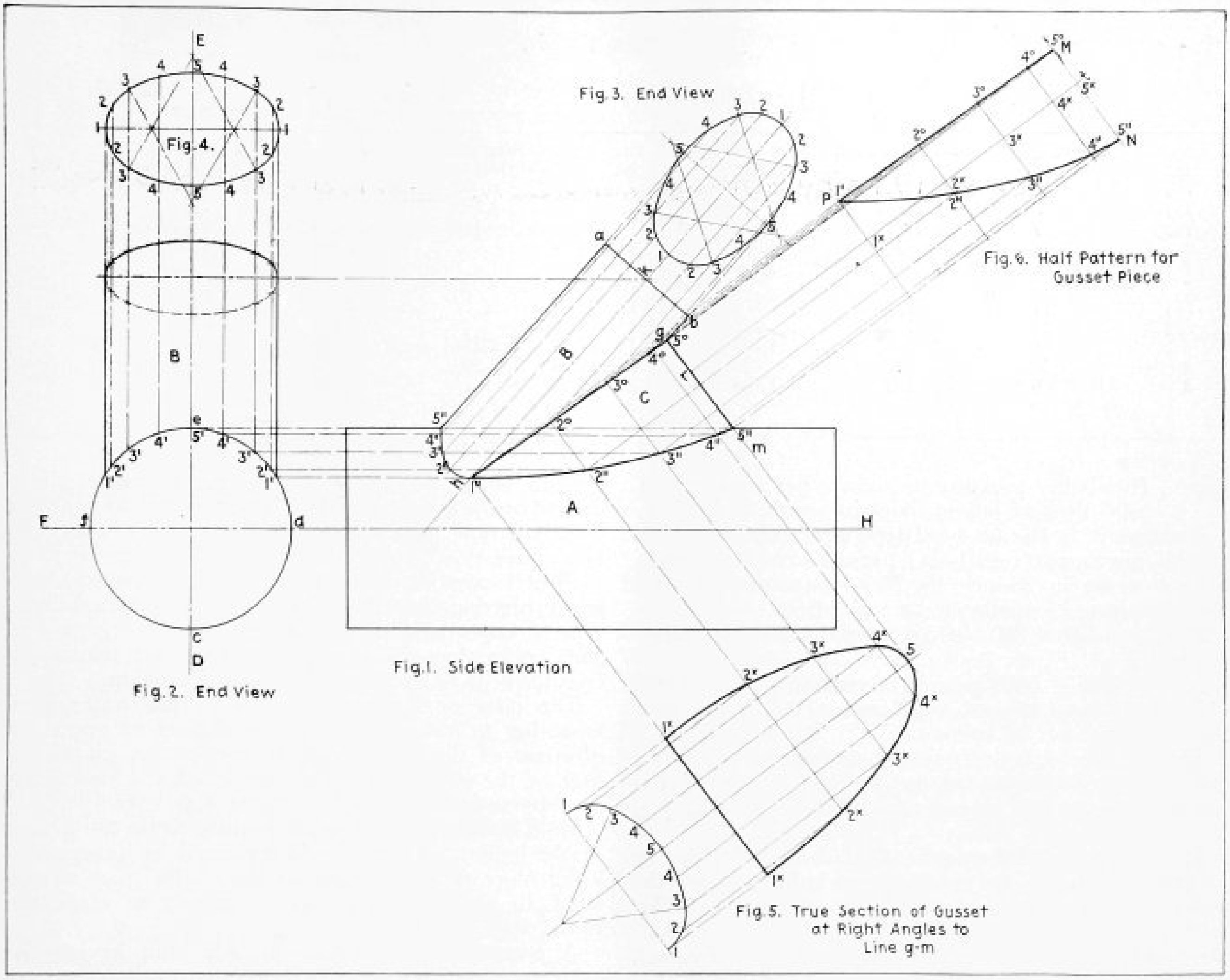
A.—To make a development of a gusset piece between an oblique elliptical pipe and a horizontal round pipe, first lay out the side elevation as shown in Fig. 1.

The next step is to draw Fig. 3 showing the profile of the elliptical pipe, the ellipse being constructed in any of the conventional ways. Next draw the line *D-E* vertical to the center line *F-H;* then draw the circle *c-d-e-f* being the end view of the circular pipe with the line *D-E* as a center. Directly above the circle *c-d-e-f* construct the elliptical profile Fig. 4 similar to Fig. 3. Divide both of these profiles into the same number of equal parts and number these from *1* to *5*, as shown.

Draw lines through points *1* to *5*, Fig. 4, parallel to center line *D-E*, cutting the circle *c-d-e-f*, Fig. 2. Number these points *1'*, *2'*, *3'*, *4'*, *5'*, as shown.

Draw lines through points *1* to *5*, Fig 3, parallel to the center line of the elliptical pipe *h-k* and extend these lines indefinitely.

Draw lines through points *1'* to *5'*, Fig. 2, parallel to the center line *F-H*, extending these lines into Fig. 1,



Method of laying out a gusset piece

cutting the lines just drawn parallel to *h-k*. This procedure locates the points *1"*, *2"*, *3"*, *4"*, and *5"*.

Where the lines through *1* to *5*, Fig. 3, drawn parallel to *h-k*, cut the line *h-g* locates the points *2°*, *3°*, *4°* and *5°*.

Through points 2°, 3°, 4° and 5° and parallel to *g-m*, draw lines and extend these to cut the lines extended from the points *1* to *5*, Fig. 2, parallel to *F-H*. This locates the points *1"*, *2"*, *3"*, and *4"* or the miter line of the connection between the gusset and the round pipe.

A true profile of the gusset piece at right angles to the line *g-m* is next determined and is obtained as follows: Take a duplicate of the half elliptical profile from *1* to *5* to *1* in Fig. 4 and place it at a convenient location as shown in Fig. 5, the center line *n-s* being drawn at 90 degrees to *g-m*. Parallel to *n-s* and through the points *1* to *5*, Fig. 5, draw lines, extending same indefinitely.

Next, parallel to *g-m* and through the points *1"*, *2"*, *3"*, *4"* and *5"* draw lines and extend them to cut the lines that have been drawn parallel to the line *n-s* through the points *1* to *5*, Fig 5. This locates the points 1^x, 2^x, 3^x, 4^x and 5^x, Fig. 5, as shown. Connect these points completing the true section of the gusset.

The next step is to make the half development of the gusset piece as shown in Fig. 6. The procedure for producing the half pattern is as follows: Take the girth of the semi-true section as shown in Fig. 5 and place it as indicated by similar numbers 1^x to 5^x on the line *r-t* drawn at right angles to *g-m*. Through these small divisions 1^x to 5^x at right angles to *r-t* draw lines, which intersect by lines drawn parallel to *r-t* from similarly numbered intersections on the joint lines *5°-1"* and *1"-5"*, Fig. 1. Trace a line through the points so obtained in the pattern. Then *M-N-P* will be the half pattern of the gusset piece *C*, Fig. 1.

Locomotive Boiler Design Problems

Q.—I would appreciate receiving the answers to the following questions:
1. For what rate of firing are modern boilers designed?
2. Is there a formula for the staying power of boiler tubes?
3. What amount is the front-to-back slope of crown sheets?
4. What is the usual distance from the bottom of water gage mounting to crown sheet?
5. For a given boiler power, which type of boiler puts the heaviest weight on the trailing truck, the Belpaire or the radial stay? K. F. G.

A.—I am assuming that all the questions refer to a locomotive boiler.

1.—For all practical calculations the quantity of coal burned per hour can be computed as follows:

Coal burned per hour = $H.P. \times 4.00$ pounds (for saturated steam)
= $H.P. \times 3.25$ pounds (for superheated steam)

where, $H.P.$ = cylinder horsepower.

$H.P. = .0212 \times P \times A$ (for saturated steam)
$= .0229 \times P \times A$ (for superheated steam)

Table I

Tube			Not belled, pressure, lb. per sq. in.		Belled, pressure, lb. per sq. in.		Beaded, pressure, lb. per sq. in.	
Diameter in.	Gage	Depth of seat, in.	Started or leaked	Blown out	Started or leaked	Blown out	Started or leaked	Blown out
1½	9	11/16	6,000	7,400	6,000	10,230	....	....
1½	8	11/16	....	....	8,380	11,540	....	....
1½	7	11/16	4,970	5,400	8,150	11,540	....	....
2	10	5/8	3,200	3,600	....	7,300	....	....
2	9	5/8	....	5,900	....	7,300	....	....
2	8	5/8	....	7,300	....	....	....	....
3¼	11	1/2	1,275	1,375	....	2,800	1,200	5,650
3¼	10	1/2	950	1,800	....	5,100	1,700	5,940
4	9	1/2	1,300	1,830	2,230	2,950	....	....
4	10	1/2	825	1,300	1,300	2,550	1,200	3,800
4	9	1/2	1,800	2,100	....	5,400	....	6,000

where, P = boiler pressure in pounds per square inch.
A = area of one cylinder in square inches.

Example: A Pacific 4-6-2 type locomotive with 200 pounds per square inch boiler pressure employs superheated steam in 23-inch by 28-inch sample cylinders when exerting its maximum tractive effort.

$H.P. = .0229 \times 200 \times 415.5 = 1904$ cylinder horsepower.

$1904 \times 3.25 = 6188$ pounds of coal burned per hour.

2.—I do not know of any formula for determining the staying power of boiler tubes.

Marks' Mechanical Engineers Handbook gives the following information on the holding power of expanded tubes, which may be of some help in aiding you in your problem.

Of the various investigations of the holding power of expanded tubes, the results given in Table I are the most recent and were obtained by careful test. This table gives the strength of expanded joints for various sizes and gages of tubes, different depths of tube seat, for tube expanded and not belled, belled, and beaded.

3.—The slope of the crown sheet from front to back on locomotive type boilers is generally ½ inch in 12 inches. The exception would be a switching engine or a locomotive designed for severe grades.

4.—Rule 37, Interstate Commerce Commission Bureau of Locomotive Inspection, laws, rules and instructions for inspecting and testing steam locomotives and tenders and their appurtenances is as follows:

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

P-291 of the A. S. M. E. Boiler Construction Code is as follows:

Water Glasses and Gage Cocks.—Each boiler shall have at least one water gage glass, with connections not less than ½-inch pipe size. The lowest visible part of the water glass shall be not less than 2 inches above the lowest permissible water level. The water gage shall be equipped with a valved drain.

The lowest permissible water level shall be that at which there will be no danger of overheating any part of the boiler when it is operated with the water not lower than that level. This level for the usual type of boilers is given in Par. A-21 of the appendix.

Par. A-21 of the appendix referred to in this paragraph is as follows:

Each boiler may have one or more fusible plugs, located at the lowest permissible water level as follows:

In traction, portable or stationary boilers of the locomotive type or star watertube boilers, fusible plugs shall be located in the highest part of the crown sheet, and projecting through the sheet not less than 1 inch.

It is important when locating the water gage and gage cocks that the maximum grade over which the locomotive is to operate be taken into account.

The distance from the bottom of the water gage mounting to the crown sheet is dependent upon the diameter of the boiler (largest course), length of the firebox, the maximum grade over which the locomotive must operate, and the type of water gage used.

5.—This of course depends entirely upon the design of the boiler. A Belpaire boiler could be designed to bring more or less weight on the trailer truck as desired, by shifting the center of gravity as could the radial stay boiler.

A comparison of engines already built having the same general characteristics shows that the engines having the heaviest weights on the trailer trucks are those equipped with radial stay boilers.

Scientific Pressure Testing for Boilers

(Continued from page 309)

melting point slightly lower than the temperature under which the test should be made. As is well known by heat-treating experts we now have many commercial salts on the market which have various melting points. By filling the pressure vessel with the proper liquefied salt at a temperature of 500 degrees, 600 degrees, 700 degrees, 800 degrees or any other desired temperature there would be no violent explosion in the event of a serious leak. The pressure and temperature of any boiler could be duplicated perfectly under tests like these. In fact the test pressure and temperature could both be higher than working temperature and pressure and even then there would not be the slightest danger involved. There would be no formation of gas or steam. The only possible objection I can think of would be the greater cost of the test solution. However this expense should be no great burden to a manufacturer of boilers as he could use the same solution over and over. It would not spoil. There would be very little loss or waste year after year.

Newark, N. J. W. F. SCHAPHORST, M. E.

Associations

Bureau of Locomotive Inspection of the Interstate Commerce Commission

Chief Inspector—A. G. Pack, Washington, D. C.

Assistant Chief Inspectors—J. M. Hall, Washington, D. C.; J. A. Shirley, Washington, D. C.

Steamboat Inspection Service of the Department of Commerce

Supervising Inspector General—D. N. Hoover, Jr., Washington, D. C.

American Uniform Boiler Law Society

Chairman of the Administrative Council—Charles E. Gorton, 253 Broadway, New York.

Boiler Code Committee of the American Society of Mechanical Engineers

Chairman—Fred R. Low.

Vice-Chairman—D. S. Jacobus, New York.

Secretary—C. W. Obert, 29 W. 39th Street, New York.

National Board of Boiler and Pressure Vessel Inspectors

Chairman—C. D. Thomas, Salem, Oregon.

Secretary-Treasurer—C. O. Myers, Commercial National Bank Building, Columbus, Ohio.

Vice-Chairman—William H. Furman, Albany, N. Y.

Statistician—L. C. Peal, Nashville, Tenn.

International Brotherhood of Boiler Makers, Iron Ship Builders and Helpers of America

International President—J. A. Franklin, suite 522, Brotherhood Block, Kansas City, Kansas.

Assistant International President—J. N. Davis, suite 522, Brotherhood Block, Kansas City, Kansas.

International Secretary-Treasurer—Chas. F. Scott, suite 506, Brotherhood Block, Kansas City, Kansas.

Editor-Manager of Journal—John J. Barry, suite 524, Brotherhood Block, Kansas City, Kansas.

International Vice-Presidents—Joseph Reed, 1123 E. Madison Street, Portland, Ore.; W. A. Calvin, 1622 Glendale Street, Jacksonville, Fla.; Harry Nicholas, 6215 S. Benton Blvd., Kansas City, Mo.; W. E. Walter, 637 N. 25th Street, E. St. Louis, Ill.; J. H. Gutridge, 910 N. 18th Street, Milwaukee, Wis.; W. G. Pendergast, 26 South Street, New York, N. Y.; W. J. Coyle, 424 Third Avenue, Verdun, Montreal, Quebec, Can.; A. M. Milligan, 262 Trent Avenue, E. Kildonan, Man., Can.; J. F. Schmitt, 28 S. Roys Street, Columbus, O.; William Williams, 502 Labor Temple, Portland, Ore.

Master Boiler Makers' Association

President—Kearn E. Fogerty, general boiler inspector, C. B. & Q. R. R., Aurora, Ill.

First Vice-President—Franklin T. Litz, general boiler foreman, Chicago, Milwaukee, St. Paul & Pacific Railroad, Milwaukee, Wis.

Second Vice-President—O. H. Kurlfinke, boiler engineer, Southern Pacific Railroad, San Francisco, Cal.

Third Vice-President—Ira J. Pool, division boiler inspector, Baltimore & Ohio Railroad, Baltimore, Md.

Fourth Vice-President—L. E. Hart, boiler foreman, Atlantic Coast Line, Rocky Mount, North Carolina.

Fifth Vice-President—William N. Moore, general boiler foreman, Pere Marquette R. R., Grand Rapids, Mich.

Secretary—Albert F. Stiglmeier, general foreman boiler maker, New York Central Railroad, Albany, N. Y.

Treasurer—W. H. Laughridge, general foreman boiler maker, Hocking Valley Railroad, Columbus, O.

Executive Board—Charles J. Longacre, chairman, foreman boiler maker, Meadow Shops, Pennsylvania Railroad, Elizabeth, N. J.

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President—Irving H. Jones, Pittsburgh Crucible Steel Company, Pittsburgh, Pa.

Vice-President—Reuben T. Peabody, Air Reduction Sales Company, New York.

Second Vice-President—E. S. FitzSimmons, Flannery Bolt Company, Pittsburgh, Pa.

Treasurer—George R. Boyce, A. M. Castle & Company, Chicago, Ill.

Secretary—Frank C. Hasse, Oxweld Railroad Service Company, 230 N. Michigan Ave., Chicago, Ill.

American Boiler Manufacturers' Association

President—H. H. Clemens, Erie City Iron Works Erie, Pa.

Vice-President—S. G. Bradford, Edge Moor Iron Company, Edge Moor, Del.

Secretary-Treasurer—A. C. Baker, 801 Rockefeller Building, Cleveland, O.

Executive Committee (three years)—Homer Adams, Fitzgibbons Boiler Company, Inc., New York; George W. Bach, Union Iron Works, Erie, Pa.; G. S. Barnum, The Bigelow Company, New Haven, Conn. (Two years)—Owsley Brown, Springfield Boiler Company, Springfield, Ill.; F. W. Chipman, International Engineering Works, Framingham, Mass.; W. C. Connelly, Foster Wheeler Company, Cleveland, O. (One year)—J. G. Eury, Henry Vogt Machine Company, Louisville, Ky.; A. C. Weigel, Combustion Engineering Corporation, New York; E. G. Wein, E. Keeler Company, Williamsport, Pa.; *Ex-officio*, H. E. Aldrich, Wickes Boiler Company, Saginaw, Mich.

States and Cities That Have Adopted the A.S.M.E. Boiler Code

States

Arkansas	Missouri	Rhode Island
California	New Jersey	Utah
Delaware	New York	Washington
Indiana	Ohio	Wisconsin
Maryland	Oklahoma	District of Columbia
Michigan	Oregon	Panama Canal Zone
Minnesota	Pennsylvania	Territory of Hawaii

Cities

Chicago, Ill.	St. Joseph, Mo.	Memphis, Tenn.
Detroit, Mich.	St. Louis, Mo.	Nashville, Tenn.
Erie, Pa.	Scranton, Pa.	Omaha, Neb.
Kansas City, Mo.	Seattle, Wash.	Parkersburg, W. Va.
Los Angeles, Cal.	Tampa, Fla.	Philadelphia, Pa.
	Evanston, Ill.	

States and Cities Accepting Stamp of the National Board of Boiler and Pressure Vessel Inspectors

States

Arkansas	Missouri	Pennsylvania
California	New Jersey	Rhode Island
Delaware	New York	Utah
Indiana	Ohio	Washington
Maryland	Oklahoma	Wisconsin
Minnesota	Oregon	Michigan

Cities

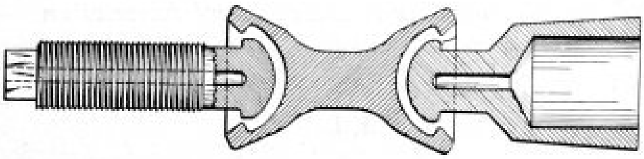
Chicago, Ill.	St. Louis, Mo.	Nashville, Tenn.
Kansas City, Mo.	Scranton, Pa.	Omaha, Neb.
Memphis, Tenn.	Seattle, Wash	Parkersburg, W. Va.
Erie, Pa.	Tampa, Fla.	Philadelphia, Pa.
	Detroit, Mich.	

Selected Boiler Patents

Compiled by Dwight B. Galt, Patent Attorney, Washington Loan and Trust Building, Washington, D. C. Readers wishing copies of patents or any further information regarding any patent described, should correspond directly with Mr. Galt.

1,750,687. STEAM BOILER STAYBOLT. ARTHUR F. PITKIN, OF SCHENECTADY, N. Y.

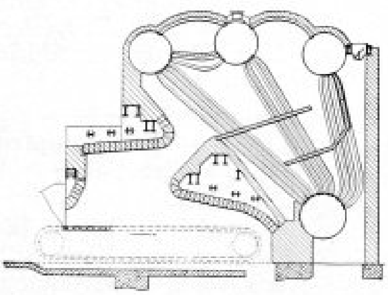
Claim.—An articulated staybolt having opposed end portions adapted to be secured respectively in the inner and outer sheets of a steam boiler, and a tension resisting intermediate section having a substantially flat



face at each end, said end portions being provided at one end thereof with a substantially flat face engaging a corresponding face of the tension-resisting section when in the assembled position, said co-acting faces providing a rocking relative movement between the end portions and the tension resisting intermediate portion without creating relative sliding movement. Four claims.

1,756,164. WATERTUBE BOILER. ARTHUR W. PATTERSON, JR., OF ROSELLE, N. J.

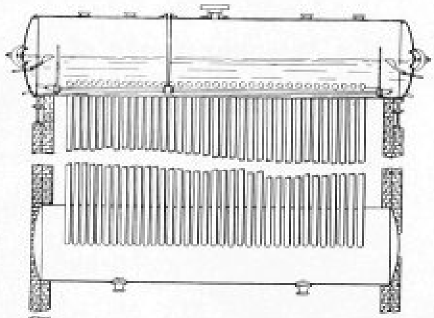
Claim.—The combination with a watertube boiler of the Sterling type having a lower drum and a plurality of upper drums and tubes connecting said drums, of a furnace having a firebox extending in front of the lower drum, a back combustion arch extending from a point adjacent the lower drum forwardly over the rear portion of the firebox and then



rearward and upward to a point adjacent the intermediate portion of the front tubes, a cross baffle extending from the top of the back arch transversely of the tubes in the same general direction as the upper face of said portion of the back arch which extends rearward and upward, and a second baffle having a section spaced below said cross baffle and extending transversely of the tubes and another section extending upwardly from the end of said section longitudinally of the tubes to the rear drum. Three claims.

1,750,985. STEAM BOILER. GEORGE W. BACH, OF ERIE, PA., ASSIGNOR TO UNION IRON WORKS, OF ERIE, PA., A CORPORATION OF PENNSYLVANIA.

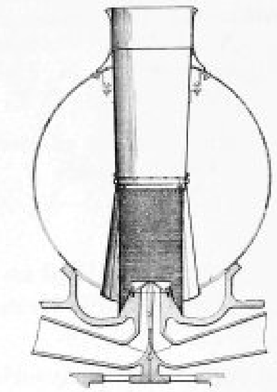
Claim.—In a steam boiler, the combination of an upper drum; a lower drum; connecting tubes, the ends of the upper drum extending outwardly



from the tube space; partitions separating the upper drum into a central steaming space and end feed water spaces; a feed water pipe leading into the steaming space of the upper drum and discharging into the feed water spaces; and furnace walls set inwardly from the ends of the drum leaving the feed water spaces projecting to without the walls.

1,749,487. SMOKEBOX AND STACK. WILLIAM F. KIESEL, JR., OF ALTOONA, PENNSYLVANIA.

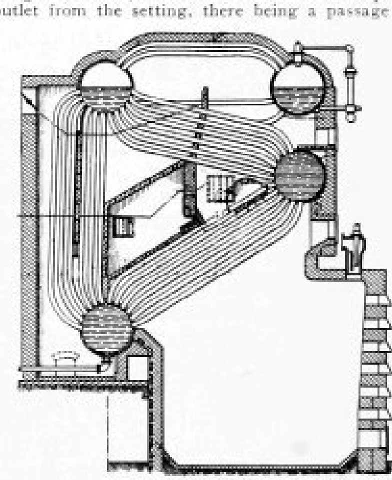
Claim.—In a locomotive, in combination, a smokebox, an inner stack extension, a petticoat depending from said stack extension and a substan-



tially cylindrical netting within said petticoat and engaging said extension at the junction of the extension and petticoat. Twenty-one claims.

1,707,418. FURNACE FOR WATERTUBE STEAM BOILERS. ELMER S. SMAIL, OF OAK PARK, ILL., ASSIGNOR, BY MESNE ASSIGNMENTS, TO KIDWELL-GRAVER CORPORATION, A CORPORATION OF DELAWARE.

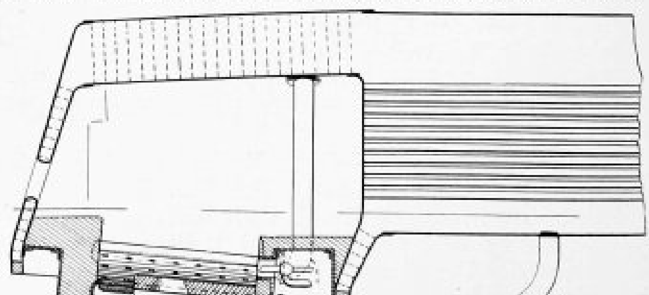
Claim.—A boiler comprising a setting, drums in the setting, banks of tubes connecting the drums, a combustion chamber for primary fuel in the setting, an outlet from the setting, there being a passage for the products



of combustion extending from the combustion chamber to the outlet, some of the tubes of some of said banks throughout their entire length being within said passage, a second passage within the setting separate from the first passage, some of the tubes of some of the banks throughout their entire length being within the second passage, an outlet from the second passage, and means for supplying waste heat gases from an independent source to said second passage. Six claims.

1,754,761. LOCOMOTIVE BOILER. ARTHUR WM. NELSON, OF PARK RIDGE, ILL., ASSIGNOR TO LOCOMOTIVE FIREBOX COMPANY, OF CHICAGO, ILL., A CORPORATION OF DELAWARE.

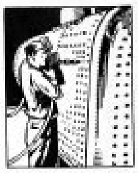
Claim.—A locomotive boiler construction embodying therein a barrel and a firebox having sheets forming parts of the front, rear and side water legs of the boiler, a pair of relatively flat hollow water-heating and circulating elements disposed in the firebox and each extending downwardly and inwardly from an associated side sheet, means providing an intake for



boiler water from the barrel of the boiler connected to the inner rear end portion of each element and other means providing an outlet for the outer front end portion of each element and opening through one of the sheets of the firebox and discharging into adjacent boiler water space. Four claims.

The Boiler Maker

Reg. U. S. Pat. Off.



Annual Index

The annual index of The Boiler Maker for the year 1931 will be mailed without cost to each subscriber whose request for it is received at our New York office on or before January 15, 1932.

Water Level Indicating Devices

Low water, caused by various conditions in the boiler, but mainly from inaccuracy or failure of the indicating devices, has been the greatest source of locomotive boiler disasters since the inception of the Bureau of Locomotive Inspection. The fatal explosion, details of which are given by the chief inspector in his report to the Interstate Commerce Commission, and which are published in this issue, was evidently caused by the apparently insignificant omission of a metal washer for retaining the rubber gasket used in the water-glass connection. This act of carelessness cost the lives of four men and the serious injury of two others.

Responsibility for avoiding such accidents rests with the railroad as well as with the men carrying out the actual maintenance work. The railroad's responsibility is to provide water level appliances, which under all operating conditions will give accurate indications, and which will preclude the failure of any one unit in the indicating system. As far back as 1920 in his annual report of that year the chief inspector, as a result of exhaustive tests on indicating devices, recommended the adoption of a suitable water column to which are attached three gage cocks and one water glass and an additional water glass located on the left side or back head of the boiler.

Since this recommendation was made, the railroads have in general adopted this system of indicating the water level. Probably no one factor has been more instrumental in the reduction of low-water failures during the past few years. There are some railroads, however, which have not applied the additional water glass on the left side or back head. The locomotive in the present disaster was not so equipped.

In so far as the responsibility of the men carrying out repair and maintenance work is concerned, the lesson of this accident is extremely clear. No item of equipment making up the locomotive is so minor that it can be treated carelessly. Both the actual workmanship and the inspection must be above reproach. No individual can afford to place himself in a position where serious results to others may follow an act of negligence on his part.

Fusion Welding Progress

The fusion welding processes during recent months have assumed the appearance of unusual activity. While their development and application up to 1931 had progressed rapidly in many fields, a few outstanding events have occurred during this year which brought them more actively to the attention of concerns which previously had been unable to utilize their advantages because of construction restrictions. In the field of boiler and pressure vessel manufacture, the action of the American Society of Mechanical Engineers in adopting the Welding Code for Unfired Pressure Vessels immediately removed most of the limitations which prevented the economic use of both welding processes.

It has been found in most cases where these processes have been applied that improved products, both stronger and lighter, at lower cost could be designed and built to meet the demand. In the tank construction field this has been particularly true. The case has been similar where large high-pressure watertube boiler drums have required fabrication. The use of the fusion welding processes in repair work of all kinds has extended over a greatly enlarged field.

One of the outstanding developments of the year has been the perfection of the shielded arc. More than 4000 miles of petroleum and gas transmission pipe lines have been laid with arc-welded joints. Progressive boiler manufacturers are bidding largely on work with arc-welded construction, basing their designs on the characteristics and strength of welds made by the shielded-arc process.

In the field of structural work action was taken during the year by the American Welding Society, establishing the first standardized code for structural materials. Many other events both here and abroad, as for example the successful completion of the welded German cruiser *Deutschland*, have had a bearing on the advance made in the short period of a year. There is every indication that progress, particularly in pressure vessel work, will be continued at an even more rapid rate, since manufacturers will acquire modern welding and testing equipment and develop the personnel and technique necessary to the successful fabrication of safe welded products.

It is mainly for the reason of this increased practical interest in fusion welding that The Boiler Maker in this issue commences the publication of a series of articles on such phases of the subject as apply particularly to the fabrication of pressure vessels and allied products. The author is an outstanding authority on matters pertaining to welding. Should any reader desire an explanation of any of the points brought out in the progress of this series of articles, his questions will be transmitted to the author for reply.

Arc-Welding Facts Adaptable Wherever Metals Are Joined

By G. G. Landis

G. G. Landis, chief engineer of The Lincoln Electric Company

The past few years have seen many machines and machine tools re-designed for arc-welded construction. This use of arc welding is hailed as a revolutionary but progressive step. To us, familiar with welding since its inception, the application of arc welding is merely a natural step in the evolution of industrial procedure.

For that reason we will begin this series of articles with some rather elementary information about arc welding. Too many engineers are unfamiliar with the basic principles and potentialities of the process. In many shops the welder operator at a few dollars per day often knows more about welding than the chief engineer who makes $10,000 a year.

This is a deplorable situation. The electric-arc process is so efficient, its possibilities are so great, that complete knowledge of welding theory, practice and procedure is as necessary as knowledge of nailing and bolting.

The first welding machine for industrial use was brought out in 1907 by the writer's company. At that time it was merely a motor-generator hook-up which cast metal into defective steel castings. That was 24 years ago, and yet today there are still engineers who consider weld metal as cast steel, although in grain structure and physical performance it approximates mild rolled steel. In fact there are arc-welding processes in wide use today which makes welds of better physical qualities than low-carbon plate steel. This is not an idle boast. Chemists and metallurgists have perfected the process to the extent that the deposited metal is stronger, as ductile and more resistant to corrosion than the mild rolled steel.

But we are ahead of our story. Arc welding began to spread slowly. Its exponents were the greatest believers in the potentialities of the process. In 1909 arc-welded steel was probably first substituted for cast iron in production. Today this application has spread to almost every industry. The advantages are obvious. Steel is stronger and cheaper than cast iron, and arc welding allows stronger construction at lower cost. Within a few years we were welding pipe and small containers. A welded seam is leak-proof; it gives in effect one-piece construction. A welded tank is really a gigantic stamping.

Arc welding is now accepted in the structural field. Where riveting or bolting requires an additional member and several handling operations, arc welding allows a direct connection, member to member, with a joint stronger than the units joined. There is a good experiment which will amplify this point. Weld and rivet two H-shapes out of I-beams and hammer the cross members until the units fail. The welded unit will fall away from the joint, and usually withstand more severe treatment than the other shape.

In 1927 the electric arc was first used in the construction of a long distance pipe line. These lines are tested under pressure and must operate without leaks. The initial investment on such a line is so great that freedom from maintenance is a necessity.

The use of electric-arc welding on these lines spread and with the introduction of the shielded-arc process in 1929 other methods became almost obsolete. From July, 1929 to July, 1931, almost 4000 miles of pipe line were welded by this process. Before this period the oil refineries began to use arc welding in the construction of their processing equipment. This equipment is often used with combustible material at high pressure. There will be no leaks in the welds, and no explosions.

Some fifteen years ago certain intelligent industrialists began to use arc welding in the production of tanks and pipe. At the same time maintenance operations on locomotive boilers were simplified with arc welding. The process spread in this field for obvious reasons. Several unfortunate persons, fired by the promises of optimists, welded up high-pressure boilers without any preliminary investigation as to the use of welding on this application and managed to kill a few people and hold back this application of arc welding.

Nevertheless, some manufacturers carried out exhaustive tests using welding in boiler and tank fabrication, and their faith in the process has been justified. In most applications arc welding was always satisfactory, and now, with an improved welding technique, the security and safety of welded units is assured. There are thousands of successful applications for every failure, and we believe that every failure can be traced to some lack of knowledge or poor craftsmanship.

The electric arc represents the same phenomena as the lighting, except that the voltage is lower and the amperage greater. Unlike the lightning it can easily be controlled for a useful purpose. The heat generated in the crater of a carbon arc is possibly the highest temperature man can secure, around 7000 degrees F.

In welding, the metallic arc is widely used. The heat of the arc melts the plate and the electrode, the two metals mingling in the molten state so that upon solidification there is a homogeneity of structure.

With ordinary metallic or carbon-arc welding, the natural affinity of molten steel for oxygen and nitrogen affects the weld metal and results in a weld, which while satisfactory in most types of work, possess many undesirable qualities. These welds usually had the tensile strength of mild steel, somewhat lower ductility and less resistance to corrosion. Oxides, nitrides, slag inclusions and porosity in the weld metal were attacked in the laboratories and the result was the development of the shielded arc process.

Chemists and metallurgists, studying the phenomena within the arc itself, discovered methods of shielding the arc within a protected atmosphere.

While there are several ways of doing this, with manual welding the best way seems to be with a heavily coated electrode. In principle these heavily coated electrodes often differ, one type being used at low current and consequently at low speed and the other being designed for high current and high speed. The physical results being equal, the economical way is to use a high speed electrode.

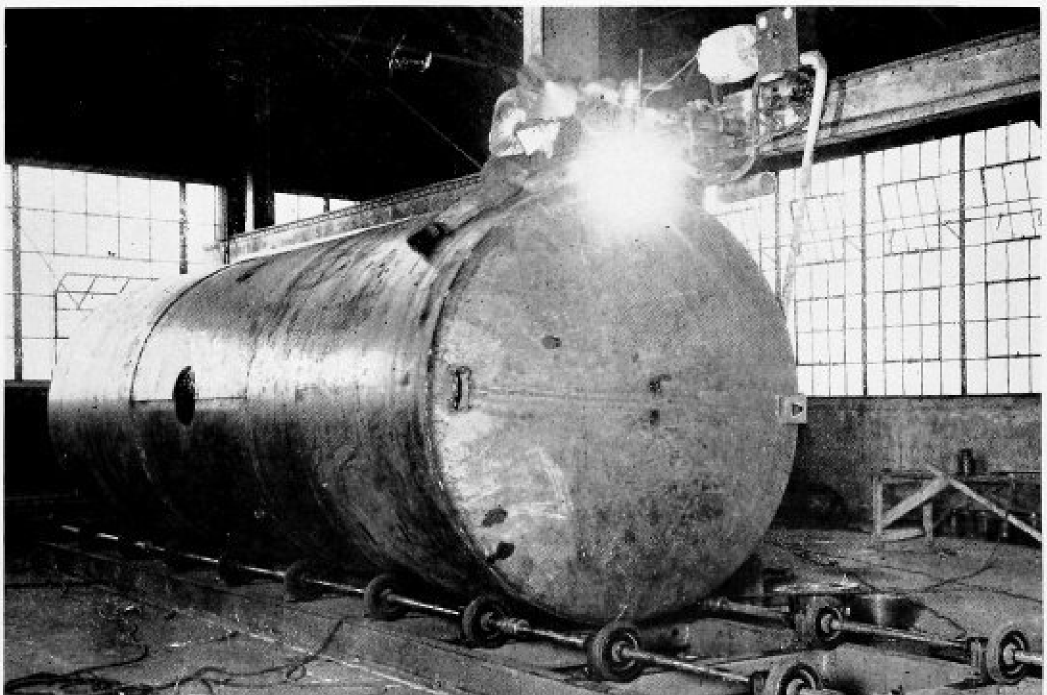
The shielded-arc electrode coating burns less rapidly than the electrode melts and forms in effect a crucible around the arc, protecting it for part of its length. As this coating burns it gives off a neutralizing gas which forms a protective envelope around the arc and attracts oxygen from the steel, actually improving its quality by reducing the oxide content. The residue from the burning coating is an easily removable slag which protects the molten metal while cooling.

Welds so made have a tensile strength between 65,000 and 80,000 pounds per square inch, ductility as high as 30 percent in two inches and better resistance to corrosion than mild steel. The greater heat used insures penetration and allows a 200 to 400 percent increase in speed.

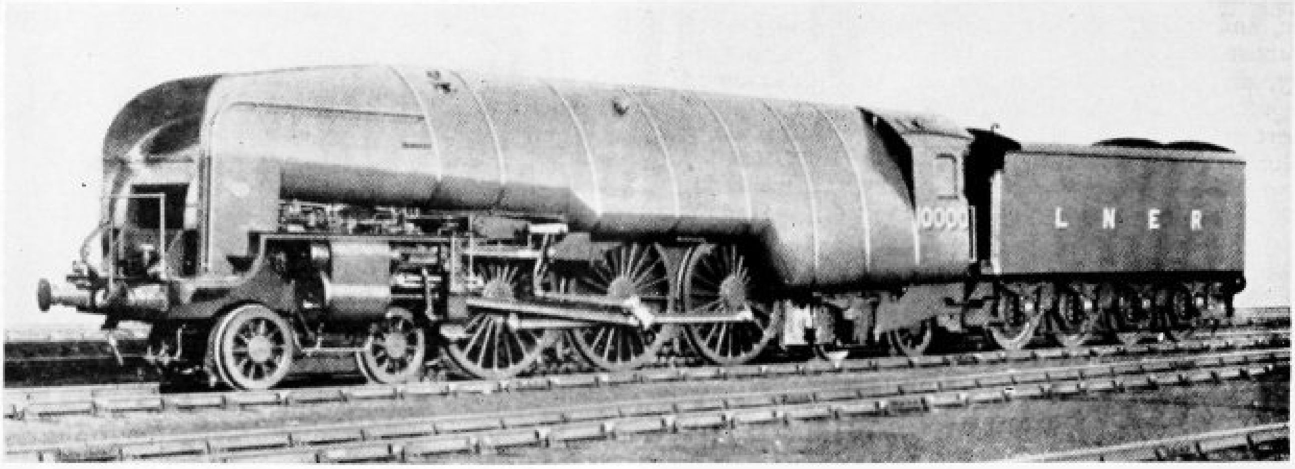
It is this shielded arc process which we consider has made practical the welding of all types of vessels, high or low pressure for any application and render any plate thickness. With it, welding costs are lowered and the product improved, for the possibility of leaks at the joints is eliminated.

(To be continued)

The author, who is chief engineer of The Lincoln Electric Company, Cleveland, has prepared a series of exclusive articles, of which the present one is the first, covering the basic principles of the arc-welding process which can be applied in any industry utilizing this modern method of joining metals. Further articles will explain in a clear, concise and understandable way, the manual welding of tanks and containers, automatic welding, pressure vessels, field storage tanks, pipe, piping and pipe lines. The series will constitute a complete working manual of this process as it applies to the field of pressure vessels, tank construction, and of boiler fabrication.



Fabricating a tank by means of an automatic arc-welding machine. Note the manner in which the tank is mounted on rollers so that it may be handled readily



London North East Railway express locomotive No. 10,000

High-Pressure Watertube Locomotive Built in Great Britain* ▲ ▲ ▲

From the early days of the locomotive it has been recognized that an increase of boiler pressure results in a decrease of coal consumption, but with the conventional type of locomotive boiler this has generally resulted in increasing the cost of firebox repairs and reducing the life of boilers with fireboxes. When the *Rocket* was built by George Stephenson, a boiler pressure of 50 pounds per square inch was employed and pressures have gradually increased until now there are many engines running in Great Britain with boiler pressures of approximately 250 pounds per square inch. Pressures up to 325 pounds per square inch have been experimentally tried for locomotives in Germany and America but 250 pounds per square inch can be regarded as approximately the maximum pressure which can be carried in a boiler of the Stephenson type, considering the cost of boiler maintenance.

It has taken 100 years to increase the pressure of locomotives from 50 pounds to 250 pounds per square inch but during the last five years pressures have increased up to 450, 900 and even to 1700 pounds per square inch. In striving for economy by the use of higher pressures, designers of locomotives are only following the lead which has been set by designers of large stationary plants and marine installations. Their problem, however, has been more difficult because of height and weight restrictions. For these reasons they are unable to take advantage of condensers and have had to extend the pressure range upwards to a greater extent. It does not necessarily follow that the use of high pressure in boilers is more dangerous than the use of low pressure. An explosion of a boiler at a pressure of 50 pounds per square inch can have disastrous results; and there is no reason, if proper precautions are taken both in design and maintenance, to assume that there is any greater liability to explosion or failure as a consequence of increasing the pressure in the boiler.

The first British high-pressure locomotive was the four-cylinder compound engine of the London North East Railway, which was completed by the end of 1929. This locomotive, known as No. 10,000 or the *Flying Scotsman* was designed by H. N. Gresley, C. B. E., chief mechanical engineer of the London North East Railway. In designing this engine Mr. Gresley thought it advisable to be content with a moderate increase of boiler pressure; that is, to 450 pounds per square inch. In coming to this decision he was influenced largely by considerations of maintenance costs and the desirability of advancing by stages. Past experience has indicated that revolutionary designs have not always been justified by results, and consequently Mr. Gresley deemed it wiser to seek progress on a less ambitious scale. He also recognized that as the pressure increased, the economies to be expected in fuel consumption are in a diminishing ratio.

Because of the successful application of boilers of the watertube type in marine practice and in large power stations, Mr. Gresley consulted Harold Yarrow, of Glasgow, in September, 1924, and suggested a design of boiler of the watertube type which might be applied to locomotives. A watertube boiler suitable for a locomotive involves a radical departure from the usual design of such boilers for marine and land use. However, toward the end of 1927 the final design was completed and a patent was issued. Early in 1928 an order was placed with Yarrow & Company, Ltd., for the construction of the boiler. This boiler was completed and tested in October, 1929. The engine was built at the Darlington Works of the London North East Railway and ran its trial trip on December 12, 1929.

The drums of the boiler are of sufficient diameter to allow a man to get inside them for the purpose of expanding the tubes. To suit the conditions peculiar to a locomotive, tubes of a large diameter only were used.

* Abstract of a paper read before the British Institution of Mechanical Engineers by H. N. Gresley, C. B. E., Member of Council.

The tubes of the firebox ends of the boiler are 2½ inches in external diameter and the tubes in the forward part are 2 inches.

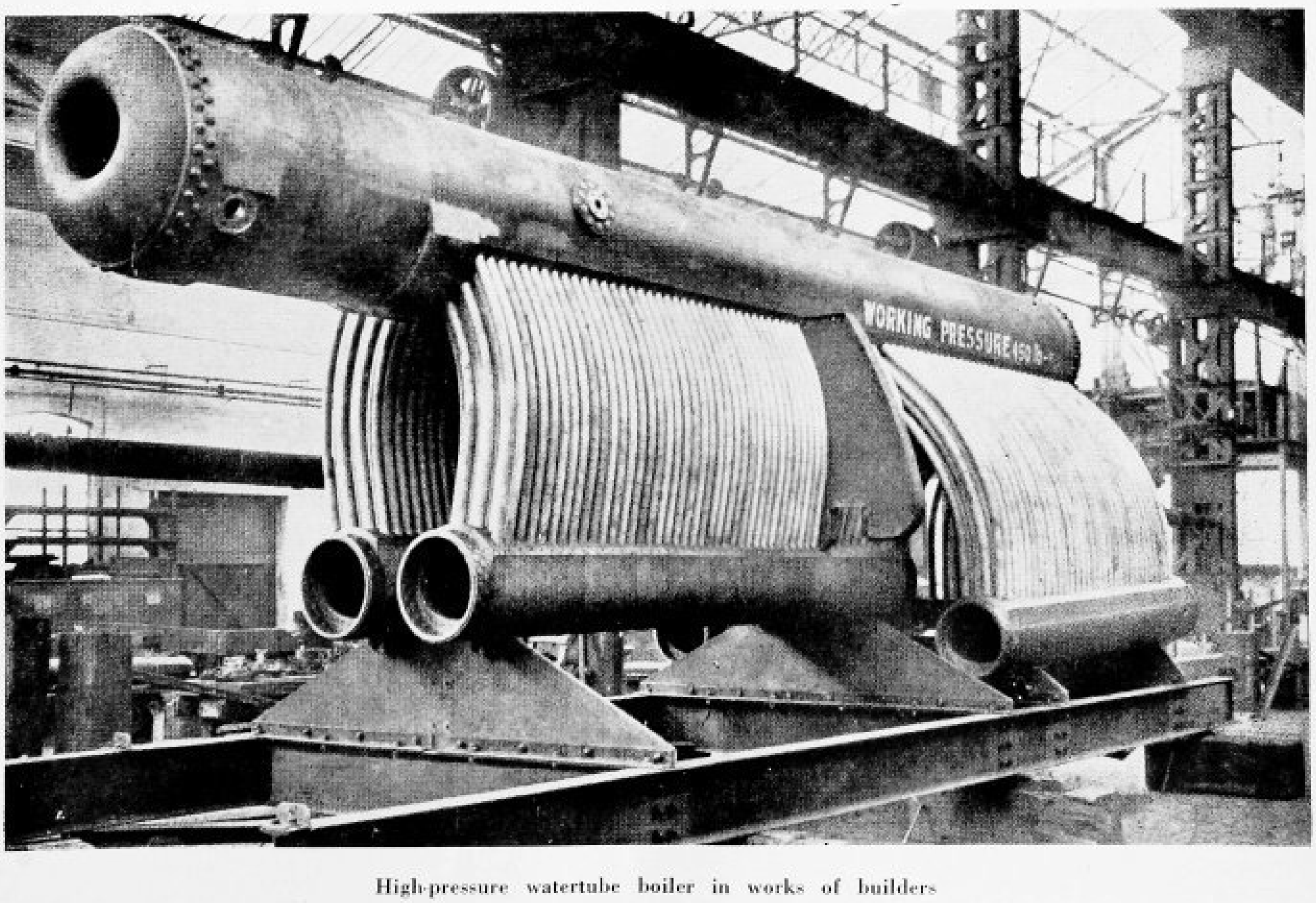
Considerations which govern the design of marine and land boilers are so entirely different from those required in a locomotive boiler that there is little similarity between the boiler used on this engine and the ordinary type of watertube boiler. In the ordinary watertube boiler resting on foundations, the boiler can expand freely in any direction and the tubes, not being subjected to vibration and the racking stresses, are not liable to leak. In a locomotive, the boiler must be so secured to the frame that, in addition to standing the shocks and vibrations experienced with the engine running at high speed, it must be capable of withstanding the shocks which occur when a locomotive is shunting, comes in contact with buffer stops or possibly becomes de-railed.

In adopting a watertube boiler, Mr. Gresley considered the troubles which might reasonably be expected to result from scale formation in the tubes. Unlike marine and power-house boilers in which the boiler feed is derived from the condensate and only a very small make-up of fresh water is required, the locomotive boiler requires 100 percent of make-up water. To prevent the formation of scale as far as possible the feed water is introduced at the highest possible temperature.

In a test carried out by the builder an evaporation of 20,000 pounds of water per hour at 450 pounds per square inch pressure was maintained for a period of 4 hours by the introduction of a steam jet up the stack. This high rate of evaporation is possibly due to a large proportion of the heating surface being subjected to direct radiant heat. In the ordinary form of locomotive boiler only the firebox is subjected to radiant heat. The evaporation per square foot of heating surface of the tubes is only about one-fifth of that of the firebox sides. The superheater elements in this boiler are located in the forward portion of the central flue and are also subject to radiant heat. In order to prevent the flame impinging directly on the ends of the elements, a brick column is provided in the center of the main flue in front of the brick arch. Notwithstanding this precaution the temperature to which the steam was superheated during the preliminary trials was excessive, temperatures of 900 degrees F. being obtained. For this reason the lengths and area of the superheater elements have been reduced so that a temperature of approximately 700 degrees F. can now be obtained.

Superheater elements are located between the boiler and the regulator and are therefore always subject to full boiler pressure. With a pressure of even 450 pounds per square inch special designs of boiler fittings and valves have to be used to overcome the cutting action of high-pressure steam but in this engine only the safety valves, regulators and water gages have been made specially for this pressure. One feature of the boiler which calls for comment is the construction of the front end and stack, which is apparently absent. In order to provide sufficient length for the watertubes it was necessary to have the top steam drum as high as the limits imposed by the height permit. Consequently there was no room for a stack of the conventional type. Engines having large-pitched boilers can only have very short stacks and trouble has been experienced in such engines owing to smoke and steam beating down on the front windows of the cab and interfering with the driver's view of signals. In this design, however, an air flume is built so that whether running at low or high speeds, steam and smoke is reflected upwards sufficiently to clear the cab.

(Continued on page 336)



High-pressure watertube boiler in works of builders

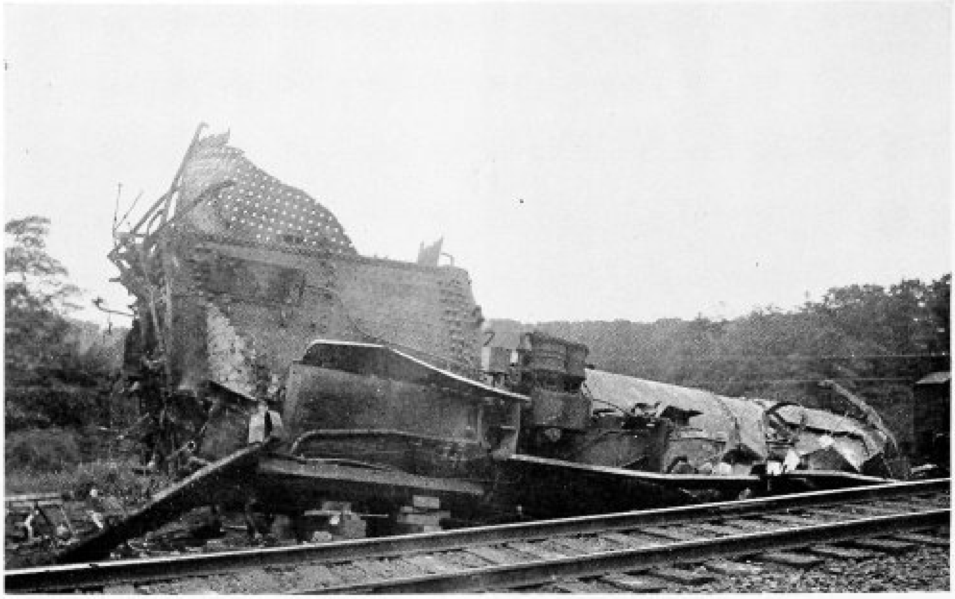


Fig. 1.—Boiler completely demolished by explosion

Fig. 2.—Water glass opening plugged by rubber gasket

Locomotive Boiler Crown Sheet Failure

By A. G. Pack*

On September 16, 1931, about 2:22 a.m., the boiler of Erie Railroad locomotive 3026 exploded at Graham, N. Y., while the locomotive was in use as a pusher on east bound freight train NY78, resulting in the instant death of two employees, the fatal injury of one employee who died two hours after the accident, the fatal injury of one employee, who died 27 hours after the accident, and the serious injury of two employees.

The force of the explosion tore the boiler from the frame, hurling it upward and forward. The boiler alighted on the west-bound track, a distance of approximately 270 feet from the point of explosion, rebounded 85 feet forward, and came to rest on its left side adjacent to and obstructing the west-bound track. The running gear and tender remained on the track. The smokebox front, smokebox door, stack extension, various parts of the smokebox, and superheater header and units were blown from the locomotive; these parts together with the escaping steam and hot water practically demolished the caboose to which the head end of the locomotive was coupled. Fig. 1 shows the boiler after having been moved to clear the west-bound track.

Locomotive 3026, 2-8-2 type, was built in 1912. The locomotive was 89 feet 2⅜ inches in length; weight in working order, exclusive of tender, 329,900 pounds; with tender 639,900 pounds.

The boiler was of the straight-top semi-wide firebox type, 82⅜ inches diameter at the first ring, and carried 190 pounds per square inch working pressure. It was equipped with a superheater having thirty-six 5½-inch superheater flues, and two hundred and twenty-four 2¼-inch fire tubes.

A new firebox was applied at Meadville, Pa., in October, 1928. The firebox was 120 inches in length and 84 inches in width at the mud ring and was of 3-piece construction consisting of crown and side sheets in one piece, back flue sheet, and door sheet. The back flue sheet was $\frac{9}{16}$ inch thick and the remaining sheets were ⅜ inch thick. The seams joining the side sheets and the back flue sheet and the seams joining the side sheets and door sheet were fusion welded for a distance of 44 inches up from the mud ring and the other firebox seams were riveted. The crown sheet had a slope of 5 inches from front to rear. A fusible plug was located on the center line of the crown sheet between the first and second transverse rows of stays from flue sheet and extended 1⅜ inches above the water side of the crown sheet. The firebox was equipped with four 3-inch arch tubes.

* Chief inspector, Bureau of Locomotive Inspection, Interstate Commerce Commission. This article was abstracted from a report submitted by Mr. Pack covering the accident described.

The crown sheet was supported by 26 transverse rows and 12 longitudinal rows of radial stays; the first four transverse rows from back flue sheet were expansion stays, the first three longitudinal rows on each side of the center line were hammered head straight stays 1 inch in diameter, the next two longitudinal rows were hammered head stays 1 inch in diameter at thread fit with body reduced to 7/8 inch, and the outer rows were tapered head stays 1 1/8 inches diameter at the thread fit with bodies reduced to 7/8 inch, all spaced 4 by 4 inches. The staybolts were 1 inch in diameter spaced 4 by 4 inches.

The locomotive was equipped with a stoker, mechanically operated fire door, a feed-water heater, one feed-water pump, one nonlifting injector, two 3 1/2-inch safety valves, and one steam gage.

A water column was located on the back head of the boiler 17 1/8 inches to the right of the center line. The bottom connection to the boiler was in line with the lowest point of crown sheet and the top connection was located 17 1/2 inches forward of the back head flange and 10 3/4 inches to the right of the center line. A 3-faced tubular water glass having a clear reading of 7 inches, and three gage cocks, spaced 3 inches vertically, were mounted on the column. The carrier's records indicate that the height of lowest reading of gage glass above highest part of crown sheet was 4 inches and that the height of the lowest gage cock above highest part of crown sheet was 4 inches.

Inspection of the boiler after the accident showed that the crown sheet had failed, caused by overheating due to low water. The line of demarcation indicating the overheated area was well defined and extended from between the ninth and tenth longitudinal rows of stays each side of center at back flue sheet down to approximately the top of top row of superheater flues and tapered uniformly back on crown sheet into door-sheet flange. From the line of demarcation it is estimated that the water was approximately 11 inches below the highest part of the crown sheet. The heads of crown stays were a pronounced blue in color and were cupped. The crown sheet was tufted between stay holes and the holes were elongated up to 1 7/8 inches in diameter. The filling of the fusible plug had melted.

Evidently the initial rupture occurred at the back flue sheet where the sheet tore through the center of the second row of fire tubes for distances of 19 inches and 21 inches on right and left sides of center line, respectively. This part of back flue sheet remaining attached to the crown sheet, being secured thereto by 22 rivets. Starting at the knuckle of the back flue sheet at a point 24 inches to the left side of the center line the crown sheet tore diagonally downward and into the left side sheet. The tear continued in the side sheet to between the first and second longitudinal rows of stays from the mud ring and to the eleventh vertical row of stays from the back flue sheet. Starting at the knuckle of the back flue sheet at a point 20 inches to the right side of the center line the crown sheet tore diagonally downward and into the right side sheet. The tear continued in the side sheet down to midway between the rows of mud ring rivets and to the twelfth vertical row of stays from the flue sheet. The sheets enclosed by this outline were forced downward and the crown sheet was forced back against the door sheet. Starting at the mud ring below the eleventh vertical row of stays from the flue sheet, the right side sheet was ruptured diagonally upward for a distance of 48 inches, apparently caused when the sheet folded.

Two superheater flues were partially pulled out of the back flue sheet and 11 firetubes and 4 superheater flues

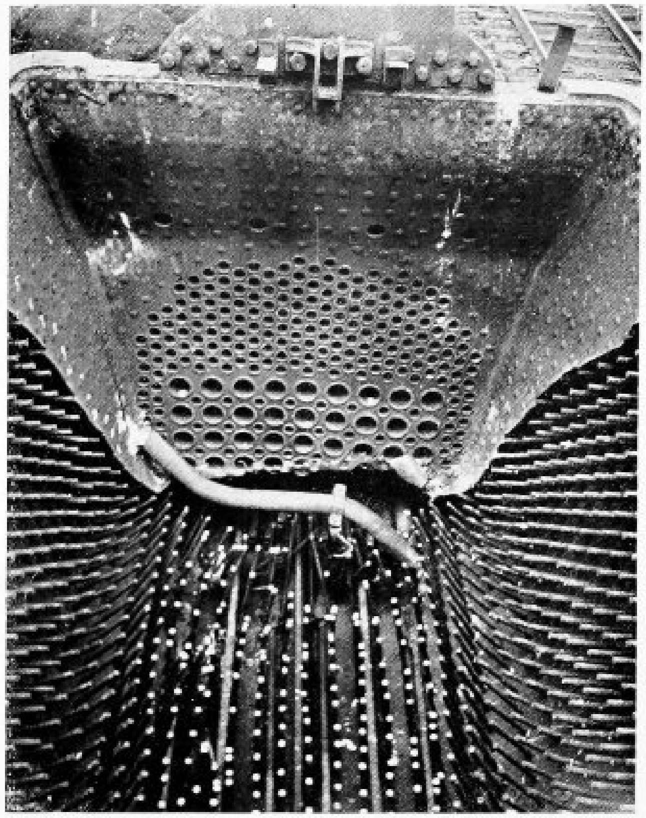
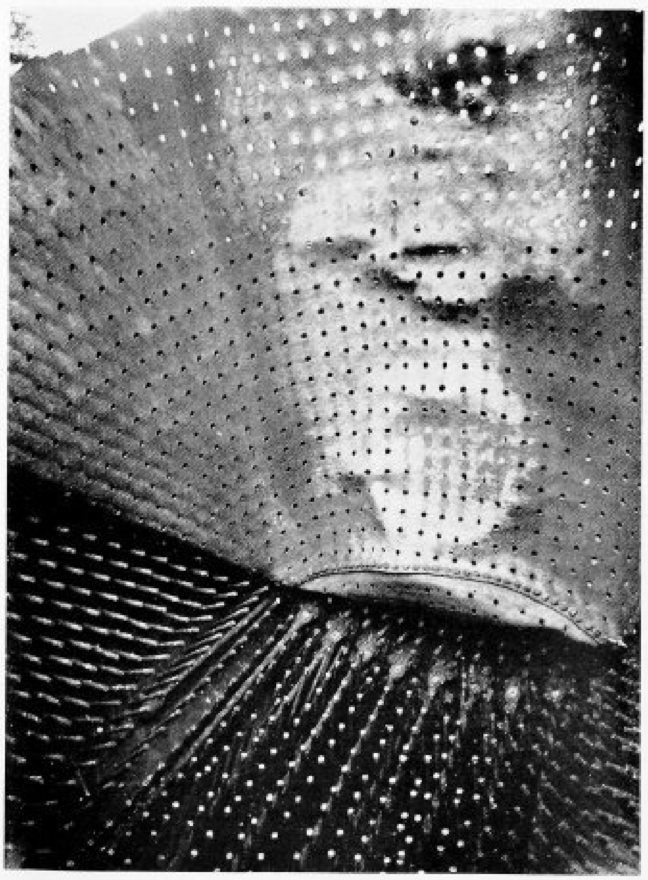


Fig. 3.—The view above shows the interior of the firebox looking toward the flue sheet. Fig. 4.—The bottom illustration shows the crown sheet and parts of the door and side sheets folded down



were completely separated from the back flue sheet. The sheets pulled away from a total of 1078 stays. The boiler was free from scale and as far as could be determined, there were no broken stays in the boiler. The short back-head brace at the extreme right side of the center line was broken and the appearance of the metal at the point of failure indicated an old fracture comprising approximately 60 percent of the cross-sectional area had existed prior to the explosion. The arch tubes were blown out of firebox, and the mechanically operated fire door was destroyed.

Fig. 3 shows a view of the interior of the firebox looking toward the flue sheet and Fig. 4 shows the crown sheet and parts of the door sheet and side sheets folded downward.

The water column, with water glass and gage cocks attached, remained intact on the boiler. The water column, steam pipe, bottom connection to the boiler, blow-off valve, and drain pipe were clean and clear of obstructions. The gage cocks, dripper and dripper pipe were clean. The top and bottom water glass valves were found open and clean. The water-glass drain valve and drain pipe were missing.

The opening at the top of the water glass was found to be closed by a rubber gasket. The carrier's standard water-glass gasket is made of rubber about ½-inch in thickness with asbestos inserted in a recess in the face of the gasket. Each end of the water glass was packed with one of these gaskets and a thinner gasket made by splitting one of the standard gaskets. The carrier's standard application calls for the use of metal washers over the gaskets at each end of the water glass to prevent extrusion of the gasket material but the washers had not been used in this assemblage. Fig. 2 shows an end view of the water-glass cage with the opening into the water glass completely stopped.

The feed-water pump turret valve was found wide open and clean and the throttle valve was found open 1½ turns. The pump and heater were damaged to such an extent that they could not be tested, but the pump was dismantled and the appearance of the various parts indicated that it was in operative condition prior to the accident. The injector throttle valve was found wide open; the main steam valve stem was broken off flush with the packing nut and the valve was in open position. The starting valve was found closed. The injector was damaged to such extent that it could not be tested but upon dismantling the appearance of the parts indicated that it was in operative condition prior to the accident. The boiler check valves were found to be clean and to have proper lift. The shut-off valve to the left check valve was disconnected from the stem and wedged between body of valve and stem but it did not obstruct the opening to the boiler. The delivery pipes were damaged by the explosion.

The safety valves were removed from the boiler and tested; the first valve opened at 187 pounds and closed at 184 pounds, the second valve opened at 194 pounds and closed at 189 pounds.

The steam gage syphon cock was broken off by the force of the explosion. The syphon cock and the syphon pipe were found to be clean. The steam gage was tested and found to be correct.

The feed-water tank was found clean and in good condition. Both tank valves were found open and clean, the tank wells, strainers, and hose were also found to be clean.

The estimated property damage was $18,000.

Annual inspection was made on August 26, 1931, at Secaucus, N. J.

The last daily inspection was made at 1 p. m., September 15, 1931, at Port Jervis, N. Y., 10 hours before the locomotive was dispatched for the trip upon which the accident occurred. The incoming engineer reported "Top nut of water glass leaks." The report was signed by the employee who was designated to make the repairs and by the foreman, indicating that the reported defect had been repaired. Leakage at the top nut of the water glass was also reported on September 1 and September 6 and the reports for these dates were signed by the employees designated to make the repairs and by their respective foremen indicating that the reported defects had been repaired.

The following defects in connection with the feed-water pump and heater system were reported on daily inspection reports on the dates shown:

August 2. Holes in return pipe from water pump stopped up.
August 5. Gland nuts on feed water pump leak bad.
August 9. New packing put in steam end of water pump.
September 3. Right pipe connection on water heater leaks bad. Water pump is no good, does not throw any water.
September 9. Bad leak in branch pipe near water drum right side front of engine.

These reports were signed by the employees designated to make the repairs and by their respective foremen, indicating that the reported defects had been repaired.

On August 10, while the locomotive was out of service for work incident to annual inspection, the water glass and water-glass valves were removed and cleaned. The employee who performed this work stated that in re-applying the water glass he found the standard gaskets to be insufficient in thickness and that he cut approximately $\frac{3}{16}$ inch off other gaskets, retaining the parts with asbestos, placed these in the bottom of the recesses away from the ends of the glass, placed a full size ½-inch gasket over the thinner gasket, with copper washers over the full-size gaskets toward ends of the glass. This employee did all other cab work required at boiler-wash period and hydrostatic test and set the safety valves on August 26. He was positive that the water glass was functioning properly at that time.

Leakage at the top nut of the water glass was reported on September 1 and the employee who made the repair stated that to the best of his recollection the repair was made by tightening the top nut. Leakage was again reported on September 6; the employee who made this repair stated that it was done by tightening the packing nut and that after making the repair he tried the water glass by blowing out through the top and bottom cocks separately. Leakage was again reported at 1 p.m., on September 15, 10 hours before the locomotive was dispatched for the trip upon which the accident occurred. The employee who tightened the nut on September 1 was assigned to do the work some time subsequent to 3 p.m. He stated that he found it necessary to tighten both top and bottom packing nuts and that after this was done the glass was blown out; the top and bottom water-glass valves were tried to ascertain if they were open but he did not close them and blow out the glass separately through each valve.

An engine preparer who was on the locomotive about 9 p. m., September 15, stated that he found the glass about one-third full of water, that he blew the glass out by opening the drain cock, that the movement of the water in the glass was very active at that time, and that he pumped the boiler full of water before he left it.

The hostler who took the locomotive out of the engine house about 10:40 p.m., on September 15, stated that while waiting for the turntable he tried the water glass by closing the top and bottom valves separately and blowing through the drain valve each time, the water level was out of sight in the glass, the glass being entirely full, the gage cocks were then tried and water was found in all three gages. He then tried the water pump and injector and found both in good operating condition.

The conclusion reached is that the explosion resulted from an overheated crown sheet due to low water. The primary cause was the misleading indication of the water glass because of the stoppage of the upper end of the glass due to extrusion of a rubber gasket.

No record could be found of the water glass having been removed subsequent to August 10, at which time it had been removed, cleaned, and replaced. The employee who performed this work stated that he replaced the metal washers over the gaskets which are provided to prevent extrusion of the gasket material; however, these washers were not in place at the time of the accident. Repeated tightening of the packing nut, together with the effect of heat, caused the gasket material to flow and eventually to extend over and close the opening in the top of the glass.

The results of a series of tests made to ascertain the sufficiency and reliability of water-level indicating appliances are given in my ninth annual report for the fiscal year ended June 30, 1920. These tests clearly demonstrated that the water-level indicating appliances then in general use gave inaccurate and misleading indications under operating conditions, and the recommendation was made, and repeated in subsequent annual reports, that locomotives be equipped with a suitable water column to which shall be attached three gage cocks and one water glass, and one additional water glass located on the left side or back head of the boiler.

The carriers have, in general, adopted the foregoing recommendations with resulting improvement in the reduction of crown-sheet failures. However, some of the carriers have not applied the additional water glass on the left side or back head of the boiler. The boiler that is the subject of this report was not so equipped. Had it been so equipped, the correct water level would have been apparent and the explosion likely avoided.

A similar accident occurred on September 9, 1930, on Reading Company locomotive 1705, a report on which was published under date of October 28, 1930, and which resulted in the instant death of five employees, the fatal injury of one employee who died 6 hours after the accident, the fatal injury of one employee who died about 33 hours after the accident, the serious injury of six employees and the minor injury of four employees. In each instance the water glass assemblage on the right side of the boiler was stopped up with gasket material causing the glass to show full of water when in fact the water level in the boiler was below the danger point. Neither locomotive was equipped with a water glass on the left side or back head of the boiler and the misleading indication of the water glass on the right side was the primary cause of both accidents.

A.S.M.E. Boiler Code Committee Work

The Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the code is requested to communicate with the secretary of the committee, 29 West 39th St., New York, N. Y.

The procedure of the committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the secretary of the committee to all of the members of the committee. The interpretation, in the form of a reply, is then prepared by the committee and passed upon at a regular meeting of the committee. This interpretation is later submitted to the council of the society for approval, after which it is issued to the inquirer and published.

Below are given records of the interpretations of the committee in Cases Nos. 687, 689, 692, as formulated at the meeting on September 18, 1931, all having been approved by the council. In accordance with established practice, names of inquirers have been omitted.

CASE No. 687. *Inquiry:* Specifications S-3 for Steel Plates for Brazing provides that sheets less than ¼ inch in thickness need not be stamped at the mill, but that the manufacturer must mark each vessel in some permanent manner so that the material can be identified. None of the other material specifications have provisions of this sort. May not this same provision be interpreted as being applicable to all sheets under ¼ inch in thickness when made to any of the specifications in the code?

Reply: It is the opinion of the committee that sheets less than ¼ inch in thickness should not be marked with a steel stamp, and until such time as revisions can be made in those sections of the code which permit the use of plates under ¼ inch in thickness, the provisions of Par. 6 of Specifications S-3 should apply.

CASE No. 689. *Inquiry:* *a* Why does Par. U-59 restrict the diameter of an opening into which a flange is seal welded to that found by the formula given, when Par. U-77 apparently permits a greater diameter for nozzles which are attached to the shell or heads by fusion welding?

b Can a nipple attached as shown in *C* of Fig. U-6, be up to 8 inches in diameter, on shell or heads of any diameters, small or large?

c Does not the attaching of flanges as shown in *A* and *B* of Fig. U-3 give a stronger connection than either *C*, *D*, or *E* in Fig. U-6?

Reply: *a* The formulas and rules in Pars. U-59*a*, U-59*b*, and U-59*c* are for plain unreinforced openings, such as tube holes and other drilled openings and connections where welding is applied for sealing and not for strength. The size of a fusion-welded nozzle is governed solely by the formulas and rules in Par. U-77. A welded-on flange or nozzle exerts a certain amount of natural reinforcing effect which can be realized only when the amount of welding is sufficient to transmit to the shell stresses capable of being developed by the flange or nozzle.

b Yes, except that the design should be such as to provide a factor of safety of 5, and on shells or heads 36 inches or greater in inside diameter, the diameter of the nipple is further limited by the rules given in Par. U-77. When the factor of safety is questionable, tests should be made in accordance with Par. U-51.

c While flanges shown in *A* and *B* of Fig. U-3 have mechanical locks, which better prevent them from being blown out of the vessel, they do not reinforce the opening made to accommodate them, since they are not welded for strength (see the reply above under *a*). Connections as shown in *A* and *B* of Fig. U-3 will be as strong as those shown in *C*, *D*, and *E* of Fig. U-6 if enough welding is added for strength.

CASE No. 692. *Inquiry:* Par. P-186 permits the use of electric-resistance butt welding under the Power Boiler Section of the Code, but no provision for such welding is made in the Unfired Pressure Vessel Section of the Code. Can this process of welding be employed in the manufacture of unfired pressure vessels?

Reply: It is the opinion of the committee that electric-resistance butt welding complying strictly with the rules provided for this process of welding appearing in Par. P-186, may be used in the manufacture of unfired pressure vessels where the entire area is welded simultaneously. For temperatures higher than 700 degrees F., the working stress allowable on joints so made shall be reduced in proportion to the scale of reductions given in Table U-3. A revision of the Code for Unfired Pressure Vessels to this effect is contemplated.

Oil-Fired Forges

While considerable sentiment no doubt attaches to the old type of coal-fired forge used for so many years in railway blacksmith shops, there can be no question about the advantages of modern oil-fired forges, from the point of view of cleanliness and production in territory where the necessary fuel oil can be secured at reasonable rates.

The illustration shows an installation of modern oil-fired blacksmith forges at the Milwaukee shops of the Chicago, Milwaukee, St. Paul & Pacific. The forges are of the round, side-fired type, equipped with Johnston burners and air under pressure from the shop blower line. There are about 20 of these forges in the blacksmith shop which, together with all other furnace equipment in the shop, are oil-fired.

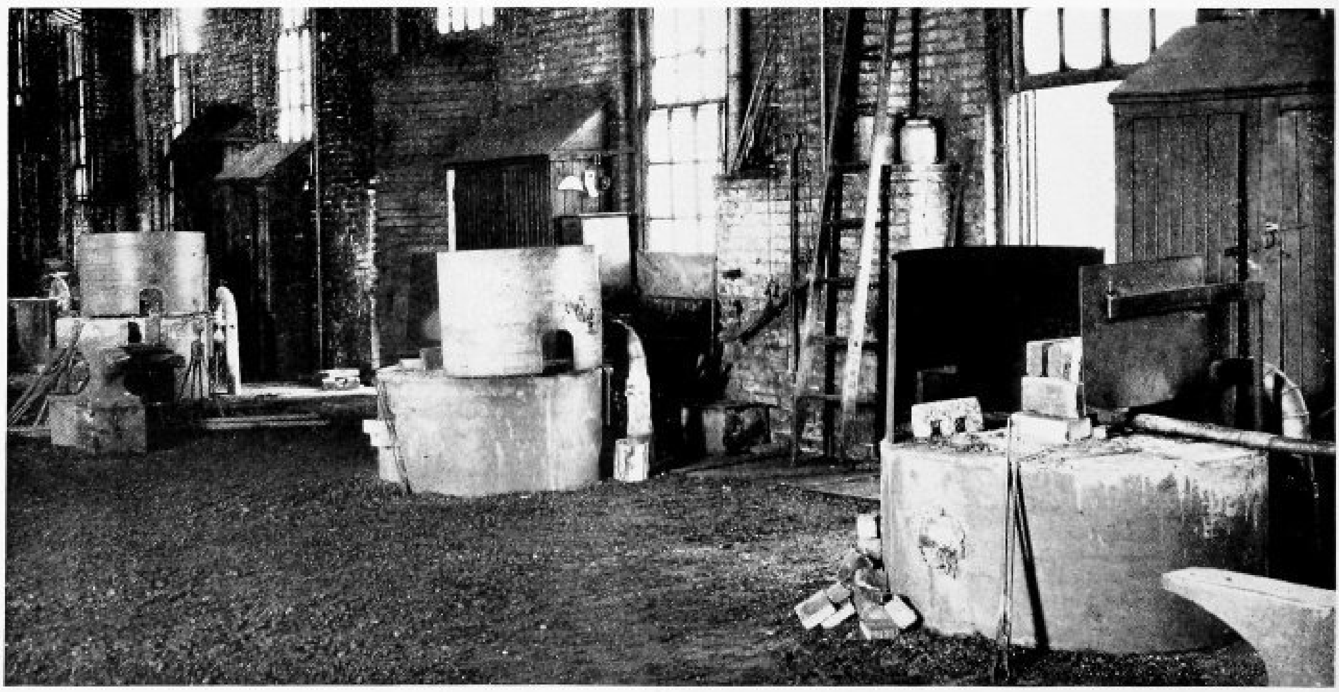
Referring to the illustration, the general construction of the forges will be evident. An arch is built of fire-brick over the fire and just high enough to enclose the steel bar or part to be heated. A large fixed sheet-iron shield serves the double purpose of keeping drafts away from the fire and confining the heat to each individual forge. An additional movable shield, which can be readily swung out of the way when not in use, also serves to confine the fire and protect the blacksmith who is working at that forge.

Experience with this equipment at the Milwaukee shop indicates that it contributes substantially to increased production and a cleaner shop. Moreover, after a little experience, a better quality of work is turned out. Even welding, at first considered impractical with oil-fired forges, is now handled with entire satisfaction, and the blacksmith force prefers this type of furnace over other types.

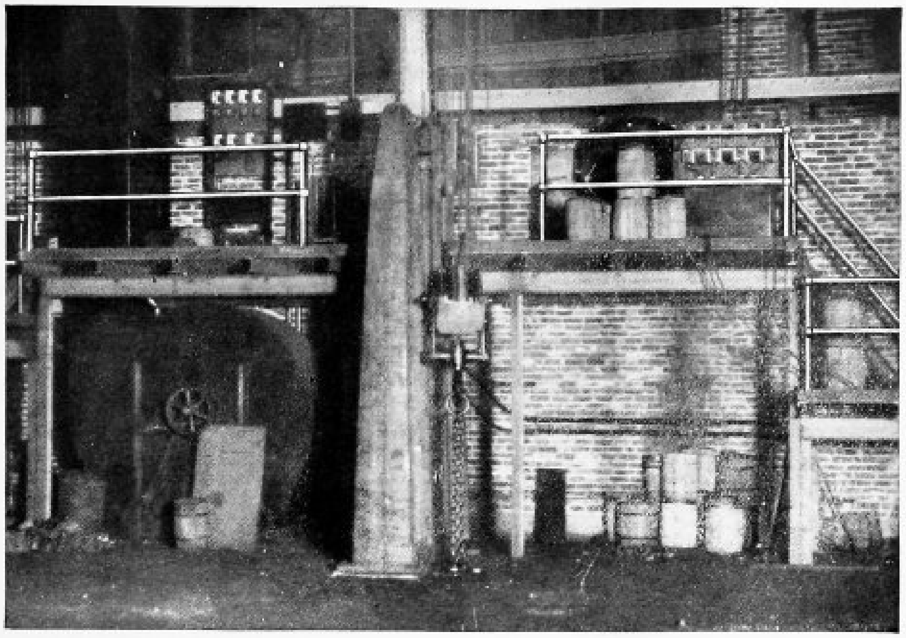
In addition to the advantages mentioned, there is a saving of 20 minutes' shop time in the morning formerly required for kindling coal fires, and the labor of handling coal and ashes is also saved. At the Milwaukee shops, one man on the second shift lights all forges about 10 minutes before the whistle blows.

Relief Valve Too Small, Tank Explosion Results

A safety valve of inadequate capacity may not prevent the explosion of a pressure vessel even though the valve is in good operating condition and set to open at a safe working pressure. This fact was demonstrated recently at the machine shop of a large mill where an air tank 30 inches in diameter and 6 feet long blew out a head, injuring one person and causing considerable property damage. The tank was provided with a one-inch lever type safety valve to take care of a compressor of 260 cubic feet capacity. About ten minutes before the accident the master mechanic observed that the safety valve was blowing and that the gage pressure was 80 pounds, the point at which the valve should blow. Evidently the valve could not release air from the receiver as rapidly as the compressor supplied it, the result being an explosion.—*The Locomotive.*



Oil-fired blacksmith forges at the Milwaukee shops of the C. M. St. P. & P.



Bull riveter platform showing guard rails, toe boards and stairs

Safety in Boiler and Sheet Metal Fabrication*

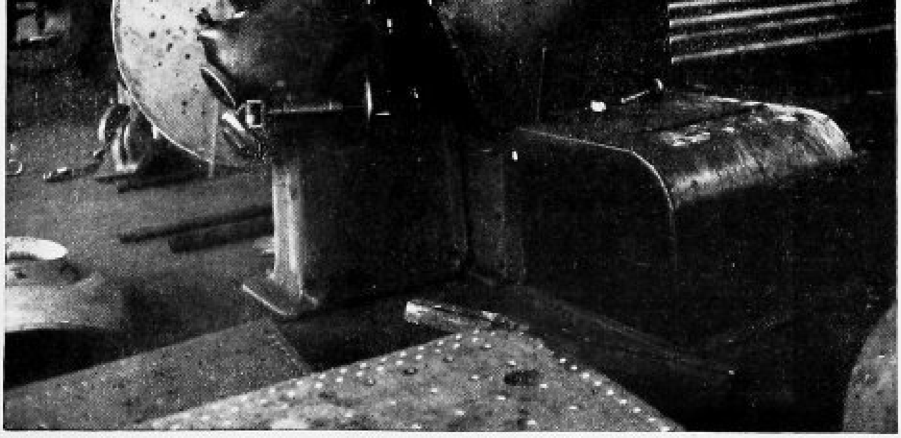
Levers, pipes, blocks or other objects used for moving or centering machines should always be removed as soon as the work for which they were used is completed. Otherwise when the machines are started someone may be seriously injured or the machines damaged.

Under no circumstances should a machine be tripped by pressing the treadle or by any other means before the operator knows that it is in operating condition. Treadles should be protected by hood guards against accidental tripping.

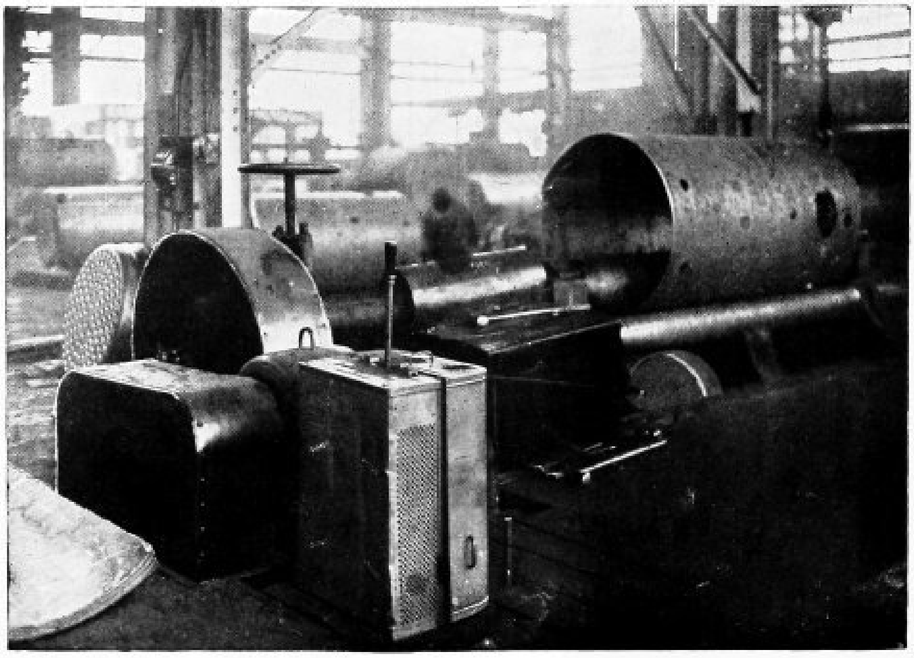
Machine operators should not attempt to move the balance wheel of a machine with levers or other objects while the power is on. This is often done, but it is a dangerous practice and should be prohibited as men have been injured because of the practice.

When drilling holes in drums or shells, operators should remove cuttings around drill points with a brush, stick or other suitable tool. Under no circumstances

* Published through the courtesy of the National Safety Council, Inc., Chicago. The first installment appeared in the November issue.



Rotary shear showing complete gear guards, motor housing and oiling door



Complete enclosure of motors and driving gears for rolls to prevent accidents

should operators use their naked or gloved hand for this purpose.

Operators should always see that the drill point is in line with the hole when reaming; otherwise the drill may bind and break.

Portable grinding wheels should be handled carefully. Under no circumstances should they be bumped against objects upon which work is being done; the impact may fracture the wheel, causing pieces to break off and fly with serious consequences. Care should also be taken to see that the grinding wheels are provided with suitable flanges.

Portable motors should always be shut down when the tools are not in use. This will prevent anyone from coming in contact with the moving points or working edges of the tool. Spring triggers on grinders eliminate wheel rotation after the operator has finished with a job.

When flanging long strips of material, care should be taken in the operation of the press. Before the operation is commenced all workmen should be in the clear to prevent accidents caused by the rapid movement of the end of the piece being flanged.

Operators of plate drills should wear leggings to protect their trousers from catching on the drills when standing on the plates.

Tongs or alligator wrenches should be used when shearing short plates, to prevent fingers being caught under the guard.

Dies on a punch should never be changed or adjusted when the machine is in motion. This is sometimes done on slow-moving machines but it is a highly dangerous practice and should be prohibited.

Dies or punches should not be used when the holes are so badly worn that the punches do not fit properly; there is danger of the punch breaking and flying.

Signs should be placed on all power shears warning against cutting hardened material.

The practice of blocking punch and shear treadles to make the machines operate continuously is dangerous and should not be allowed.

Hydraulic accumulators should be guarded to prevent workmen from coming near the stops below them.

Steel bolts with threads in good condition on both bolts and nuts should be used for holding die legs on presses.

Flanging dies should be provided with hooks to facilitate handling them with crane sling hooks.

On multiple drills (such as used for drilling firebox frames) "soup" hose should be arranged so that cocks may be adjusted without reaching between revolving drills.

Overhead working platforms around drill presses, bull riveting machines, boring mills and other machinery should be provided with standard guard rails and toe boards.

The usual fast rotating "small rolls" used in rolling sheet iron and light gage metal are dangerous and men have caught their hands in the rolls when working about them.

The installation of a reversing mechanism actuated by a cable running the full length of the frame should be provided. In the event of an accident on a roll so equipped, the operator by striking the cable with his leg or other part of his body will automatically reverse the rolls and thus release his hand.

Bull riveter and drill press pits should be guarded in such manner that a person cannot fall into them.

Substantial flooring or other protection should be installed under the overhead sheaves of vertical bull riveter hoists.

Punch presses used in punching holes in plates should be equipped with guards made of metal rods or strips placed on each side of the rams to prevent the operator's hands coming in contact with the punches as the plate is moved after each punching operation.

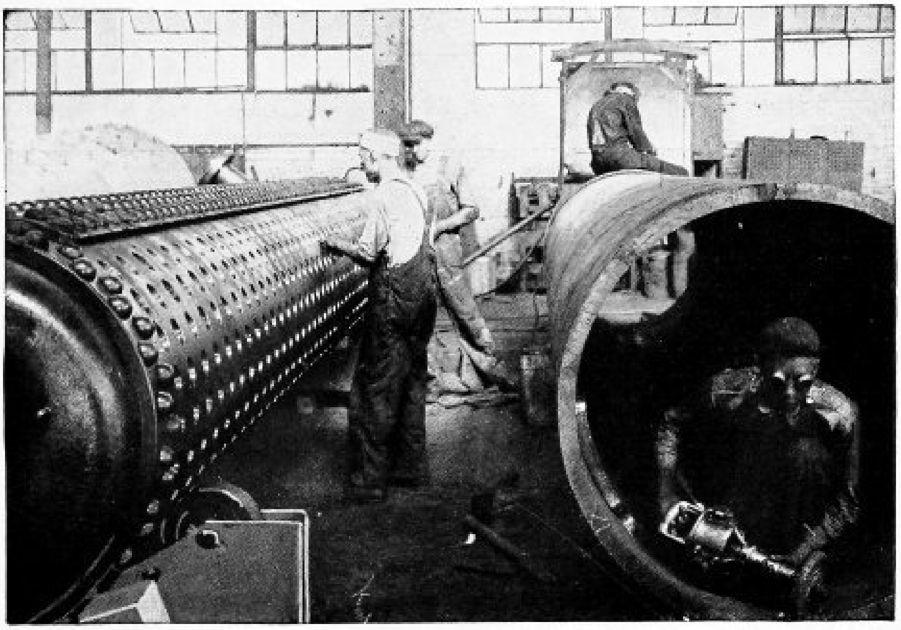
Machine driving gears and other power drives should be completely enclosed with substantial metal guards or otherwise suitably guarded.

Care should be taken to set small die blocks right side up on punch machines so that the "burrs" will pass through the machines and prevent the punch from bursting the die as it descends.

If long plates are handled in piles by crane a special beam rig that will support the pile at several places along its length should be used.

When handling short plates in piles, a double sling should be passed entirely around the pile and the pile carried edge up, if possible.

In fitting up, when handling plates or formed parts, ears securely bolted to plates should be used and attached to the sling chain so that the sling cannot become



Safe practices in boiler drum fabrication. Note safety devices being used

detached from the ears. Hooking in a manner that will permit the hook to disengage if the load should rest momentarily on some object should be avoided.

Layout work should be done on heavy wood or suitable metal horses, well constructed and securely bolted together. Rickety horses or supports should not be used.

The hooks on blocks, cranes and other lifting apparatus may become straightened out or "fatigued." They should be carefully inspected at frequent intervals and promptly replaced or repaired when defective.

The clamps used for lifting or holding plates at machines should be examined frequently for evidence of spreading or cracking in the flanges. Clamps designed for the loads to which they are subjected should always be used.

When it is necessary to move a clamp before proceeding with work on a plate, the clamp should be always up against the plate properly. Frequently clamps slip after being moved.

When lifting sheets for the insertion of clamps, workmen should always use a spud bar and be sure to place a substantial metallic object between the plates to hold them apart. The fingers should not be closed around the bar but kept open to avoid injury in case the bar should slip or be dislodged. After the plates have been properly supported the clamps or hooks should be inserted. When more than one plate is being moved or carried care should be taken to see that the edges are even and that the clamps have full hold on both sides of the under plate.

A clevice clamp with a bolt inserted in the hole should be used when hoisting sheet iron.

The common "C" clamp is unsatisfactory for hoisting sheet iron in place, because if the cutting edge of the bolt is worn the plates may slip and fall. Workmen should always be sure that the bolts have the proper cutting edge and are not excessively worn. In some shops when moving plates by crane or when supporting plates with slings at punch and shears, the slings are provided with toggle clamps which grip the plates and prevent them slipping from the slings.

Set-screw clamps used for picking up sheets should be selected in sizes which will fit the material to be handled. Care should be taken to see that the screw fits the clamp and is not bent.

When it is necessary to examine the underside of a plate, it should be turned over on the floor. It is unsafe to stand under the plate while it is suspended for the purposes of inspecting its underside.

When courses of shells are stacked in the shop, suitable timber stops should be placed at the bottom of each course to prevent rolling.

When lifting kegs of rivets or bolts, men should be sure that there are no protruding nails or ragged hoops which may cause injury.

Hoops removed from rivet kegs should not be thrown on the floor or working platform of riveting machines. Hoops present a serious tripping hazard and should never be permitted to lie where they may be stepped upon.

Stop bolts in chain blocks should be examined frequently and kept in place, to prevent the chains from slipping out and dropping loads.

The dampness which is unavoidable around test pits makes it necessary to keep plates and metal objects off the floor, because wet plate or metal objects will cause a serious slipping hazard. The surface of metal used in construction around a test pit should be roughened.

When vessels are placed on the test block they should be carefully lowered and centered so that the blocks will not tilt or fall. Before a vessel is moved it should be definitely known that there are no workmen in the adjacent vessels, or between adjacent vessels who may be injured if the vessels strike together.

When work is done on plates supported above the floor level near gangways or walkways, the work should always be arranged so that square or sharp corners will not injure persons who may pass by.

Wire rope slings are preferable to chains for lifting loads wherever it is possible to provide protection against abrasion or cutting.

When square or sharp-cornered loads are lifted with wire rope slings, proper backing should be used to relieve the rope at the corners, and to prevent any injury to the rope which may cause a failure and the dropping of the load.

When making a lift requiring only one chain, the idle chain should not be hooked up in such manner that it may be dislodged by the snap of the lifting chain when the slack is taken up.

When drums or other vessels are placed they should always be properly blocked. The vessel may roll on account of overbalancing caused by heavy butt straps, nozzles, domes, valves or overhanging castings unless blocked.

The breaking of chains is a serious hazard and can be avoided by careful and frequent inspection and the prompt discarding of any chains found defective. Chains for lifting a given load should be selected with careful consideration for their strength and the load which will be imposed upon them.

Stacking dished heads and other flanged parts should be avoided. Vibrations and jars set up in the shop have caused the piles to fall with serious results to workmen.

Load chains on chain blocks should be of sufficient length to allow the loads to be fully lowered to floors and platforms. The necessity for manually lifting objects to the desired places will thus be eliminated and the possibility of strains, ruptures and other injuries avoided.

Chain blocks used on work away from the shop before being placed in shop service should be carefully examined for defects that may have developed in the field.

Chains should not be used around objects to be raised by cranes unless holes are provided for the insertion of lugs or stops because there is danger of unbalancing and slipping of the load. If a cable with a loop is used the weight of the load will tighten the cable around the object lifted.

Dial pins used to facilitate movement and handling of material about machines should always be kept smooth and free from burrs to prevent cuts and gashes to workmen's hands.

Tube holes in drums and other vessels should not be filed or chamfered from the outside while men are doing work of any kind on the inside.

When structures of unusual height are built the work should be done in parts of the shop which will allow for safe passage of crane loads and thus avoid danger of collision due to limited clearances. The work should preferably be located away from under cranes so that workmen will not be exposed to the danger of passing loads.

All cylindrical structures and shapes should be blocked to prevent accidental rolling.

Crane loads should not be carried over workmen unless it is absolutely necessary to do so. If it is necessary the crane operator should warn workmen by sounding his crane gong when approaching them.

Hooks of crane chains should not be placed on the lugs or crowfeet of manhole or handhole plates in vessels as there is danger of these breaking or slipping under the weight of the load.

When work is being done on large horizontal cylindrical structures a double ladder should be constructed over the structure and a platform should be erected to join the two ladders at the top to provide a safe means of ascent and descent.

Workmen loading or unloading material from railroad cars or doing work of any kind on boilers, tanks or structures loaded on railroad cars should be notified before any movement or switching of the cars is to be done.

Pick-up chains should be inspected at frequent intervals for any defects. Such chains when twisted or kinked should never be used to pick up a load.

Manhole flanges and facings of manhole openings in structures should be ground smooth and free from burrs before workmen enter the structures through the manhole openings.

Defective rivets should not be backed out while men are doing any kind of work on the inside of a structure.

Care should be taken in handling light sheets that have been sheared as severe cuts to the hands may result from the burred edges.

When paint, oil or compounds are being sprayed on the inside of tanks, vessels or other structure, suitable protection should be provided for the eyes and respiratory organs and no open flame or lights permitted nearby.

When material is handled with hooks on chain block or crane chains, the hooks should be of such size as to properly enter the holes in the material. Hooks that are only partially inserted in holes have a tendency to straighten and drop the loads.

If gasoline or naphtha is used around machines, workmen should always remove it before leaving the shop. If gasoline or naphtha is left at the machine, the relief man may not know of its presence and a fire or explosion may be caused.

When oil torches or heaters are lighted care should be taken to prevent the projected flame from striking persons.

Care should be taken with oil torches in confined spaces such as on the inside of structures during fabrication. Should the torch be extinguished, shut it off immediately, as the spray of oil might be ignited by heated parts of the structure. The torch should always be removed from the inside of the structure for relighting.

When driving up large domes or stack bases, the structures should be blocked up off of the floor to allow an exit for the workmen in case of a fire due to failure of the oil torch, or of the oil or air hose.

Workmen firing flange furnaces should always stay in the clear to avoid burns in the case of a blow back. Control valves for the furnace should be placed at least six inches from the door so operator's arms will not be burned in case of a back fire.

At times serious accidents are caused by turning air into the wrong flanging forge. To eliminate confusion, flanging forges and the air lines connected to them should be plainly designated and numbered.

Great care should be exerted in lighting and firing oil forges and flange furnaces. Particular caution is necessary when relighting a fire after it has been extinguished, to prevent a flare back or gas explosion. Emergency shower heads should be installed as near as possible to such furnaces and should be connected to a water line that is constantly under pressure. Notices should be placed near showers to explain their purpose and operation, and free access to showers maintained at all times.

Lighted paper or waste should be placed in forges before they are lit.

Defective rivets should not be burned out of structures while men are doing work of any kind on the inside.

Open lights of any kind should not be used in boiler drums or other vessels when painting or oiling the inside surfaces. Oiling or painting should always be started at the far end so that as the work progresses the workman will be as near the manhole as possible.

Passageways or gangways should be closed off when it is necessary to throw hot rivets across or through them. When this is impossible, someone should be stationed at the danger point to warn passing workmen.

Oil or acid tanks should be tested with a suitable gas detector for flammable or explosive gases before commencing repairs or doing any welding or hot work upon them.

The grating over water ducts of test pits should always be kept in place and any parts which have become broken should be promptly replaced.

Skylights and windows should be examined at regular intervals and all broken and cracked glass promptly replaced with sound glass, as vibrations from the sharp operations will cause the broken glass to be dislodged with perhaps serious results to a worker.

Steel plates should not be used as a floor covering under doors or other openings where moisture may freeze because of the slipping hazard. If they must be used they should be roughened to prevent slipping.

Rough unfinished lumber should be used for scaffolds around boilers or drums which may be tested or assembled. Smooth finished boards are slippery when they are wet or saturated with oil.

Planks used at the test pits should be rough, and should be provided with toe boards and proper toe holds so that calkers can get a satisfactory footing.

Scaffolds should be at least two 10- or 12-inch planks wide.

Strong horses should always be used for scaffolds. The use of improvised or improper staging such as boxes, blocks, etc., piled together should be avoided.

Planks should not extend beyond the horses or scaffold cross members because workmen may step on the overhanging ends and lose their balance.

Split, warped or knotty planks should not be used for scaffolds.

High scaffold horses should be provided with diagonal bracing to prevent end sway. This applies especially to scaffolds for air tool operators when it is necessary for them to push against the boiler, tank, etc.

The Union Chain & Manufacturing Company, Sandusky, Ohio, has recently appointed C. H. Upson, 1012 Traction Building, Cincinnati, Ohio, representative in that territory.

The Yarnall-Waring 2500-Pound Boiler*

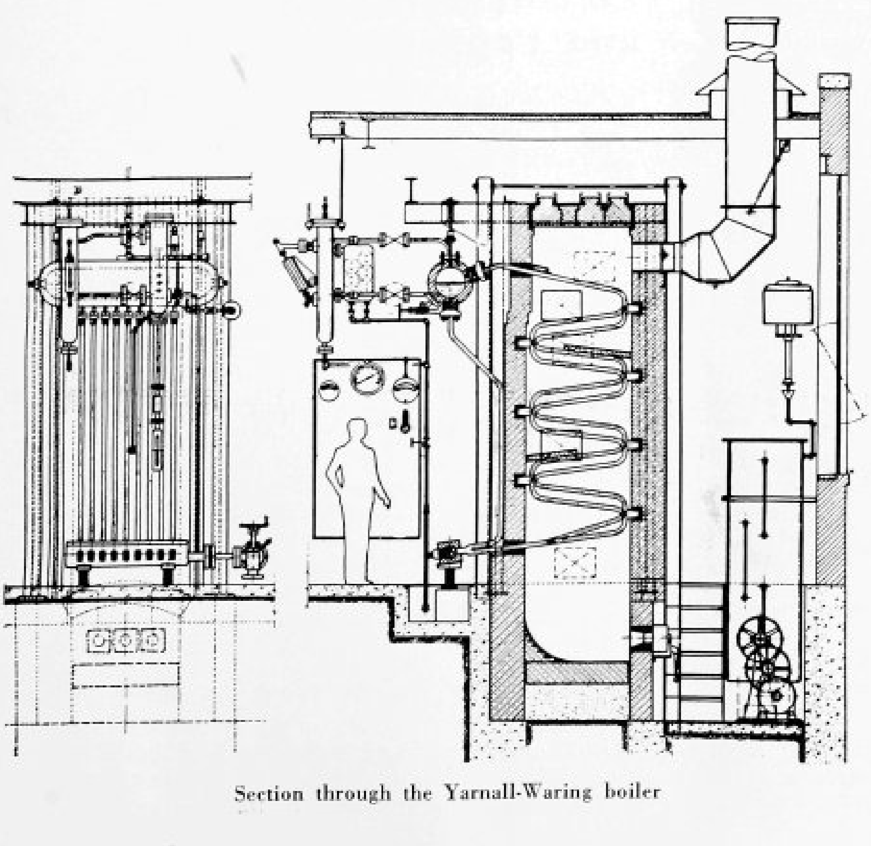
By D. Robert Yarnall

A high-pressure boiler has just been installed and placed in service in the new steam laboratory of the Yarnall-Waring Company, Chestnut Hill, Philadelphia, Pa. With 130 square feet heating surface and 82 feet furnace volume, it has been designed for the purpose of developing apparatus for power and industrial plants. The necessary characteristic which was incorporated in the design was the provision of a controllable water level at the highest pressures and temperatures likely to be met by such apparatus in the large steam-power stations now built and likely to be built in the next few years.

The boiler, built by the Superheater Company, is of unusual design, as will be noticed from Fig. 1, which shows a section through the assembled boiler and its accessories. To the best of knowledge, it is the only boiler built to date for 2500 pounds working steam pressure that depends only on thermal circulation for the protection of the evaporative surfaces. This was chosen as the maximum working pressure because the Yarnall-Waring officials felt that the commercial range for high-pressure plants for the next ten years would probably be below 2500 pounds working pressure. Moreover, the company's particular kinds of apparatus are concerned more with the water end of the boiler than with the steam end, since they are indicating and recording water levels, and hence a boiler that would definitely have a controllable but variable water level would be required for this type of development. It is for this reason that a boiler of the water-line type was decided upon rather than a boiler of the so-called flash design.

The evaporative surface is in the form of an ascending multi-loop construction, the terminals of which are connected to the two drums. This eliminates all contraction and expansion strains at the points where the tubes are connected to the mud drum and the steam drum. The downcomers from the steam drum to the mud drum for feeding this evaporative surface are located out of the gas pass but inside of the setting to insure against any steam generation on the piping, thus eliminating any tendency for change of direction of flow in the evaporative surface.

In the generation of steam at 2500 pounds pressure, the steam bubbles are considerably smaller than at the lower pressures, therefore care must be exercised in the design of the boiler that the metal temperature be kept within a safe operating range, taking into consideration the metal used. This protection is obtained by fabricating the surface above in ascending multi-loop construction. The water is compelled to circulate continuously in the same direction. By so doing those parts of the heating system exposed to the greatest heat always have water present, and not until the gases have cooled down do they come in contact with the tube



Section through the Yarnall-Waring boiler

* Published through the courtesy of Power.

containing the mixture of steam and water. Thus a positive circulation is established.

The evaporative surface is joined to the mud drum by a rolled joint with handhole openings opposite, whereas the surface is joined to the steam drum by a special clamp construction, making a metal-to-metal joint and eliminating the necessity of handhole openings for making that joint. This type of joint was used on the steam drum to cut down the number of joints necessary due to the changes in temperature which may be expected on the steam drum. The steam drum, having an outside length of 5 feet 10 inches, an outside diameter of 18 inches and an inside diameter 12 inches (or 3-inch wall thickness), is made from a solid forging such as is used on most high-pressure boilers. The mud drum is also bored from a solid forging.

To relieve the boiler at 2500 pounds a conventional type of safety valve is used, but for a series of tests at lower pressures extra springs were provided.

A series of different types of forged-steel water columns and high-pressure flat and round glass water gages are provided, as shown. The blow-off valves installed for test purposes are of the forged-steel seatless type, designed for high pressures.

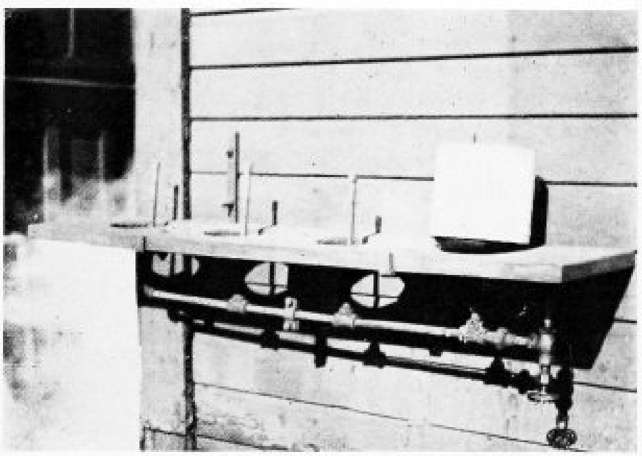
City gas is used for fuel, the rate of combustion being automatically controlled by the steam pressure for the particular test being made at the time.

In view of the small bore of the tubes which form the heating surface of the boiler, elimination of scale is important. For this purpose an evaporator has been provided, the condensate from which is stored in a vertical tank, shown at the left of the illustration.

Sterilizing Water Jugs

A convenient and sanitary arrangement for the sterilization of trainmen's and enginemen's water jugs is shown in the accompanying illustration. A ⅜-inch pipe leading from the radiator line in the supply room to a shelf attached to the outside of the building will furnish sufficient steam to sterilize the jugs.

The capacity of the shelf and the number of exhaust nozzles needed depends on the number of water jugs

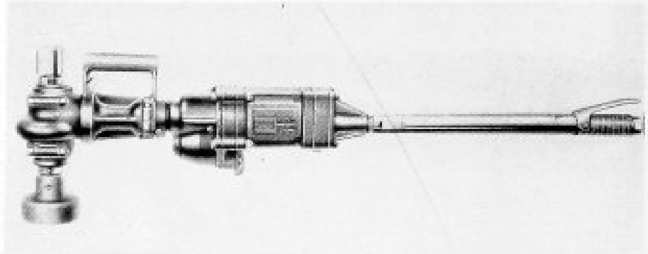


Steam pipes projecting up through the shelf provide a handy method of sterilizing water jugs

handled; however for a terminal despatching from 75 to 100 engine crews daily, the four-connection arrangement as shown is ample.

Rotary-Type Pneumatic Wrench

A new pneumatic wrench of the rotary type, that develops more horsepower at a higher rate of speed, has been designed by the Independent Pneumatic Tool



High-speed rotary-type wrench

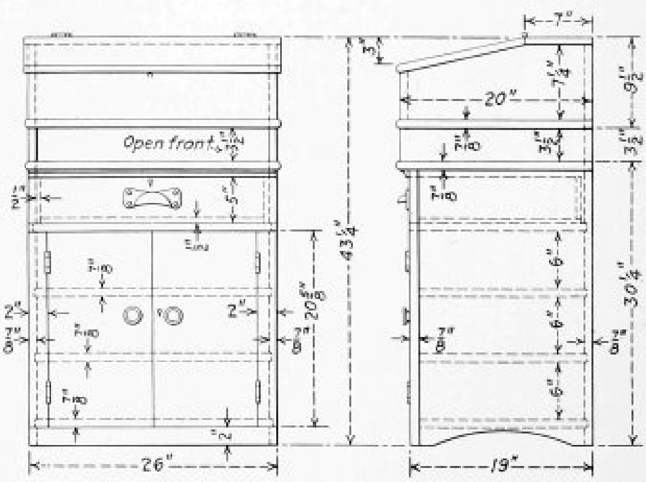
Company, Chicago. Its uses in railroad shops, boiler shops, bridge and tank works, shipyards and machine shops, in putting on and removing a wide range of nuts, are numerous. It will remove 1⅛-inch cylinder head nuts and all flexible staybolt caps.

An auxiliary handle of the swivel type is provided for the operator's assistant where the wrench is to be used in close quarters. Where space is unlimited, instead of the spade handle, the wrench can be equipped with a right-angle head with lug, providing for an extension dead handle in line with the throttle handle.

The Thor 288 wrench is non-reversible and has a speed of 160 revolutions per minute. Length overall is 41½ inches. Weight is 48 pounds. Spindle offset is 2⅛ inches. Length of spindle is 9¾ inches.

Combination Tool Box and Cupboard

The combination tool box and cupboard shown in the drawing is one of the standard facilities used in the back shops and engine terminals of an eastern



A combination tool box and cupboard for machine operators

railroad. It is made of poplar and is 43¼ inches high by 26 inches wide. A depth of 19 inches affords commodious shelf and cupboard room.

Development of the Oxy-Acetylene Fusion Welding Process ▲ ▲ ▲ ▲

By Frank C. Hasse*

Continuing this account of the application of oxy-acetylene welding, which was originally prepared for the proceedings of the Master Boiler Makers' Association, and which was commenced in the November issue, the author emphasizes the important bearing that the use of proper welding equipment in the hands of trained experienced men has had in obtaining satisfactory welded structures. In their use by the railroads the processes of gas welding and gas cutting have become extremely important tools. The many changes in locomotive design have developed uses for the cutting torch which make it invaluable in every shop. Special attention to this phase of oxy-acetylene appliance development is given. For repair and maintenance of locomotive boilers the oxy-acetylene welding process as well as that of arc welding have become indispensable to the industry.

Oxy-acetylene welding is truly an art. It is very deceptive to the observer, in that it appears to be easy of application resulting in many most discouraging experiences to the beginner.

Successful operators must have a mechanical bent, possess a certain amount of dexterity, conception and susceptibility to instructions and their subsequent use. The development of these qualifications makes for proper welding.

Proper welding equipment and welding materials by carefully trained and experienced operators, under the direction of interested supervision, will assure reliable results produced in a uniform way and with less variation in quality than is usually found in other methods of construction.

The introduction of gas welding and cutting into the railroad industry prompted much just and honest criticism, which objections have been largely overcome; the developing and perfecting of the process has been rapid. We say, "just and honest criticism and objections" because these objections were based on theoretical knowledge which we were at that time acquainted with and which knowledge condemned a great many things in connection with autogenous welding and cutting of metals. Even the promoters of welding and cutting for this same reason hesitated to develop some of the operations which are now standard practices in all industries.

The greatest mistake we made at that time was that we, so to speak, unconsciously accepted theory as final. We perhaps forgot that while theory is built on a foundation of basic factors or principles, which cannot be dispensed with, it is, nevertheless built on this foundation by research and can only be a fact insofar as the research has been carried out; therefore, theory is an unfinished structure on this foundation and must be constantly added to if our development is to continue. The promoters of acetylene welding and cutting realized that to the men theoretical knowledge did not furnish remedies for some of the faults existing in welding and cutting and saw the necessity for further extensive research. This brought out remedies and information which have largely overcome former objections to acetylene welding and cutting.

To deal with acetylene welding and cutting in the railroad industry we will subdivide these into three separate subjects; namely, gas welding, gas brazing and gas cutting.

The gas process for welding and cutting metals has become a very important, if not the most important, major operation on the railroads today. Perhaps it is not the very substantial saving in money and material effected by gas welding that is of the greatest importance but rather the saving of time and labor. When we think of the time, in the days before gas welding, that was consumed to take down a locomotive frame for repairs or renewal, to take off and replace a broken cast cylinder, deck castings, worn or broken pads and braces, sharp flanges on both tired and steel wheels and various other operations that are today successfully being repaired by gas welding without removing these parts from the engine, we get a very good conception of the time saved in the railroad shops of today.

In addition to this great time saving, is the added life and efficiency from such operations, as all steam and water pipe welding,, firebox welding, both new and repairs, such as new side sheets, half side sheets, new flue sheets, flue-sheet patches bottom and top, and enlarged or cracked staybolt and stud holes, mudring corners, worn spring saddles, spring hangers, air-pump parts, air-brake parts and rigging, tender repairs, truck and draft gear repairs; in fact, all repairs which were taken care of by other methods before the introduction of gas welding.

In the car departments of the railroads gas welding is just as important as in the locomotive department even though the car department does not have as many major operations; yet the saving in both time and money is just as important. Many different repairs can be made with the welding torch and are permissible, on loaded cars which in the days before gas welding had to be unloaded before repairs could be made. It is not, however, only in the repairs that gas welding has been adopted in the car department on the railroads but the construction of new cars and parts by welding is fast coming into prominence. Without fear of contradiction it can be said that on some roads the car departments have cut their purchase of new parts in half since welding was introduced.

Uses of the process continue to grow. Pipe lines are installed by welding, often using discarded pipe that would be considered unfit for use if it had to be threaded for screw connections. Thus, scrap pipe is made to

* General manager, the Oxweld Railroad Service Company, Secretary Boiler Makers Supply Men's Association.

serve in place of new pipe and the cost of fittings is saved. Discarded locomotive flues also are used for pipe lines of secondary nature, and these, of course, are available for the purpose only when welded.

Welding of air brake piping is recognized as good practice as it reduces compressed air losses through elimination of screwed joints and sharp bends.

Change in design necessitated by the addition of accessories such as feed-water heaters, steam-cylinder lubricators, flange oilers, boosters and similar devices, makes necessary the redesign of certain parts such as smoke boxes, boiler pads, brackets, cross frame braces and assemblies. Many of these can be fabricated at a cost less than that of castings or forgings.

Staybolt and rivet cutting have been speeded up greatly by new tips oxidizing or burning the entire rivet head or staybolt through the sheet. Technique of operation is simplified with these tips, practically the same being employed on staybolts, buttonhead and countersunk rivets.

The attitude of the Bureau of Locomotive Inspection, Interstate Commerce Commission, although conservative, is becoming more liberal as more welders become proficient in the art. Interpretations of the rules no longer are literal as a rule; they are tempered more and more with judicial intelligence and recognition of very real progress made.

The track and signal departments also come in for their savings, in time, material and labor since welding has been introduced to them. The greatest saving of all to the railroad in these departments is the building up by gas welding of worn or battered rail ends, crossings, frogs, switch points, switch stands, connection rods and tie bars.

It is not alone in the repair of locomotives, cars, coaches and track department repairs that the gas welding process is used on the railroad, but it has been found just as indispensable in the repair and construction of machinery and all shop equipment and in the installation of all plant water and steam pipe construction. It is also valuable in construction work where iron and steel are used. Some railroads have constructed large shop additions wherein gas welding was used exclusively in place of riveting or bolting. Men who are familiar with the wide field of gas welding operations in the railroad industry know that this fine, scientific process is indispensable—perhaps more so than any other mechanical operation.

Brazing and aluminum welding with the oxy-acetylene blowpipe date back to the early days of the process. However, in the early days it is doubtful if anyone ever visualized to what extent the brazing of iron and steel with bronze would be developed.

At first this method of brazing or bronze welding was only used on operations that had been brazed by other methods, previously. It was not thought that a braze made with bronze or other brazing agents was strong enough for the repair of heavy broken steel parts or castings. It was also known that the brazing metals then used carried properties in their structure that caused physical injury in iron and steel if applied at certain temperatures. However, as time showed the advantages of brazing in place of welding in a great many operations, the need for a stronger brazing agent and one that would not be injurious to iron and steel became apparent and some of the promoters of the oxy-acetylene welding process as well as the makers of welding rods started extensive research in order to develop such a bronze for brazing. Their success in this research was such that today the brazing operations in the railroad shops are almost, if not quite, as complete as the welding work done by the various railroads.

After the proper brazing metal had been developed, the railroads began to use brazing on all parts where severe wear took place from abrasion, building up such parts as worn locomotive cylinder pistons, valve pistons, air-brake cylinder pistons, air-brake valves and valve seats, renewing injector and lubricator bodies and parts, brazing copper, iron and steel pipe, welding up the shoe and wedge wear on frame pedestals, the spring saddle and spring equalizer wear on frame top members; in fact, using brazing largely for welding on iron and steel where only steel or iron welding had been previously attempted. It was gradually realized that, as soon as a bronze had been developed which was not injurious to the iron or steel and which was high enough in tensile strength, the brazing would be very desirable for the repairing of heavy steel, iron and cast iron parts due to the fact that it could be applied with much less heat than that which was necessary for welding. Therefore, welding was not only made quicker but in a great many cases a large amount of time was saved in preparation such as building up preheating furnaces around the work and devising other means for getting the necessary expansion for welding.

While brazing on steel does not make as strong a job as welding, yet it is strong enough in a great many cases to permit this process being used on large repair jobs with a sufficient factor of reserve strength. In the repair of cast iron and many other cast metals, the brazed joint is as strong as the parent metal. With these known facts, it is obvious that brazing in the railroad shops is a greater time and labor saver than welding. This is especially so in the repair of locomotive cylinders for which repair brazing has almost become a standard operation on all roads.

Gas brazing is also used in the pipe shops taking the place of the old fire brazing, with the result that stronger, more consistent and more reliable jobs are done. It is also used in a great many shops in the sheet metal department for brazing tanks, cans, and various utensils made of galvanized or plain steel sheets where soldering and riveting had been standard practices until gas brazing was introduced; so we are justified in saying that today gas brazing in the railroad shops is as indispensable as the welding.

The cutting of iron and steel with the oxy-acetylene torch was perhaps the first operation to receive favorable notice from mechanical engineers in the railroad and other industries. In the early days of the development of welding and cutting, the cutting torch was used extensively while the welding torch was only used occasionally and in some cases not at all, and today while welding has developed to a point of efficiency and standardization where it is indispensable to the railroads yet the cutting of iron and steel is just as important and perhaps more so. The scope of operations covered by the gas cutting blowpipe in its field of work is almost beyond conception even by those who have followed its development.

In the early days of gas cutting, operations were all performed by hand and all parts in process of construction had to be machined after cutting because the hand cutting was rough. However, a great saving in time, labor and money was effected by using a cutting blowpipe for cutting to rough shape numerous parts that were made in every day repair work in the railroad industries. As the cutting was being developed, constant research was being carried on by some of the promoters of gas welding and cutting and remedies were constantly being discovered for the faults that were found to exist when cutting high-carbon steels.

This research developed remedies for these faults to the point where it was positively known that all parts made from practically all steels regardless of physical or chemical properties could be shaped with the cutting torch with as little or perhaps less injury than was possible to shape them by any other known method. This led to a desire for mechanical operation of a cutting torch so that the cutting surface would be smooth, it being realized by this time that a large number of parts could be fabricated by such a machine-operated torch and would not have to be machined afterwards, thereby saving a part and sometimes all of the blacksmith's work and all of the machining work.

Such machines have been successfully developed in our industry and today are used extensively in all the railroad industries. Nearly all parts made from steel and iron for new and repair work today are shaped by these mechanically operated cutting blowpipes at a saving in time, labor and money far beyond the visions and expectations of the promoters. In some instances where the cutting machine is extensively used, the savings effected in the blacksmiths' and machinists' time have made it possible to almost double the production in these two departments. A large number of parts are cut on these machines to finished size while other parts are cut to leave a small amount of stock for machining afterwards. However, while the machine cutting has to a large extent supplanted the hand cutting torch for shaping new parts made from steel and iron, yet the hand cutting torch still has a large field. It is being used extensively for scrapping or dismantling work when engines or cars are dismantled either for repairs or to be scrapped, cutting off and burning out bolts, studs, rivets, pipe, cutting off the ends of new staybolts, cutting out staybolts, cutting out side sheets, flue sheets, back sheets, removing a complete firebox; in fact, all the cutting that is to be done when repairs are being made to a locomotive, cars and coaches, cutting to stock or changing box size, locomotives, tenders, cars, rails—in short the scrapping of all materials used in all departments of the railroad industry.

The cutting torch also comes into its share of work in construction and in the signal and track departments. In these departments it is used for cutting rails to lengths, removing nuts from angle bar bolts, cutting new parts and frogs and crossings; in fact, it is used in all operations where it is desirable to cut a piece of steel or iron for use or for scrapping.

The bridge and building departments also have extensive use for the cutting torch in cutting down old structures and salvaging and scrapping the materials from these structures. They also use the cutting torch for construction work cutting the various parts to size, shape and length and also piercing holes in place of drilling them. The cutting torch has also proven its indispensability in the wrecking department, making it possible to clear away the obstructions caused by wrecks in a few minutes or hours that would in some cases have taken days.

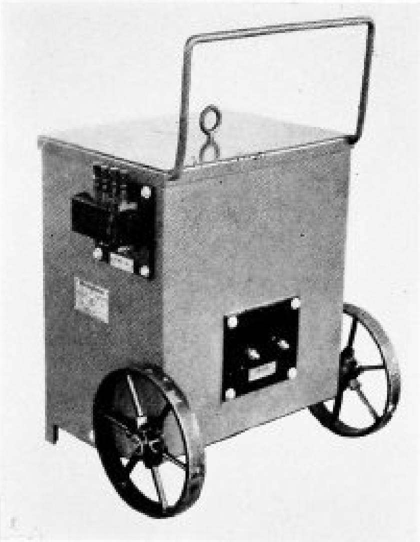
This paper would not be complete if it did not make special mention of the use of the cutting blowpipe for cutting off rivets and bolts from steel and wooden cars, bridges, and other construction work being dismantled either for scrapping or repairs. Devices have been designed by some manufacturers of cutting and welding equipment and supplies which make it possible for ordinary operators to completely remove the heads from four to five hundred rivets per hour.

In conclusion, like gas welding and brazing, gas cutting has become indispensable in the railroad industry today.

Westinghouse Flex-Arc Welder

An alternating-current arc welding set designed for operation at between 8.5 amperes and 125 amperes has recently been developed by the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa. This welder meets a demand for the economical arc welding of thin gage material.

The Flex-Arc alternating-current welder may be used in conjunction with either bare or coated electrodes from 1/32 inch to ⅛ inch diameter. Many of the ferrous-alloy materials commonly used with reversed polarity direct current are effectively and easily applied in conjunction with this welder. It has also proved successful in the welding of aluminum.



Westinghouse portable welding outfit

The entire equipment consisting of a special self-cooled transformer, short-wave arc-control system and current regulating details are substantially mounted in a compact welded steel case. With this welder, a special high-frequency arc stabilizing circuit developed by Westinghouse eliminates the usual high open-circuit secondary voltage. The maximum open circuit voltage at the work is only 73 volts, thereby assuring safety to the operator at all times. The short-wave arc-control system eliminates the interference to radio reception usually caused by an alternating-current welder. High operating economy is made possible by a high average power factor and extremely low no-load power requirements. Low maintenance is secured by having no moving parts and a totally enclosed construction. It is light in weight, compact and readily portable.

The Wickes Boiler Company, Saginaw, Mich., announces the installation of a most modern X-ray machine and complete laboratory facilities, which provide the Wickes shops with the necessary equipment to fabricate welded pressure vessels and power boiler drums strictly in accordance with the A.S.M.E. Fusion Welding Codes.

The Lincoln Electric Company, Cleveland, Ohio, manufacturers of Linc-weld motors and Stable-Arc welders, announces the change of the New York office from 136 Liberty Street to the new McGraw-Hill Building at 330 West 42nd Street. The new offices include a showroom of equipment and facilities for the demonstration of motors, welders, new electrodes and innovations in welding technique. G. N. Bull continues as district manager in New York.

The Use of High-Speed Steel for Staybolt Spindle and Boiler Taps*

In compiling a report on this subject, the committee formulated a questionnaire of 17 items pertaining to uses, practices and opinions on performance of high-speed taps in comparison with carbon and special-steel taps, which have been in general use for past years. These questionnaires were mailed to 80 leading master boiler makers throughout the United States and Canada. Less than half of these responded to our appeal. However, we received answers from about 24 or 25 and from these answers and our personal knowledge we submit the following for consideration:

From answers received only four of these have adopted high-speed staybolt taps as standard, also, four have adopted the boiler taps as standard. Eighteen reported as using both carbon and high-speed, 12 reported having made tests on high-speed steel taps, five of these report favorably on high-speed taps, while the balance, seven, report excessive breakage and cost. The question was asked as to the number of holes actually tapped with one tap (high-speed) on a new firebox, before scrapping of the tap. One man who has had wide experience on new firebox work, reported tapping as high as 12,000 holes for flexible staybolts and 8000 for rigid staybolts. This surely is a timely boost for the high-speed tap. Others report from 3500 to 7000 holes on new work. One prominent master boiler maker reports tapping 140 holes in nickel steel with one tap. In comparison with the carbon tap the above is excellent for the high-speed tap.

For comparison the question was asked as to performance on similar work using carbon taps. From 300 to 2500 holes were reported on carbon taps. The best performance on carbon taps was 1000 holes short of the poorest reported on high-speed taps. Due to so few using high-speed taps it is difficult to estimate the cost reduction by adoption of high-speed taps. However, we asked this question and received only 15 answers. Eight were favorable to high-speed and seven were against. On boiler taps the percentage was higher on account of boiler taps of high-speed steel being in more general use.

On the question of full taps or the end welded on, this was about evenly divided. Some favor buying or making the full length, while others advocate welding on each end; quite a number screw on pilots using a pipe thread; some few shrink them on.

Several members had used high-speed steel staybolt taps but discontinued on account of excessive breakage and reverted to carbon taps.

The Baldwin Locomotive Works has adopted as a standard, not only the high-speed tap but a high-speed tap with ground threads which gives a tap which is accurate within 0.0001 on pitch diameter. The form is also extremely accurate.

After a thorough trial of this type of tap the company is firmly convinced of its economic value. Where formerly only 150 to 600 holes per tap were obtained with the average carbon tap, they now have taps which have tapped over 7000 holes and are still good for use.

This company states it would be almost impossible to figure the exact money value of this tap, as it saves in many directions and gives to the user a first-class job in every particular, because of the close fit of bolts in holes.

You can set your staybolt machine to a given size and cut your bolts with perfect assurance; you will not find a lot of bolts which cannot be used on account of variation in size of tapped holes, which was the case when the carbon tap was used. There is a very large saving in this factor on scrap material.

It must, however, be understood in order to get this ideal condition you must also have machines which cut the bolts as perfectly as the hole is tapped by the use of the ground thread high-speed tap.

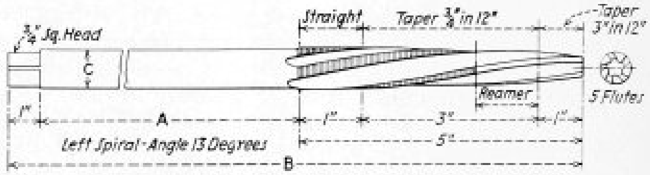


Fig. 1.—High-speed flexible staybolt tap

United States Form Threads

Line No.	Size of Tap (Inches)	Minimum Pitch Dia. (Inches)	Maximum Pitch Dia. (Inches)	Threads per Inch	A (Inches)	B (Inches)	C (Inches)
1	1	.9458	0.9488	12	12	18	7/8
2	1	.9458	0.9488	12	22	28	7/8
3	1 1/16	1.0084	1.0114	12	12	18	15/16
4	1 1/16	1.0084	1.0114	12	22	28	15/16
5	1 1/8	1.0709	1.0739	12	12	18	1
6	1 1/8	1.0709	1.0739	12	22	28	1
7	1 3/16	1.1334	1.1364	12	12	18	1 1/16
8	1 3/16	1.1334	1.1364	12	22	28	1 1/16
9	1 1/4	1.1959	1.1989	12	12	18	1 1/8
10	1 1/4	1.1959	1.1989	12	22	28	1 1/8

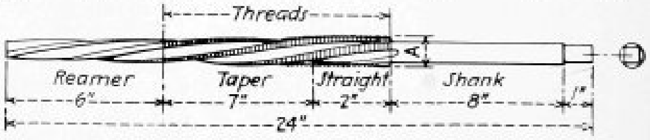


Fig. 2.—Carbon tap for general work

Tap Size (Inches)					
A	31/32	1	1 1/16	1 1/8	1 3/16

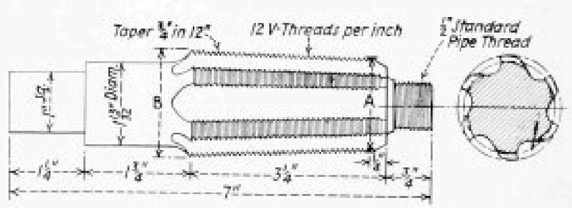


Fig. 3.—Flexible sleeve tap of high-speed steel

A (Inches)	B (Inches)
1 5/8	1 13/32
1 3/4	1 19/32
2 1/8	2 1/16

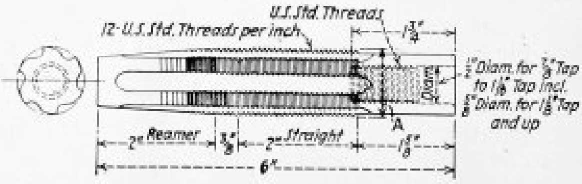


Fig. 4.—High-speed tap designed for threaded drive shank

Tap Size (Inches)											
A	7/8	15/16	1	1 1/16	1 1/8	1 3/16	1 1/4	1 5/16	1 3/8	1 7/16	1 1/2

* Report prepared for the 1931 proceedings of the Master Boiler Makers' Association.

When the first cost of tap is mentioned the one who has not had experience with the great saving made can hardly appreciate the economical value of making a first investment when the difference is so great as is the case between carbon taps and the high-speed ground taps.

High-speed taps have been used such a short time that it is very difficult to give a definite report and one which would be a decided factor to anyone who is looking forward to making a change. The same was very true when high speed drills and reamers were being introduced. How many of us today would care to go back to drilling with carbon drills and reaming holes in all classes of work, including mud ring, heavy boiler, tank and structural work with carbon reamers? In summing up on this important subject, the committee would like to advance the idea, which we think has been proven, that it is possible to tap staybolt, radials, and half radials and other boiler tapping, economically with high-speed taps, by giving these tools the careful consideration due them on account of their non-flexibility. These tools must be handled carefully at all times and kept from contacting other tools.

Fig. 1 represents one type of high speed flexible staybolt tap used on one of our leading railroads.

With it are given a table of United States form standard threads, including the size of tap, minimum pitch diameter, maximum pitch diameter, number of threads per inch, length of shank for each size, overall length, and diameter of shank. Fig. 2 shows a typical carbon tap as generally used. Fig. 3 illustrates a type of flexible sheeve tap now made of high-speed steel, while Fig. 4 is also a high-speed tap designed for threaded drive shank.

It is the opinion of the committee that high speed steel for staybolt and boiler taps is a step forward and like all other new things must be given a fair trial before a final decision is made. We believe that inasmuch as some enterprising master boiler makers and locomotive works have proven that it is possible and feasible economically to tap holes with high-speed steel taps they should be given careful consideration for adoption.

The foregoing report was prepared by a committee composed of W. H. Moore, chairman, L. C. Ruber and Harry Bell.

Development of the Frustum of a Cone With Apex Remote

By I. J. Haddon

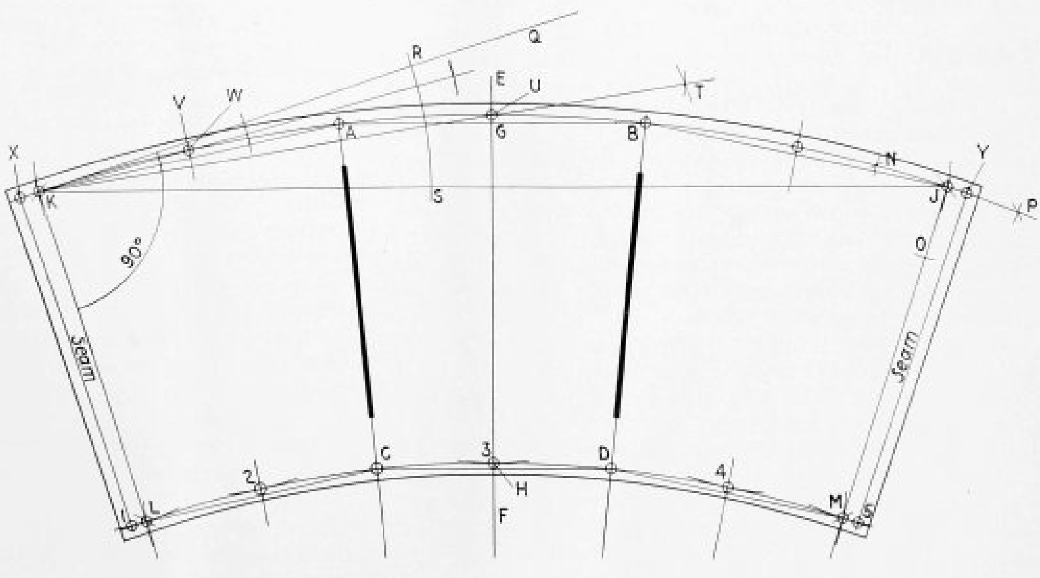
There are a number of different methods of solving the problem of developing the frustum of a cone with the apex unattainable, but I think, for simplicity, and perfect accuracy the one described here is the best, and may be used irrespective of how slight the taper of the cone may be.

Let *A-B-C-D* represent the frustum of the cone when completed. The lines *A-C*, *B-D* represent the center of thickness of the metal.

Draw the lines *A-B* and *E-F* at right angles to each other, intersecting at *G*. With *G* as a center and a radius equal to the radius of the large end of the frustum, cut the line *A-B* in *A* and *B*, as shown. Draw the line *C-H-D* parallel to *A-B* and equal to the depth of the frustum. Make *H-D* and *H-C* each equal to the radius of the small end. Join *A-C* and *B-D*.

From *D* and *C* as centers and with radius *D-A* or *C-B* describe arcs *J* and *K*. Then with the same radius from *A* and *B* as centers describe the arcs *L* and *M*. Now from *A* and *B* as centers and radius *A-B* cut the arcs *K* and *J* in *K* and *J*, as shown. Now from *C* and *D* as centers and radius *C-D* cut the arcs *L* and *M* in *L*

Details of a simple and accurate method of developing the frustum of a cone when the apex is unattainable



and *M*. Join *K-L* and *J-M*. The true arcs of the frustum will pass through the points *K*, *A*, *B*, *J* and *L*, *C*, *D*, *M*, but neither of these arcs is long enough and therefore must be further produced later on.

Any number of points may be obtained that will lie upon the curve by using the following method: Draw the line *K-J*. Now place one leg of your square to the line *K-L*, the other leg is represented by the line *K-Q*. Now bisect the angle *Q-K-J*, as shown by arcs *R-S-T*, thus obtaining the point *U* on the line that bisects the line *K-J*. Join *K-A* also *B-J*. Now if *K-A* be bisected by the line *V*, as shown, and the angle *Q-K-A* be bisected as shown, the bisecting line will pass through the line *V* at *W*, and *W* will be another point on the required curve. Now suppose another point was required on the curve, say between *K* and *W*; then you would join *K-W*, bisect it and raise a short perpendicular to it; then bisect the angle *Q-K-W*. This bisection would cut the short perpendicular raised exactly on the desired curve.

The one leg of the square may be placed on *A-C* or *B-D* or any line that if produced would terminate at the apex of the cone. A curve may now be drawn through the points *K*, *W*, *A*, *U*, *B*, *J*.

To produce this curve as *X* and *Y*: With *J* as a center and any radius draw arcs *P-O-N*. Now from *O* as a center and radius *O-N* cut the arc *P* in *P*. The curve may now be extended to *P*. Obtain the point *X* in a similar manner.

Measure along the curve from *U* half the circumference, thus cutting off *U-P* in the point *Y*. Make *K-X* equal to *J-Y*. Now from any number of points on the curve *X-U-Y* and with radius *A-C* draw short arcs as shown in *1-2-3-4-5*. Then draw the curve through *1-L-2-C-3-D-4-M-5*, as shown. Measure along the curve from *3* to *5* and *3* to *1* each, half of the circumference of the frustum at that end. Join *X-1* and *Y-5*. These lines would represent the center of the holes on the seam.

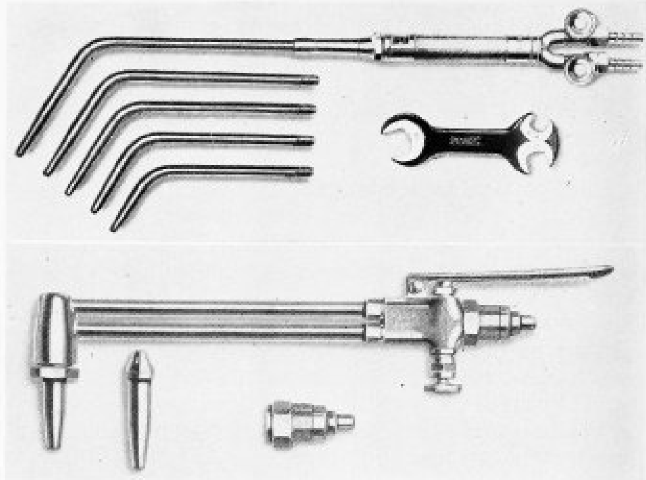
The curved lines should also represent the center of the holes for the top and bottom of the frustum, allow on the necessary lap.

Note: Lines *K-L*, *V-2*, *A-C*, *G-3*, etc., are rolling lines.

Welding Torch

The Linde Air Products Company, 30 East 42nd Street, New York, has recently made two new additions to its line of Purox medium-pressure apparatus for oxy-acetylene welding and cutting. The new Purox No. 11 welding torch, which supersedes the Purox No. 10 torch, has a very wide welding range extending from the lightest sheet metal up to work as heavy as ½-inch plate. In spite of this wide range the torch is very light in weight and has perfect balance. The tips are of one-piece, hard-drawn copper construction and are so designed that the head angle can be easily adjusted as desired by the user. Tips Nos. 2, 4, 6, 8, and 10 are furnished as standard equipment.

The Purox No. 21 cutting attachment designed for use with the Purox No. 11 welding torch will cut metal up to 2 inches in thickness. It is furnished with one- and two-piece Purox cutting tips. By means of this cutting attachment the welding torch can be easily and quickly converted into a cutting torch. This is the lightest cutting attachment on the market, weighing only 1 pound 8 ounces. An adapter is also available which makes it possible to use the Purox No. 21 cutting attachment with the Purox No. 20 welding torch.



Above—Purox No. 11 welding torch as supplied with five tips and wrench. Below—Purox No. 21 cutting attachment with two cutting tips and adapter

High-Pressure Watertube Locomotive

(Continued from page 319)

The locomotive has hauled trains of over 500 tons weight for long distances at express speeds with consistent success and reliability, and there is every indication that it will prove more economical in fuel consumption than express locomotives of the latest normal types. It has been ascertained that the cost of a watertube boiler similar to that completed on engine No. 10,000 is not appreciably greater than that of the ordinary wide-firebox type as fitted on Pacific-type engines. The most expensive components of the watertube boiler are the solid-forged steam and water drums. These are not subjected to the action of the fire and consequently may be expected to have a long life. On the wide-firebox type of the ordinary boiler the copper firebox is the most costly section and it is well known that its life is short and its renewal an expensive item. Again, in the ordinary type of locomotive, the boiler tubes and firebox sides are sources of trouble involving costly maintenance and occasional failures. In the design of the boiler under consideration there are no sides, the tubes are more effectively secured and are not subjected to variation in temperature and stress at the points where they enter the drums.

Mr. Gresley claims that with the moderately high pressure and simple design which he has adopted, economy both in fuel and maintenance costs will be secured, and that at the same time reliability will be fully maintained.

Nickel-Steel Specifications.—The International Nickel Company, 67 Wall Street, New York, has issued Nos. 1 to 8 of its Recommended Specifications for Nickel Alloy Steel in railroad applications. These cover forging billets, normalized and tempered low-carbon forgings, boiler and firebox plates and the like.

The Boiler Maker

VOLUME XXXI NUMBER 12

PUBLISHED Monthly by the Simmons-Boardman Publishing Company, 34 North Crystal Street, East Stroudsburg, Pa., with Executive Offices at 30 Church Street, New York City.

Samuel O. Dunn, Chairman of Board. Henry Lee, President. C. R. Mills, Vice-President. L. B. Sherman, Vice-President. Roy V. Wright, Vice-President and Secretary. F. H. Thompson, Vice-President. E. T. Howson, Vice-President. F. C. Koch, Vice-President. John T. DeMott, Treasurer. George Slate, Vice-President and Business Manager.

Chicago: 105 W. Adams Street. Washington, D. C.: 17th and H Streets, N. W. Cleveland: Terminal Tower. San Francisco, Cal.: 215 Market Street.

Subscription Price: United States and Mexico, $2.00, Canada, $3.50, including duty. Foreign Countries, $3.00 a year. Single Copies, 35 Cents.

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THE BOILER MAKER is a member of the Associated Business Papers, Inc. (A. B. P.), and the Audit Bureau of Circulations, (A. B. C.)

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Contents

Communications

Method of Removing Boiler Studs

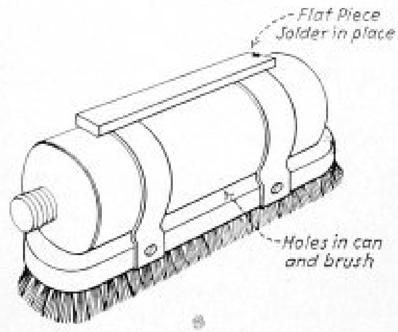
TO THE EDITOR:

Removing broken or leaking boiler studs is considered a disagreeable job. It is seldom possible to unscrew a broken-off boiler stud, even by the use of an "easy out," after a hole has been drilled in it. If the shell of the broken stud is chipped out, the threads will be damaged and it may be a several hours' job to tap the hole, especially if the boiler sheet is reinforced and is 1 inch or more thick. A tapered boiler tap cuts very slowly in a deep hole. To overcome the difficulties of tapping, the oxy-acetylene torch has been used to heat the shell of the stud after drilling a hole in it. If heated red hot and allowed to cool, the shell of the broken off stud may be easily unscrewed with the square drift of an easy-out. If carefully handled the use of the torch does not seem to injure the surrounding metal. If the shell of the stud is unscrewed in this manner, the operation of tapping consists in little more than cleaning out the threads.

Stock Oiling Made Simple

TO THE EDITOR:

The use of such a simple little device is shown in the illustration, made from a screw top can and a shoe brush has made the work of oiling strip and plate stock



Device for oiling plate stock

for punching at the press an easy task. It distributes the oil where needed on the stock to be punched.

It is made by piercing a few small holes in the can and drilling to match them in the wooden back of the brush. The can is then secured to the brush. When the device is not in use it is rested upside down on the flat piece to prevent waste of the oil.

Penacook, N. H. CHARLES H. WILLEY.

Hand Drilling A Large Hole

TO THE EDITOR:

Drilling a ¾-inch hole 2 inches deep with a carpenter's bit-brace is not a profitable or very pleasant way of making such a hole, but it can be done, as one boiler maker found, somewhat to his surprise. He was out on a repair job and found it necessary to drill such a hole, but had overlooked bringing a ratchet drill-stock and the "old man" with him. No such tools were available in the little village where the repair work chanced to be located.

The village carpenter, however, came to the rescue and started the hole, worked it down ½-inch, then turned the tools over to the boiler maker with instructions to "Go to it"! The carpenter produced a large brace with 6-inch throw, a ⅜-inch bit-stock drill, another drill ¾-inch in diameter and a center-punch.

The punch was driven into the metal to be drilled as far as it would go under lusty hammer blows. Then the ⅜-inch drill was placed in the brace and the hole pushed down easily to the bottom of the center-punch mark. Then, the punch was used again and driven as deeply as possible, and the small drill again brought into action. These operations were repeated as long as the center-punch would go into the drilled hole, and then, the ¾-inch drill was placed in the brace and

(Continued on page 340)

Questions and Answers Pertaining to Boilers

This department is maintained for the purpose of helping those who desire assistance on practical boiler shop problems. Inquiries should bear the name and address of the writer. Anonymous communications will not be considered. The identity of the writer, however, will not be disclosed unless the editor is given special permission to do so.

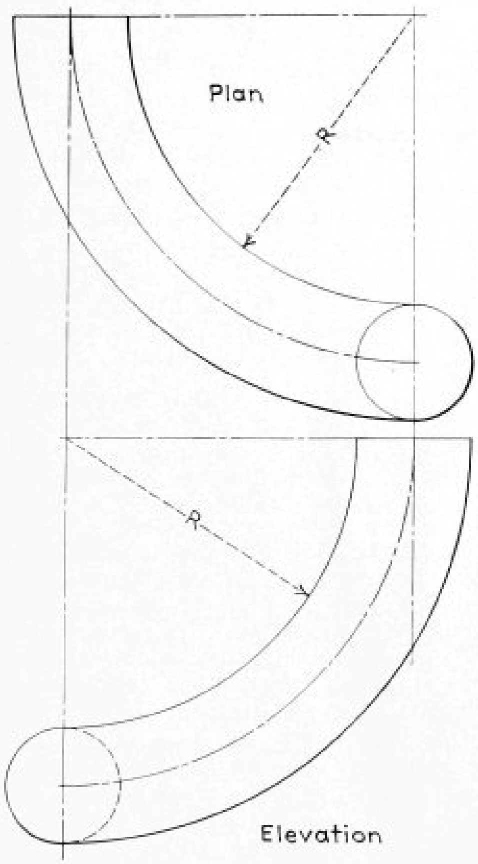
By George M. Davies

Compound Elbow Layout

Q.—Please describe the proper method for developing the pattern for a compound elbow of the cylinder type, sketch attached. F. F.

A.—A development of the elbow, as shown on the sketch submitted, with the question, so that a series of duplicate patterns turned a given number of degrees on the miter line between each connection or joint does not seem practical on account of the fact that after dividing the elbow into a series of equal sections, the rise of each section, on account of the double radii, is not uniform.

A comparison would be to consider the elbow as a quarter turn of a spiral or helical pipe. In this case the rise of each section is uniform and a development of one section is all that would be necessary, each section being a duplicate of the section developed.



Plan and elevation of compound elbow

This method applied to the compound elbow shown in the sketch would eliminate the curve, as shown in the elevation.

If any of our readers can suggest a method to lay out the elbow as described, the solution will be accepted for publication and will be paid for at regular rates.

Specifications for Refinery Seal Tank

Q.—I am a subscriber to The Boiler Maker and I take the liberty of asking you for information regarding the construction of a tank, unfired, 48 inches in diameter, 10 feet long; to hold 250 pounds working pressure. J. M.

A.—A horizontal tank as outlined in the question should be fabricated by means of welding, unless otherwise specified, and built in accordance with the A.S.M.E. Code for Unfired Pressure Vessels.

The tank would come under either of two classifications:

Class 1—All vessels covered by this Code, constructed in accordance with the rules herein given, may be used for any purpose.

The joint efficiency for this class, to be used in computing the maximum allowable working pressure of the shell shall be taken as 90 percent.

The welding for this class shall meet the test requirements for Class 1 Vessels.

Class 2—All vessels covered by this Code may be included in this class, excepting those containing lethal gases or lethal liquids and, or those containing liquids operating at a temperature of 300 degrees F. or above. The maximum pressure at which any vessel in this class may be operated is 400 pounds per square inch and, or the maximum temperature is 700 degrees F. and the plate thickness as required by the permissible stress allowance shall not exceed 1½ inches. This pressure limitation does not apply to vessels operated under hydraulic pressure at atmospheric temperature.

The joint efficiency for this class, to be used in computing the maximum allowable working pressure of the shell; shall be taken as 80 percent.

The welding for this class shall meet the test requirements for Class 2 Vessels.

The tank outlined in the question would come under the Class 2 requirements and the tank shown in the illustration is designed on this basis:

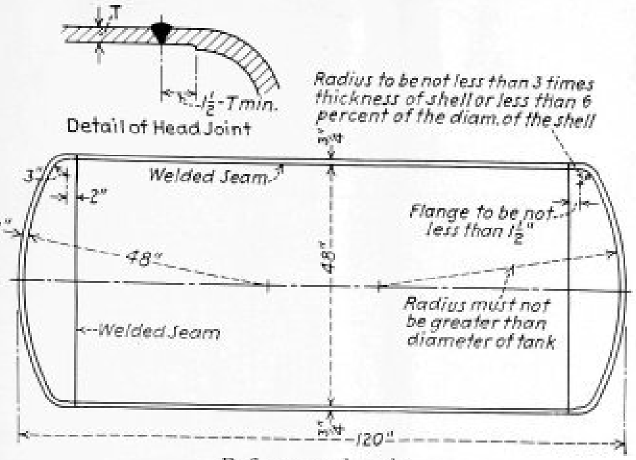
Shell.—Material to be of steel boiler plate and shall conform to Specification S-1 for Steel Boiler Plate, A.S.M.E. Code, Section II, 1930.

Thickness:

$$t = \frac{WP \times R}{S \times E}$$

where

t = Minimum thickness of shell plate in weakest course



Refinery seal tank

WP = maximum allowable working pressure, pounds per square inch

S = maximum allowable working stress in pounds per square inch

E = efficiency of longitudinal joint or of ligaments between openings

R = inside radius of the weakest course of the shell, inches, provided the thickness of the shell does not exceed 10 percent of the radius. If the thickness is over 10 percent of the radius, the outer radius shall be used.

$$t = \frac{250 \times 24}{10{,}000 \times 0.80} = \frac{6000}{8000}$$

$t = 0.75 = \frac{3}{4}$-inch plate

The tensile strength is assumed as 10,000 pounds per square inch; the actual tensile strength of the plate used should be checked.

Welding.—Longitudinal joints shall be of the double-welded butt type and shall be reinforced at the center of the weld on each side of the plate by at least ⅛ inch. The reinforcement may be removed, but if not removed shall be built up uniformly from the surface of the plate to a maximum at the center of the weld. Particular attention is called, however, to the importance of the provision that there shall be no valley or groove along the edge of or in the center of the weld, but that the deposited metal must be fused smoothly and uniformly, into the plate surface at the top of the joint. The finish of the welded joint shall be reasonably smooth and free from irregularities, grooves or depressions.

Circumferential Seams.—The shell of the tank should be made in one piece if possible, thus eliminating the necessity of welding an extra circumferential seam. However, if the tank is made in two courses, they should be butt welded together with a double-welded butt-type joint, the same as for a longitudinal seam. The longitudinal joints of the adjacent courses must be placed not less than 60 degrees apart.

Distortion.—The shell shall be circular at any section within a limit of one percent, and if necessary to meet this requirement shall be re-heated, re-rolled and re-formed.

Heads.—To be of steel boiler plate and shall conform to specification S-1 for Steel Boiler Plate, A.S.M.E. Code, Section II, 1930.

Thickness:

$$t = \frac{8.33 \times P \times L}{2 \times TS}$$

where

t = thickness of plate, inches

P = maximum allowable working pressure, pounds per square inch

TS = tensile strength, pounds per square inch originally stamped on plate used in forming the head, assuming 50,000

L = radius to which the head is dished, measured on the concave side of head, inches.

$$t = \frac{8.33 \times 250 \times 48}{2 \times 50{,}000} = \frac{93{,}960}{100{,}000}$$

$t = 0.9396$ = 1-inch thick plate.

Welding Heads.—Circumferential seams shall be of the double-welded butt type. A joint with filler metal added from only one side is considered equivalent to a double-welded butt joint when and if means are provided for accomplishing complete penetration and reinforcement on both sides of the joint.

Heads concave to the pressure and, or plate edges at girth joints to be attached by butt joints shall be alined so that the joints shall not have an offset from each other at any point in excess of one quarter of the thickness of the plate, but if greater correction shall be made by re-forming the shell or head, whichever is out of true, until the errors are within the limits specified. The edges of the head and girth joints shall be kept separated at the point of welding enough to insure thorough penetration of the weld metal.

In all cases where plates of unequal thickness are abutted the edge of the thicker plate shall be reduced in some manner so that it is approximately the same thickness as the other plate.

Inlet and Outlet Connections.—The information contained in the question does not give sufficient data as to the kind or size of connection desired.

The thickness of the shell is suitable for 2-inch threaded connections. Threaded connections of larger sizes should be reinforced by a pressed-shell, cast-steel or bronze composition flange or plate welded on.

All such connections shall be in accordance with the Rules for the Construction of Unfired Pressure Vessels, Section VIII of the A.S.M.E. Code.

Testing.—All fusion-welded pressure vessels shall be subject to a hydrostatic test of not less than 1½ times the maximum allowable working pressure, and while subject to this pressure shall be given a thorough hammer or impact test.

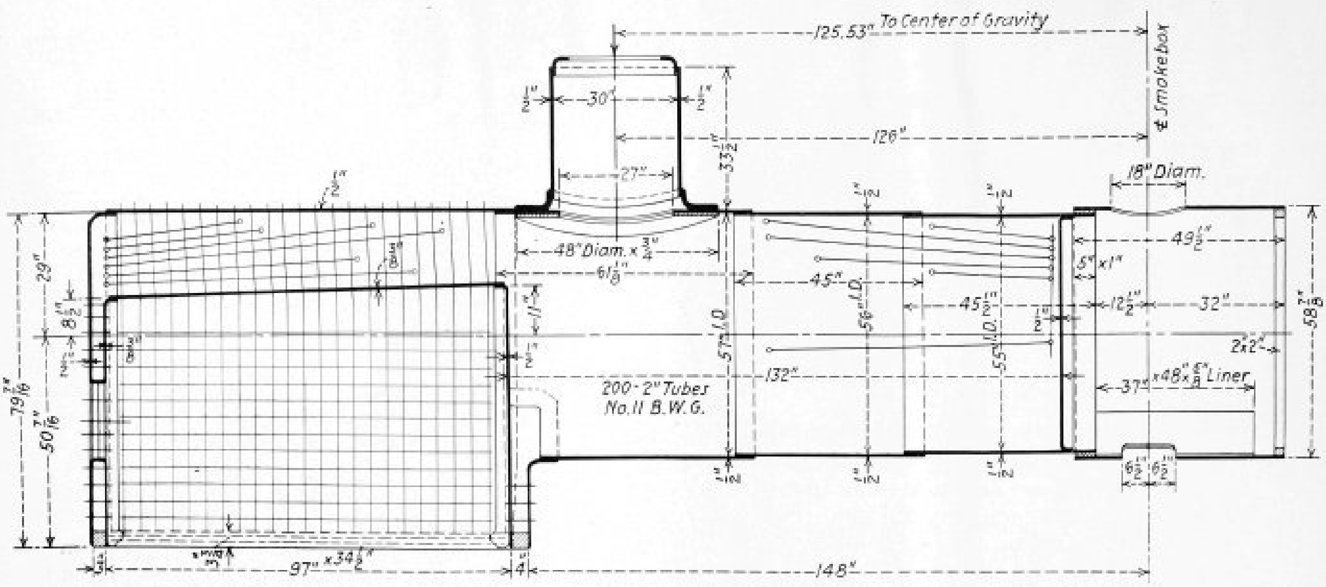
Following this test, the pressure shall be raised to not less than twice the maximum allowable working pressure and held there for a sufficient length of time to enable an inspection to be made of all joints and connections.

Safety Appliances.—All pressure vessels shall be protected by such safety and relief valves and indicating and controlling devices as will insure their safe operation. These devices shall be so constructed, located, and installed that they cannot readily be rendered inoperative.

The relieving capacity of safety valves shall be such as to prevent a use of pressure in the vessel of more than 10 percent above the maximum allowable working pressure, and their discharge shall be carried to a safe place.

In vessels where pressure is not generated, but is derived from an outside source, each safety valve shall be so connected to the vessel, vessels or system which it protects, as to prevent a rise in pressure beyond the maximum allowable pressure in any vessel protected by the safety valve.

Inspection.—To be in accordance with the requirements of the A.S.M.E. Code.



Section of locomotive-type boiler

Center of Gravity of Locomotive Boiler

Q.—Please show method of obtaining the center of gravity of a locomotive boiler. G. M.

A.—To obtain the center of gravity of the locomotive type boiler as illustrated in Fig. 1, it is necessary to take each part of the boiler, as the first course, second course, dome, braces, staybolts, etc., and determine the weights and center of gravity of each individual part.

Then working from some definite point as the center line of the smokebox, and using this line as the center of the moment arms of the various parts, compute the center of gravity of the boiler as follows:

To illustrate; taking the first course, which is 55 inches inside diameter, 45½ inches long and ½ inch thick, the center of gravity of this section longitudinally is $\frac{45.5}{2}$ or 22¾ inches from either end. It is 12½ inches from the center of the smokebox to the front of the first course and therefore 12½ + 22¾ = 35¼ inches from the center line of the smokebox to the center of gravity of the first course.

The weight of this sheet is 1140 pounds.

1140 × 35¼ = 40,185 inch-pounds, the moment produced by the first course.

In like manner the weights and moment arms for each part of the boiler are obtained and listed as shown in the table at the bottom of the page.

Hand Drilling A Large Hole

(Continued from page 337)

it was comparatively easy to cut the ⅜-inch hole out to ¾ inch in diameter. It is the center of a hole which resists a drill; remove that, and the outer radius cuts comparatively easily.

As soon as the hole had been enlarged to the bottom of the small hole, the center-punch and ⅜-inch drill were used again as described and in less than two hours, the ¾-inch hole had been driven to the required depth, or, through the metal to be drilled. The boiler maker said it was "harder work, but beat out an 'inch an hour' with ratchet and 'Old Man!'"

Indianapolis, Ind. JAMES F. HOBART.

Sheet	Dimensions	Weight, pounds	Arm, inches	Positive moment	Negative moment
Smokebox	58 inches dia., 49½ inches len., 7/16 inch th.	1130	— 7¼		8192
Smokebox ring	58 inches dia., 2 inches by 2 inches	200	—31		6200
Smokebox liner	37 inches by 48 inches by ⅝ inch	315	— 6		1890
Smokebox band	56 inches dia., 5 inches by 1 inch	255	15	3825	
Tube sheet	57¼ inches dia., ½ inch th.	365	20¾	7573	
First ring	55 inches diameter, 45⅜ inches len., ½ inch th.	1120	35¼	40185	
First ring welts		155	35¼	5463	
Second ring	56 inches dia., 45 inches len., ½ inch th.	1150	76	87400	
Second ring welts		180	76	13680	
Third ring	57 inches dia., 61⅛ inches len., ½ inch th.	1575	123	193725	
Third ring welts		250	124½	31125	
Dome (comp.)		1350	126	170100	
Roof	198½ inches by 98¼ inches, ½ inch th.	2750	199⅝	548968	
Throat	58½ inches by 29½ inches, 9/16 inch th.	275	148	40700	
Back head	85 inches by 42 inches, ½ inch th.	510	250	127500	
Firebox tube	65 inches by 54 inches, ½ inch th.	500	252½	126250	
Firebox crown	161¼ inches by 94 inches, ⅜ inch th.	1465	200½	293732	
Firebox back	65 inches by 54 inches, ⅜ inch th.	375	248½	93187	
Firebox ring	3 inches by 3¼ inches by 242½ inches and 4 inches by 3¼ inches by 34½ inches	920	195	179400	
Front tube braces		250	62	15500	
Back head braces		400	216	86400	
Crown and side staybolts		1250	200½	250625	
Throat braces		60	144	8640	
Back head staybolts		85	250½	21292	
Tubes		5300	86½	458450	
		22,205		2,803,720	16,282
				— 16,282	
				2,787,438	

$$\frac{2,787,438}{22,205} = 125.53$$ inches center of gravity back of center line of smokebox.

Associations

Bureau of Locomotive Inspection of the Interstate Commerce Commission

Chief Inspector—A. G. Pack, Washington, D. C.
Assistant Chief Inspectors—J. M. Hall, Washington, D. C.; J. A. Shirley, Washington, D. C.

Steamboat Inspection Service of the Department of Commerce

Supervising Inspector General—D. N. Hoover, Jr., Washington, D. C.

American Uniform Boiler Law Society

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Boiler Code Committee of the American Society of Mechanical Engineers

Chairman—Fred R. Low.
Vice-Chairman—D. S. Jacobus, New York.
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Vice-Chairman—William H. Furman, Albany, N. Y.
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International Brotherhood of Boiler Makers, Iron Ship Builders and Helpers of America

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Assistant International President—J. N. Davis, suite 522, Brotherhood Block, Kansas City, Kansas.
International Secretary-Treasurer—Chas. F. Scott, suite 506, Brotherhood Block, Kansas City, Kansas.
Editor-Manager of Journal—John J. Barry, suite 524, Brotherhood Block, Kansas City, Kansas.
International Vice-Presidents—Joseph Reed, 1123 E. Madison Street, Portland, Ore.; W. A. Calvin, 1622 Glendale Street, Jacksonville, Fla.; Harry Nicholas, 6215 S. Benton Blvd., Kansas City, Mo.; W. E. Walter, 637 N. 25th Street, E. St. Louis, Ill.; J. H. Gutridge, 910 N. 18th Street, Milwaukee, Wis.; W. G. Pendergast, 26 South Street, New York, N. Y.; W. J. Coyle, 424 Third Avenue, Verdun, Montreal, Quebec, Can.; A. M. Milligan, 262 Trent Avenue, E. Kildonan, Man., Can.; J. F. Schmitt, 28 S. Roys Street, Columbus, O.; William Williams, 502 Labor Temple, Portland, Ore.

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States and Cities That Have Adopted the A.S.M.E. Boiler Code

States

Arkansas	Missouri	Rhode Island
California	New Jersey	Utah
Delaware	New York	Washington
Indiana	Ohio	Wisconsin
Maryland	Oklahoma	District of Columbia
Michigan	Oregon	Panama Canal Zone
Minnesota	Pennsylvania	Territory of Hawaii

Cities

Chicago, Ill.	St. Joseph, Mo.	Memphis, Tenn.
Detroit, Mich.	St. Louis, Mo.	Nashville, Tenn.
Erie, Pa.	Scranton, Pa.	Omaha, Neb.
Kansas City, Mo.	Seattle, Wash.	Parkersburg, W. Va.
Los Angeles, Cal.	Tampa, Fla.	Philadelphia, Pa.
	Evanston, Ill.	

States and Cities Accepting Stamp of the National Board of Boiler and Pressure Vessel Inspectors

States

Arkansas	Missouri	Pennsylvania
California	New Jersey	Rhode Island
Delaware	New York	Utah
Indiana	Ohio	Washington
Maryland	Oklahoma	Wisconsin
Minnesota	Oregon	Michigan

Cities

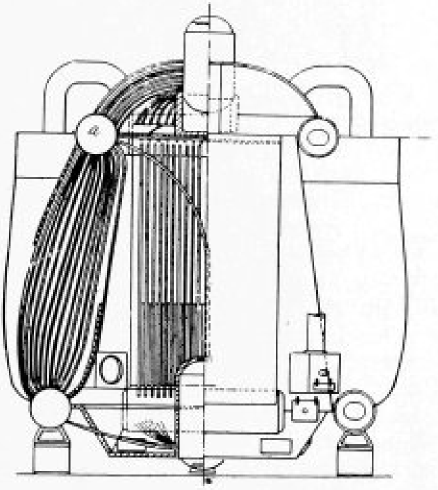
Chicago, Ill.	St. Louis, Mo.	Nashville, Tenn.
Kansas City, Mo.	Scranton, Pa.	Omaha, Neb.
Memphis, Tenn.	Seattle, Wash	Parkersburg, W. Va.
Erie, Pa.	Tampa, Fla.	Philadelphia, Pa.
	Detroit, Mich.	

Selected Boiler Patents

Compiled by Dwight B. Galt, Patent Attorney, Washington Loan and Trust Building, Washington, D. C. Readers wishing copies of patents or any further information regarding any patent described, should correspond directly with Mr. Galt.

1,798,830. STEAM GENERATOR AND FURNACE THEREFOR. JAMES JOHN CANTLEY BRAND, OF STRAND, LONDON, ENGLAND, ASSIGNOR OF ONE-HALF TO BRYAN LAING, OF LONDON, ENGLAND.

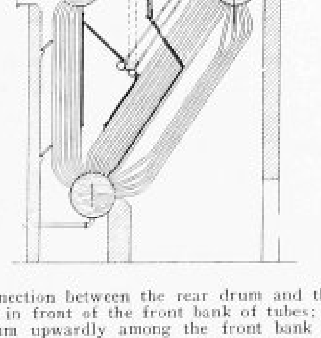
Claim.—A steam generator comprising superimposed steam drums and water drums, generator tubes disposed in a substantially vertical plane in the path of the combustion gases from a combustion chamber and interconnecting said superimposed steam drums and water drums, a feed-water



drum located centrally of the base of the combustion chamber, tubes extending outwardly from said centrally located drum to one of said other drums, a superheater chamber, superheater tubes located within said superheater chamber, and means for admitting a controlled volume of gases directly from the combustion chamber to said superheater chamber. Eight claims.

1,798,454. STEAM BOILER. CARL T. CARLSON, OF ERIE, PA., ASSIGNOR TO ERIE CITY IRON WORKS, OF ERIE, PA., A CORPORATION OF PENNSYLVANIA.

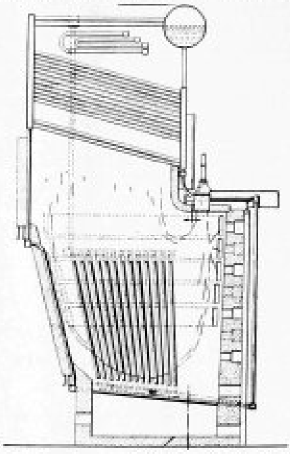
Claim.—In a steam boiler, the combination of a front drum; a rear drum, said drums being in the plane of the water level; a lower drum; a front bank of tubes more nearly vertical than horizontal connecting the front and lower drums; an upper bank of watertubes connecting the front and rear drums, the tubes of said upper bank being directioned to make the steaming direction of travel toward the rear bank of tubes; a rear bank



of tubes in the connection between the rear drum and the lower drum; a combustion chamber in front of the front bank of tubes; a baffle extending from the lower drum upwardly among the front bank of tubes dividing the front bank of tubes into front and rear sections, the front section being exposed to the direct radiant heat of the combustion chamber throughout the major portion of their lengths, the baffle terminating below the upper drum; a baffle crossing the upper bank of tubes and leading from the front bank of tubes forming a single reverse pass through the upper bank of tubes; and means compelling the return flow of gases to pass through the lower portion of the rear section of the front bank of tubes, said tubes, drums and baffles controlling the temperatures and water flow to create a ring flow of water up the front bank of tubes toward the rear, through the upper bank of tubes and downwardly through the rear bank of tubes.—Five claims.

1,708,862. APPARATUS FOR BURNING FUEL. JOHN E. BELL, OF BROOKLYN, N. Y., ASSIGNOR TO COMBUSTION ENGINEERING CORPORATION, A CORPORATION OF NEW YORK.

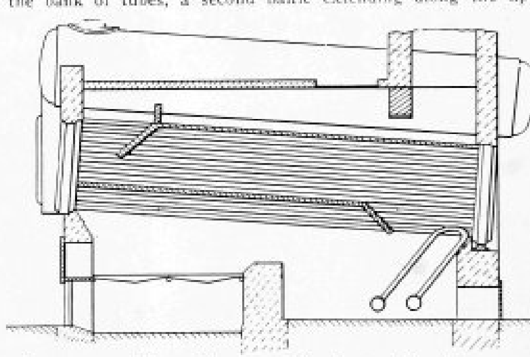
Claim.—In a furnace, a combustion chamber; a boiler having a downcomer and an upcomer header; a water screen in the bottom of the chamber exposed to radiant heat and comprising tubes and a pair of headers exterior of the chamber with which the tubes are connected; means for



connecting one of said headers with the downcomer header; a second water screen along the bridge wall exposed to radiant heat and connected with the other of said headers; a header with which the tubes of the second screen are connected; and a plurality of tubes exposed to radiant heat and extending along the bridge wall for connecting said last header with the upcomer header. Eight claims.

1,772,919. BOILER BAFFLE. SANFORD C. SMITH, OF HAMBURG, N. Y., ASSIGNOR TO KING REFRACTORIES COMPANY, INC., OF BUFFALO, N. Y., A CORPORATION OF NEW YORK.

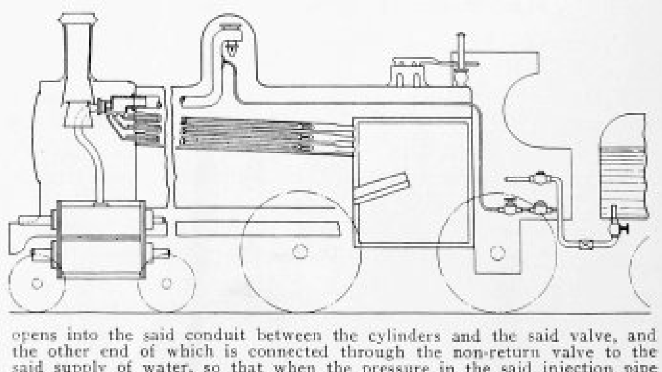
Claim.—In combination with a boiler of the horizontal tube type, a substantially horizontal baffle extending along the lower tubes from the front to within a distance of the rear of the boiler so as to leave a gas passage into the bank of tubes, a second baffle extending along the upper tubes



from the rear to within a distance of the front of the boiler so as to leave a gas passage from the bank of tubes, and a third baffle extending at an obtuse angle from the free end of the second baffle and crossing a portion of the tubes of the bank, the space between the end of the third baffle and the front of the boiler being substantially equal to the space between the end of the third baffle and the first baffle. Six claims.

1,754,184. APPARATUS FOR SUPPLYING STEAM TO ENGINES WHEN THE MAIN SUPPLY IS CUT OFF. ROBERT WOOD, OF GARWICK, ISLE OF MAN.

Claim.—In combination; a steam engine; a supply of steam therefor; a conduit connecting the cylinders of the engine to the said steam supply; a valve adapted to close the said conduit; a supply of water always subject to a pressure less than the fluid pressure necessary to actuate the steam engine; a non-return valve; an injection pipe, one end of which



opens into the said conduit between the cylinders and the said valve, and the other end of which is connected through the non-return valve to the said supply of water, so that when the pressure in the said injection pipe rises above that of the water supply the latter is cut-off from the injection pipe; and heating means for vaporizing the water supplied to the injection pipe after the said water has passed through the non-return valve. Twelve claims.