# THE BOILER MAKER

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JANUARY TO DECEMBER, 1922

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## JANUARY TO DECEMBER, 1922

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# THE BOILER MAKER

JANUARY, 1922

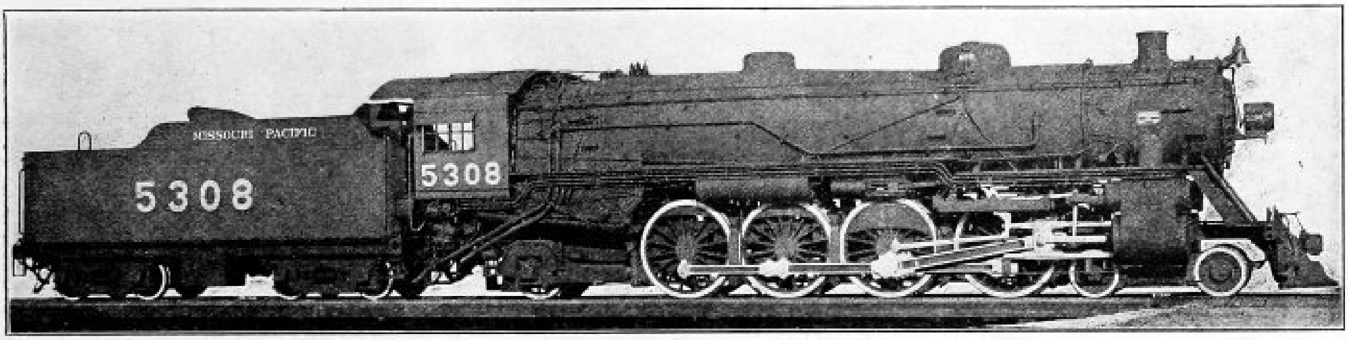



Fig. 1.—Medium Weight Mountain Type Locomotive. Circulating Plates Are Installed on This Engine

## Circulating Plates on Missouri-Pacific Locomotives

*Positive circulation of water in a locomotive boiler is essential to efficient operation. The addition of circulating plates to 200 locomotives of the Missouri-Pacific Railroad has increased the capacity of these engines about 10 percent. The construction and application of this device come within the province of the boiler maker and so the details for the work as carried out on the Missouri-Pacific are given below.*

HAVING found that circulating plates in the boilers of many of its locomotives increased their operating capacity to an appreciable extent, the Missouri-Pacific had this device installed on 50 new locomotives which were recently completed by the American Locomotive Company. These locomotives include fifteen 6-wheel switchers (0-6-0 type), twenty-five Mikado (2-8-2 type), five Pacific (4-6-2 type) and five Mountain (4-8-2 type), all of which types have previously been operated by the company. The 6-wheel switchers are similar in design to a number of engines received by the company about a year ago. The Pacific type locomotives are practically duplicates of engines previously built for the road and in operation, while the Mikado and Mountain types are entirely new in design.

The Mikado locomotives previously used were of the Government light or U. S. R. A. 2-8-2 type allocated to the road during the war. These engines have a tractive effort of 54,600 pounds, a total weight of 290,800 pounds, while the new engines have 10 percent greater tractive effort and an equivalent increase of weight and are handling considerably more tonnage. Special improvements on these locomotives include Alco reverse gear, Duplex type "D" stokers, Franklin grate shakers and other features.

As noted, the boilers of the Mikado type as well as the other locomotives are equipped with Harter circulating plates which have been largely responsible for the gain in capacity of these engines.

Essentially, this device consists of a horizontal plate located slightly below the center line of the boiler extending entirely across the boiler from a point just behind the feed water inlet to within about 6 inches of the back tube sheet. Outlets for steam are provided by pipes placed at intervals on either side which lead to the steam space on the top of the boiler barrel. The general arrangement is shown in the

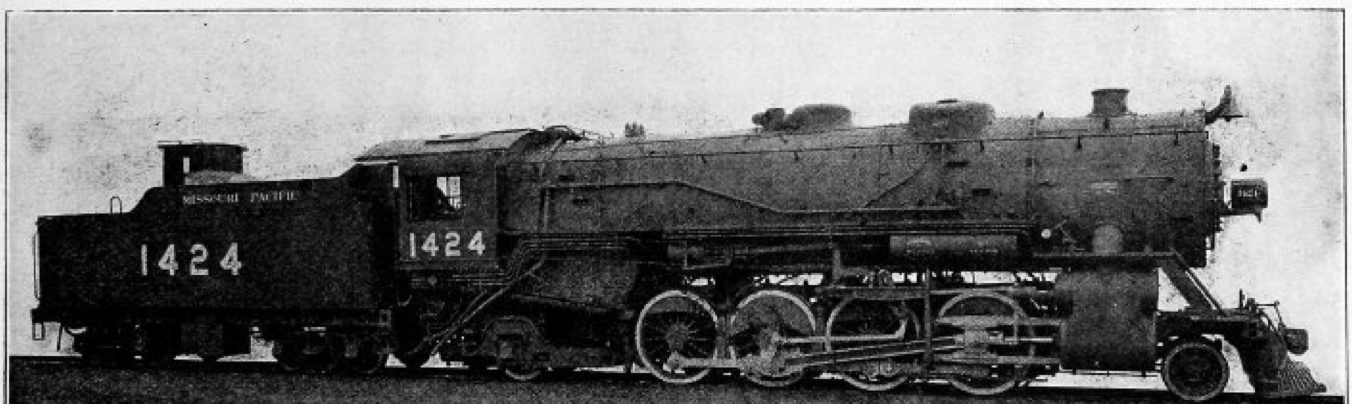



Fig. 2.—New Type Mikado Locomotive Recently Completed for the Missouri Pacific Railroad

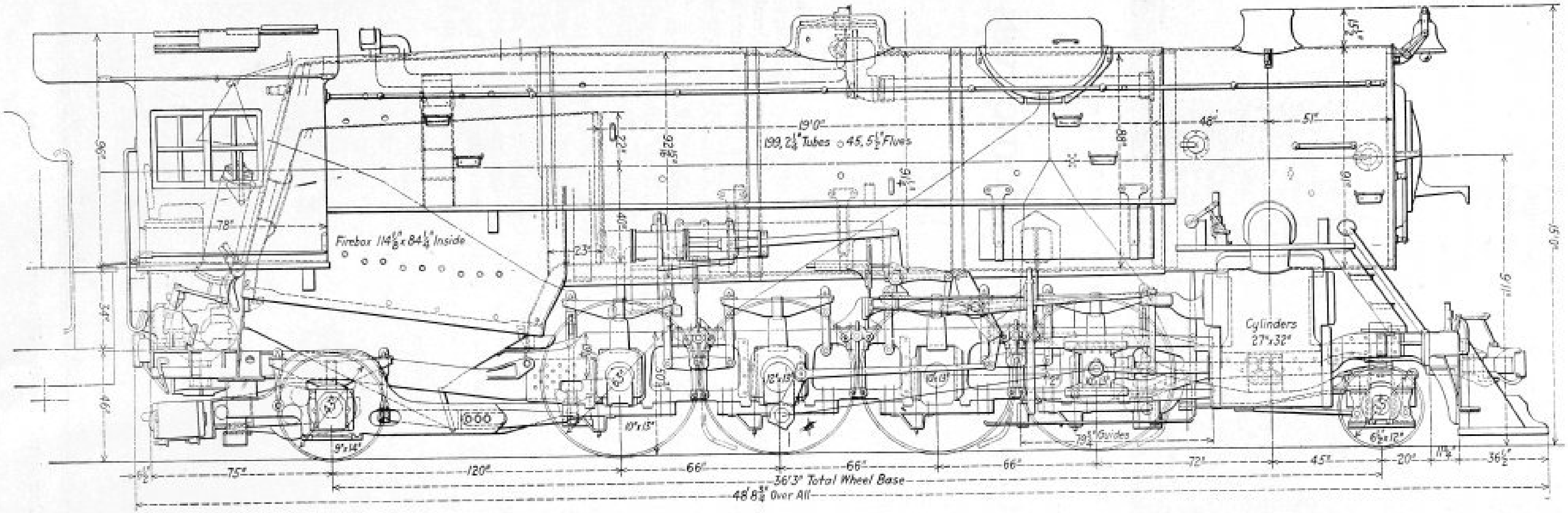



Fig. 3.—Elevation and Sections of New Mikado Type Locomotives for the Missouri Pacific

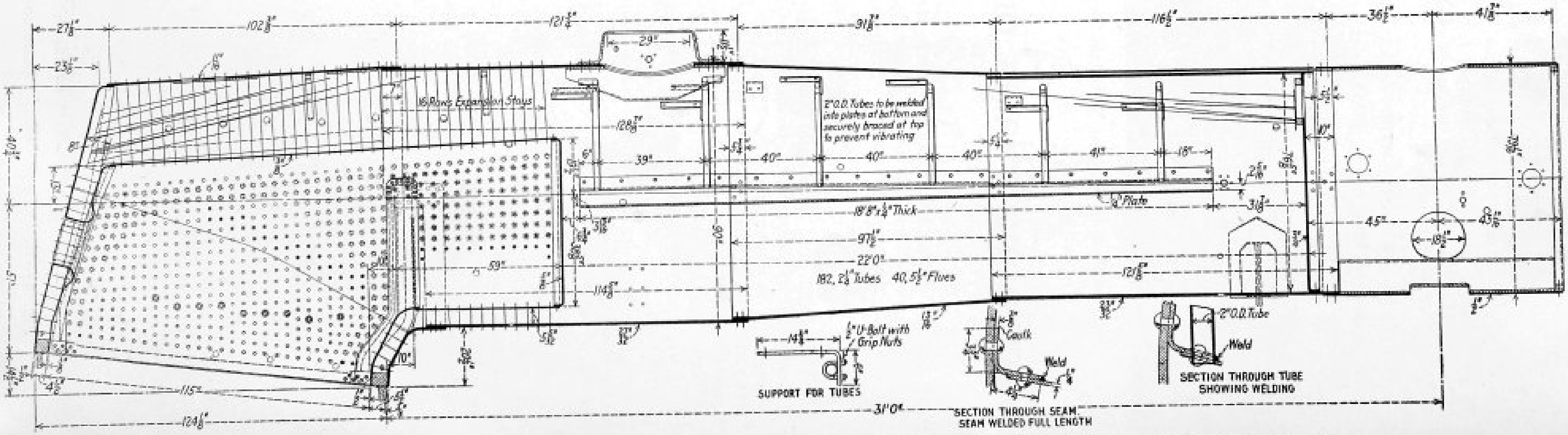



Fig. 4.—Sectional View of Mountain Type Locomotive Boiler, Showing the Harter Circulating Plate and Installation Details

drawings of the boiler for the Mountain type locomotives, Fig. 4. Complete details of the installation are given below.

On the Mikado locomotives the boiler horsepower is 93.9 percent of the cylinder horsepower without allowance for the circulating plate and on the Mountain type the rated boiler power is even less. All of the engines have, however, proved to be free steamers in service.

### Construction and Application of Circulating Plates

As applied to Missouri-Pacific locomotives the device is a diaphragm plate of ¼-inch tank steel placed about midway between the top of the crown sheet line and the belly of the boiler, separating the top and the bottom halves of the flues. The plate is secured to the side of the barrel sheet by angles flanged from ¼-inch material, riveted to the barrel with ¾-inch rivets spaced about 8 inches on centers. The plate is riveted to the side angles with ½-inch rivets spaced about 4 inches on centers. The plate is made in right and left halves with butt straps riveted at the center with ½-inch rivets, spaced about 4 inches.

The plate does not extend from the front flue sheet to the back flue sheet, but allows a space from 6 inches to 7 inches at the back flue sheet, depending on the size of boiler. This space is to permit water to circulate up the face of the flue sheet. At the front end, the plate extends to within 24 inches to 30 inches of the front flue sheet, depending on the diameter of the barrel of the boiler.

There are two types of plate, one designed in the form of an arch, having the highest point at the center and the other a flat plate with a turn-up at the side. The latter design is preferable because of the fact that fewer flues are left out of the system.

The steam risers are made of 2-inch flues spaced about 36 inches apart and the number applied depends on the length of the boiler. These risers are to release the steam that is generated adjacent to the flues below the plate which would, if not released, form steam bubbles and force the water down from the flues directly under the plate.

The cost of material; that is, plates, angles and risers, is practically offset by the flues that are eliminated.

### Application of Plate Not Difficult

The plate can be applied at any time, when it is necessary to renew the back flue sheet. The oxy-acetylene torch is used to cut the face of the tube holes from the front flue sheet without disturbing the rivets, braces or flange of the flue sheet. The labor cost averages about $125.

It is not necessary to remove the plate to make inspections or to scale the boiler. Thorough inspection and scaling of a boiler can be made above and below this plate any time the flues are removed. It has been found by experience that no corrosion forms on this plate and, therefore, the plate will last during the life of the boiler.

### Necessity of Providing Positive Water Circulation

Engineers have worked for years on the problem of creating a positive circulation in locomotive and other fire tube boilers, but with little success. The circulation in the firebox is sluggish; that in the barrel is much more so. This retards the evaporation of water as a steam film forms close to the sheets and tubes and acts as an insulator. If a rapid circulation is created in such a boiler the steam film is removed quickly and replaced by water. The heat units are then transmitted to the water and a very much better evaporation is obtained.

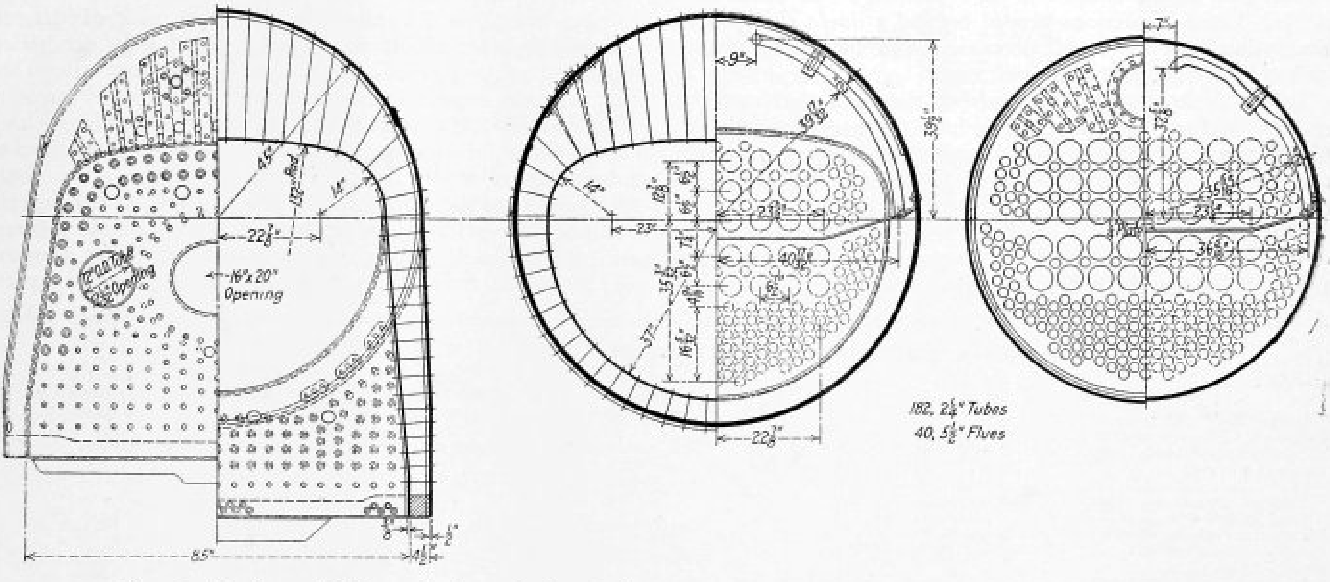


Fig. 5.—Sections of Mountain Type Boiler, Indicating Method of Attaching Circulating Plate to Shell

It has been found that the circulating plate overcomes many of the difficulties and provides the circulation desired. A certain amount of steam is created under the plate when the locomotive is in service and vertical risers have been provided in the design to carry the steam so formed into the space above.

Through the positive circulation obtained by the installation of the plate, it has been found that a boiler keeps much cleaner and that impurities in the water are swept backwards and deposited in the water legs of the firebox where they can be easily washed out. On the Missouri-Pacific, this fact was demonstrated by comparing several engines with plates and others not so equipped and running under the same conditions over the same divisions. In these service tests it was found that the boilers equipped with the plates were practically free from scale in the firebox as well as in the barrel of the boiler while this was not true of the boiler not so equipped. As a general rule if a locomotive has been in service for a short time, the front part of the boiler is filled with scale and mud, especially where it operates in a dirty water district.

After an average of eighteen months' service, inspections have indicated that the increased circulation has practically eliminated the formation of scale around the dry pipe, braces and flange with only slight accumulations of scale

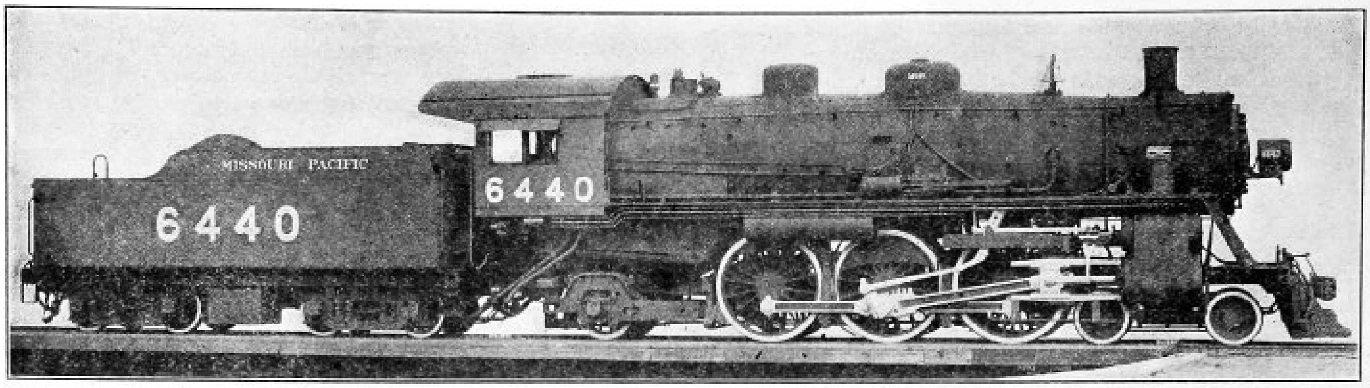



Fig. 6.—Pacific Type Locomotive of 40,000 pounds Tractive Effort

on the shell of the boiler and tubes as well as on the firebox plates. These inspections proved beyond a doubt that proper circulation in a boiler will decrease the grooving and pitting in both shell sheets and tubes.

It has been stated by officials of the road that material savings in fuel have been effected by the use of circulating plates and that engines so equipped can be fired up in the roundhouse in considerably less time than others not so equipped.

Due to the circulation through the flues it is not necessary to draft the engines so hard so that the nozzles can be opened from ¼ inch to ½ inch larger than standard. Foaming is decreased in bad water districts and the mileage between washouts can be increased materially up to approximately 25 percent.

## Mountain Type Engines

The light Mountain type locomotives which have been used for some time by the Missouri-Pacific were used as a basis for the design of the new type with such changes as would eliminate some of the troubles experienced with these engines in service.

Driving wheels were increased in size and lateral motion driving boxes were applied on the front pair of drivers, which with other modifications necessitated a longer boiler, thus tending to increase the weight beyond that allowable. The previous engines had a rated boiler horsepower capacity of 97.5 percent of the cylinder horsepower. In order to keep the weight within the maximum allowable, it was decided to reduce the boiler size so that the rated horsepower was only 85.3 percent of the cylinder horsepower. This it was thought could be done safely by using the circulating plate to increase the boiler capacity. In the new design the boiler pressure was increased from 200 pounds to 210 pounds per square inch. The firebox was made 6 inches shorter, the length of tubes was increased from 20 feet 6 inches to 22 feet and the number decreased from 216 to 182.

The new Mountain type locomotives are being run in a pool with the older locomotives and consequently both are handling the same trains on the same division. Despite the smaller boiler, the new engines steam just as freely as the older ones, are running with ¾-inch larger exhaust nozzles, are making better records and take the same trains thirty miles further for water.

COMPARISON AND RATIOS OF THE MISSOURI-PACIFIC'S NEW LOCOMOTIVES

| | 0-6-0 Switcher | 2-8-2 Mikado† | 4-6-2 Pacific | 4-8-2 Mountain |
|---|---|---|---|---|
| Tractive effort (85 percent) | 39,100 lb. | 59,800 lb. | 39,500 lb. | 53,500 lb. |
| Cylinders, diameter and stroke | 21 in. by 28 in. | 27 in. by 32 in. | 26 in. by 26 in. | 27 in. by 30 in. |
| Valves, size and kind | 10 in. piston | 14 in. piston | 14 in. piston | 14 in. piston |
| Greatest travel | 6 in. | 7 in. | 6½ in. | 7 in. |
| Lap | 1 in. | 1 1/16 in. | 1⅛ in. | 1¼ in. |
| Exhaust clearance | 1/16 in. | 0 | 1/16 in. | 1/16 in. |
| Lead in full gear | 0 | ⅛ in. | 3/16 in. | 3/16 in. |
| Weight in working order—total engine | 163,000 lb. | 320,000 lb. | 267,500 lb. | 335,000 lb. |
| Total engine wheelbase | 11 ft. 6 in. | 36 ft. 3 in. | 33 ft. 7 in. | 41 ft. 4 in. |
| Boiler, style: | Ext. Wagon Top | St. Top | Ext. Wagon Top | Conical Conn. |
| Diameter, inside first ring | 64 11/16 in. | 88 in. | 72⅜ in. | 76⅝ in. |
| Steam pressure | 190 lb. | 190 lb. | 193 lb. | 210 lb. |
| Firebox, length and width | 78 in. by 70¼ in. | 114⅛ in. by 84¼ in. | 108 in. by 66 in. | 114⅛ in. by 84¼ in. |
| Grate area | 38 sq. ft. | 67 sq. ft. | 49.5 sq. ft. | 67 sq. ft. |
| Tubes, number and diameter | 158—2 in. | 199—2¼ in. | 207—2 in. | 182—2¼ in. |
| Flues, number and diameter | 24—5½ in. | 45—5½ in. | 32—5⅜ in. | 40—5½ in. |
| Tubes and flues, length | 14 ft. | 19 ft. | 20 ft. | 22 ft. |
| Heating surface, firebox | 145 sq. ft. | 263 sq. ft. | 207 sq. ft. | 300 sq. ft. |
| Heating surface, arch tubes | ........ | 27 sq. ft | 26 sq. ft. | 27 sq. ft. |
| Heating surface, tubes | 1,149 sq. ft. | 2,214 sq. ft. | 2,155 sq. ft. | 2,346 sq. ft. |
| Heating surface, flues | 480 sq. ft. | 1,223 sq. ft. | 895 sq. ft. | 1,261 sq. ft. |
| Heating surface, total evaporative | 1,774 sq. ft. | 3,727 sq. ft. | 3,283 sq. ft. | 3,934 sq. ft. |
| Superheating surface | 393 sq. ft. | 1,051 sq. ft. | 778 sq. ft. | 1,084 sq. ft. |
| Equivalent heating surface* | 2,363 sq. ft. | 5,303 sq. ft. | 4,450 sq. ft. | 5,560 sq. ft. |
| Tender: | | | | |
| Water capacity | 6,000 gal. | 10,000 gal. | 8,000 gal. | 10,000 gal. |
| Fuel capacity | 10 tons | 16 tons | 14 tons | 16 tons |
| Ratios: | | | | |
| Weight on drivers ÷ tractive effort | 4.3 | 3.9 | 4.2 | 4.2 |
| Total weight ÷ tractive effort | 4.3 | 5.3 | 6.8 | 6.3 |
| Tractive effort ÷ equivalent heating surface | 16.5 | 11.3 | 11.3 | 9.6 |
| Tractive effort × diameter drivers ÷ equivalent heating surface | 844 | 711 | 823 | 702 |
| Equivalent heating surface ÷ grate area | 62.3 | 79.2 | 89.9 | 83.0 |
| Weight on drivers ÷ equivalent heating surface | 68.9 | 43.9 | 37.4 | 40.6 |
| Total weight ÷ equivalent heating surface | 68.9 | 60.4 | 60.1 | 60.3 |
| Firebox heating surface ÷ equivalent heating surface, percent | 6.1 | 5.0 | 4.6 | 5.4 |
| Volume of cylinders, cu. ft. | 11.2 | 21.18 | 15.96 | 19.86 |
| Equivalent heating surface ÷ volume cylinders | 211 | 250 | 278 | 280 |
| Grate area ÷ volume cylinders | 3.4 | 3.2 | 3.1 | 3.4 |
| Superheater surface ÷ evaporative surface, percent | 22.1 | 28.2 | 23.7 | 27.5 |

*Equivalent heating surface = total evaporative heating surface + 1.5 times the superheating surface.
†The weights and ratios for those without boosters.

# Standards of Railroad Shop Welding Practice*

## General Rules for Using Autogenous Processes in Boiler Repairs with Typical Examples of Successful Welds

By G. M. Calmbach

IN order that greater uniformity and better results may be obtained in preparing work and making welds, the following methods and practices have been selected after considerable study, experiments and personal observation of the welding work in many shops throughout the country. They are considered the best and most practical methods in use today and are recommended as standard practices, to be followed as closely as local conditions will permit. Each foreman and welder who follows these instructions will find his work more reliable and satisfactory.

1.

In welding cast iron, brass, cast steel and forgings, all such work should be fire heated whenever possible to insure a better weld, as well as to save gases. That is to say, all parts that take considerable time to heat with the torch sufficient to commence welding should be preheated so that when the welding flame is applied the part to be welded will respond almost immediately. As the oxy-acetylene torch cost per hour is extremely high it is easy to see that the heating of ordinary heavy parts with the oxy-acetylene flame is a very expensive operation and should be eliminated as far as practicable.

All foremen in charge of such work should use good judgment and take a personal interest in this matter and see that the proper provisions are made and work carried out accordingly. The preheating of cast iron, brass and other heavy castings is not only necessary for the saving of gases and time, but is also necessary in many cases to take proper care of expansion and contraction.

2.

In making a successful weld there are five very essential and important things to consider; (1) the condition of surfaces; (2) the bevel of sheets; (3) the position of sheets; (4) provision for expansion and contraction, and (5) proper filler metal.

The importance of these points cannot be over-estimated and the failure to comply with the instructions covering any one of them will result in a questionable or bad weld. The success of a weld depends on the rigid observation of these items.

3.

When sheets and patches are to be applied extreme care should be taken that all defective parts are cut out and also that they are cut so there will be a good foundation for the weld.

4.

All sheets and patches should be cut out on a straight or uniform line, avoiding staybolts wherever possible so that staybolts threads may be cut in unwelded plate.

5.

Never cut out sheets or patches through the old weld where sheets have been welded previously. For side sheets or three-quarter door sheets, extend the new sheets at least one staybolt row higher; for crown sheet, one staybolt row lower; for patches, at least one row of staybolts larger; for the flue sheet, extend the weld to one row of staybolts lower.

6.

Do not cut out sheets or patches and bevel the sheets at the same time. If the sheets are to be beveled with the torch before chipping, this can be done after the parts are cut out; this is necessary to insure a uniform line, as well as a more perfect fit of the new parts.

7.

Clean surfaces are absolutely necessary for making good welds. If scale, rust, or grease is permitted to remain on the surface to be welded a slag is formed that will make a streaked and seamy weld. All surfaces must be kept free from foreign substances; all welding surfaces must be kept clean and bright.

8.

Experience has proven that the most satisfactory angle of the beveled faces preparatory to making the weld is an angle of 45 degrees with the surface of the sheets. The total angle between bevel faces must be 90 degrees in all cases, even if one sheet has to be beveled more than the other. Improperly beveled sheets prevent the welding flame from penetrating to the bottom of the weld and so prevent the weld from uniformly uniting with the edge of the sheet.

9.

Where horizontal welds are to be made with the electric welder, it has been found good policy to bevel the bottom edge to about a 60-degree angle and the top edge to about 30 degrees.

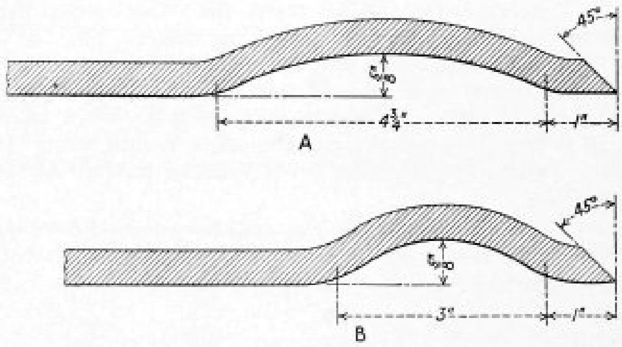



**Fig. 1.—Standard Corrugations for Boiler Sheets and Patches**

10.

All sheets and patches are to be fitted carefully with an opening of ⅛ inch, no more and no less, between bevel edges. Less than ⅛ inch opening between the sheets will not permit the welding flame to penetrate the weld properly and a greater opening requires too much filler metal to be used, not only increasing the cost of the weld, but making it impossible to keep the surface of the weld opposite the torch smooth. This rough surface permits lamination and seams on the water side of the sheet, weakening the weld and permitting early corrosion of the metal which tends to part the sheets.

11.

All other precautions may be carefully made and yet a faulty weld will be made if due care is not taken to allow for expansion and contraction of the sheets. Where it is not possible to obtain the necessary expansion and contraction through curves of the adjacent sheets, it is then necessary

*Reprinted from the Railway Mechanical Engineer to provide some method to take care of expansion and contraction. In this case all sheets and patches will be corrugated, as shown in Fig. 1. A strain on a weld, especially where the new sheet is welded to an old sheet, which

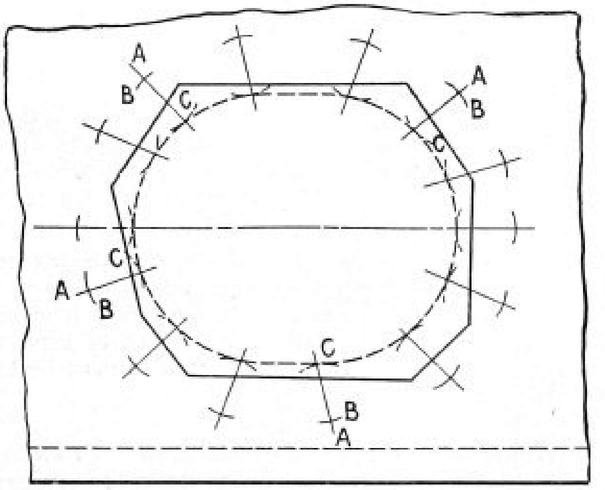



Fig. 2.—Method of Laying Out Patches for Welding

is generally the case, is particularly harmful as the old sheet will not stretch as much or as uniformly as the new one.

12.

When fitting corrugated sheets or patches, they should be bolted securely in place and when they extend to the mud ring good drift pins should be inserted in the mud ring holes so that the sheet cannot move upward due to the contraction as the contraction should be taken from the corrugation. Bolt the sheets at the welding end as usual. That is to say, insert a 5/8-inch bolt through every fifth staybolt hole and screw in a staybolt from the outside between each of the 5/8-inch bolts, thus holding the sheets in line. Then insert small wedges between the welding edge spaced about 14 inches apart to keep the sheet from pinching together during the welding.

13.

Where side sheets are to be welded at the ends it is necessary to remove the adjacent row of staybolts to the edge

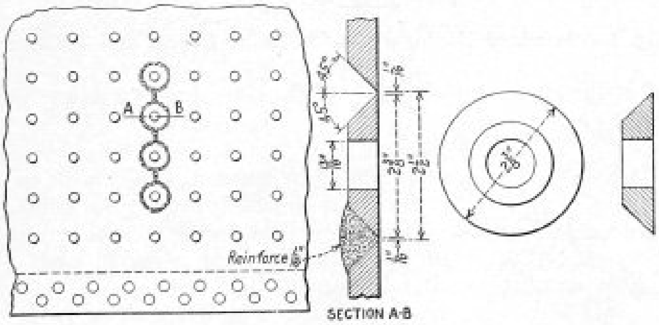



Fig. 3.—Method of Welding Cracks Through Staybolt Rows; Gas

of the flange of the door of the flue sheet before welding is commenced. It is also advisable to remove all staybolts adjacent to welds after the welding is completed.

14.

When welding corrugated sheets or patches with the oxy-acetylene method the following instructions are to be carried out: with every 12 inches of welding completed, the operator will stop and heat a line 1 inch wide through the center of the corrugation to a red heat and continue this until the weld is finished.

15.

No firebox welds should be reinforced more than 1/16 inch as too great a reinforcement is injurious to a weld due to over-heating when in service.

16.

For firedoor patches when collars are to be welded they should be cut out at a point where at least one row of stay-

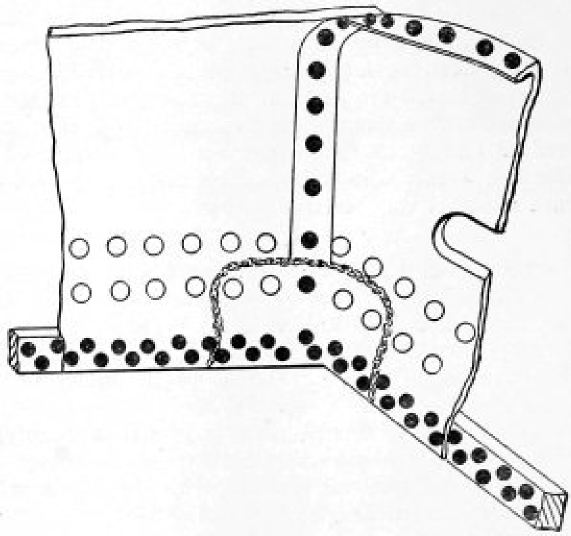


Fig. 4.—Application of Mud Ring Corner Patches; Gas or Electric

bolts is in the patch and as nearly round as possible. When the patch is cut out at a point 6 inches or more from the firedoor edge it should be corrugated all around as shown in Fig. 5. It will not be necessary to corrugate if the patch

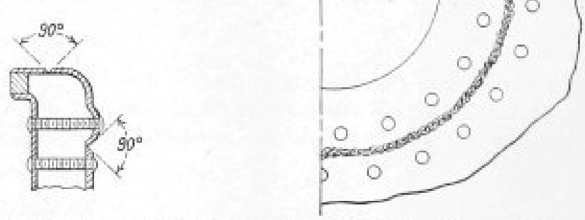



Fig. 5.—Butt Welded Fire Door Patch; Gas or Electric

is cut out less than 6 inches from the door hole. When firedoor patches are extended to the mud ring and 6 inches or more from the firedoor edge the patch will be corrugated all around. Where patches do not extend to 6 inches from the firedoor edge, it will only be necessary to corrugate both sides of the patch from a point about half way from the firedoor down to the mud ring.

17.

The welding of cracks in side sheets, door sheets, firedoors, crown sheets, bottom and top of flue sheets should never be attempted as such attempts have been a source of much trouble and many engine failures. However, it may be considered necessary at times to weld certain cracks. This practice should be resorted to only in occasional emergency cases and then such work should be classed as strictly temporary and be corrected at the first opportunity. It is, of course, known that such work as welding cracks in the barrel of a boiler, welding over staybolts and welding staybolts is strictly against the law and will not be allowed at any time.

18.

When it becomes necessary to weld seams that have given away, such as those between door or flue sheets and side sheets, the rivets should be removed and the outside of the fire side lap should be cut off through the center line of the rivet holes. Do not cut the side sheet and see that it is cleaned thoroughly before welding is commenced. Weld the holes solid and lap weld sheets.

### Fitting, Preparing and Welding Fireboxes

For fitting, preparing and welding a firebox without removing the back end, the firebox should be set up on the floor with all staybolts and mud ring rivet holes drilled, except the mud ring corner holes, which should be drilled after the sheet is up and welded.

The welding edge should be chipped to a 45-degree angle

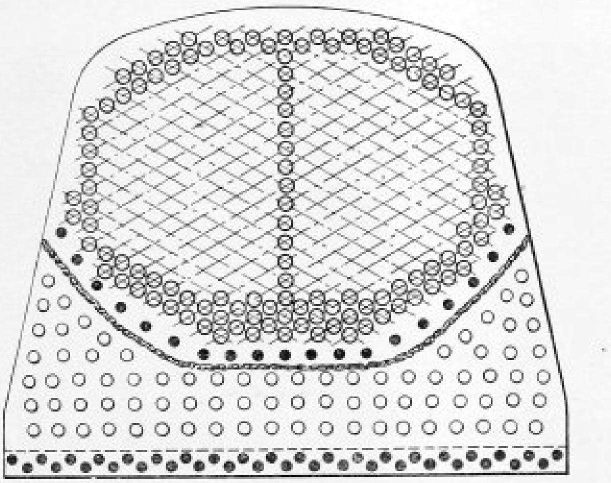


Fig. 6.—Method of Applying New Tube Sheet Section; Gas or Electric

and chipped on a straight line so as to insure a uniform opening of 1/8 inch between the welding edges.

The lower portion of the sheet from a point about 14 inches from the bottom of the flue and door sheets should not be chipped until the box is in place and the mud ring corners in place.

Bolt the sheet securely in place, being sure that there is a uniform opening of 1/8 inch all around the welding edge.

Use a 1/2-inch drill and drill holes spaced about 14 inches apart, using 1/2-inch machine bolts with clamps made of boiler plate 1/2 inch by 2 inches by 4 inches. Use one of these pieces on each side of the sheet, being sure that all bolts are drawn tight.

Rivet the top of the flue sheet to a point not less than 12 inches below the center of the crown; start welding at a point about 10 inches below the rivet and weld up to the rivets. Then drop down 10 inches and weld up to the end of the previous weld. Continue this operation until completed, removing clamps when necessary. Weld the entire door sheet.

### Examples of Boiler Shop Welding

The method of making corrugations for side and door sheets to allow for expansion is shown at A, Fig. 1. The corrugation for patches is more pronounced and is shown at B in the illustration.

In laying out patches previous to welding it is sometimes difficult to cut them accurately unless some such method as the following is used: After the sheet has been cut out and beveled, the lines A, Fig. 2, are scribed as shown. With the

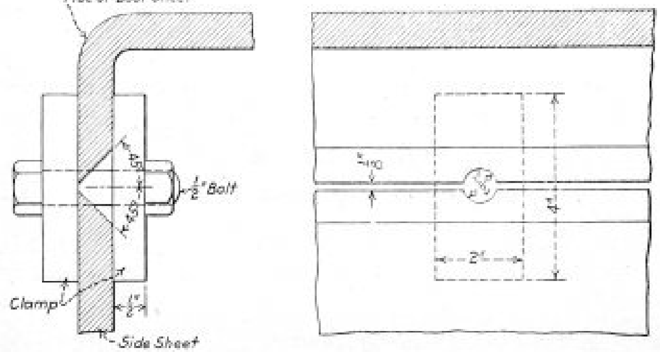



Fig. 7.—Clamp for Holding Firebox Sheets in Line When Welding

dividers set at about 6 inches arcs B are scribed from the edge of the bevel. When the patch is ready to lay off for size, it is bolted firmly into place, as shown in Fig. 2. The lines A are then scribed back on the patch a short distance. With the dividers set at the same distance used before and with the intersections of lines A and B as centers, arcs C are scribed on the patch. Where these arcs intersect lines A, are points on the edge of the patch. A smooth curve is drawn through these points and the patch cut to the line. It can then be beveled and welded in place in accordance with the standard practice at local shops.

Boiler plates cracked through staybolt holes are a common occurrence and often give much difficulty before repairs can be made. One method of overcoming this difficulty is illus-

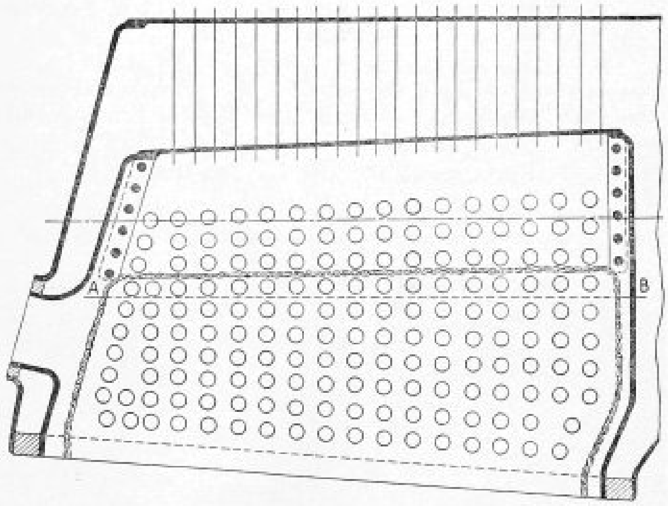



Fig. 8.—Side Sheet Application; Gas or Electric

trated in Fig. 3 in which a new circular section of boiler plate drilled and beveled as shown at the right is applied by welding. It will be noted that the bevels are cut at an angle of 45 degrees and the weld is reinforced by adding 1/16 inch to the thickness of the original plate.

An interesting example of the method of applying mud ring and corner patches is shown in Fig. 4. This operation can be performed either by gas or electric welding, but the caution should be observed of never laying out the patch

(Continued on page 28)

# Forming Press for Boiler and Structural Work

## Special Attachments Make Possible Riveting, Dishing and Flanging Operations on New Press

**By R. A. Horne**

As a result of 25 years' experience in practical boiler making the writer has developed a press for handling the various bending problems that are continually coming up in the boiler shops. The press in question is specially designed for forming plates and bending structural shapes.

The machine itself is built up of structural shapes and is operated by steam, air, or water, whichever is most readily

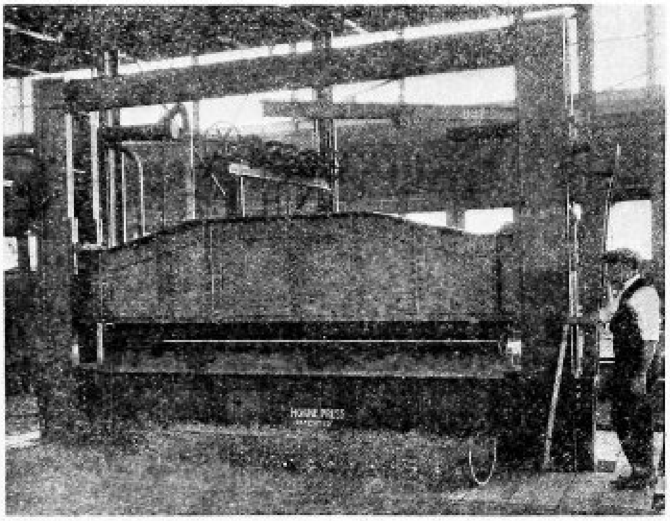


Fig. 1.—Frame and Toggle Arrangement of Plate Forming Press

available and will do the work of the heavier and more cumbersome equipment generally installed for bending and forming.

### Structural Details of Machine

In Fig. 8, the general arrangement of toggles is shown. Here *A* is a cast steel bracket, the bottom of which is made

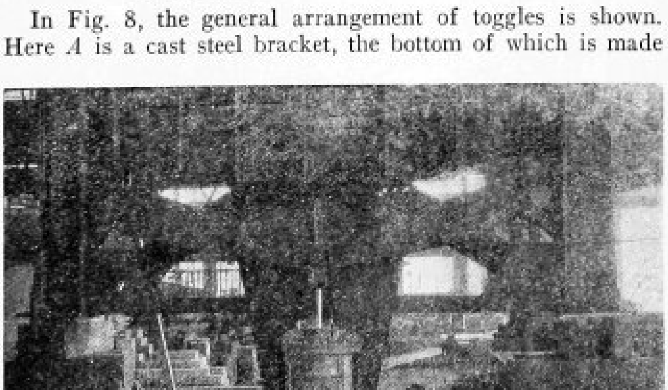


Fig. 2.—Section of Press Below Shop Floor, Showing Lever Arms and Actuating Cylinder

in the shape of a jaw to receive the top part of the cast steel rocker arm *B*. These are joined together by means of a pin passing through the jaw *G*. *A* also acts as a separator for the channels, while *C* is a cast steel link made in the shape of a jaw on both ends and is fastened to rocker arm *B* and bracket *D* with pins. *D* is bolted down on top of the top platten and serves the purpose of raising and lowering it as desired.

In the drawing, the rocker arm *B* and the link *C* are shown in a straight line, but this is not the case in the finished machine. These members assume the position shown by the heavy dotted lines when the piston *I* has made its full stroke and the cast steel lever *F* is in the horizontal position. Lever *F* and rocker arm *B* are coupled together with *A*, the cast steel connecting bar, separated in the center to permit the passing through of long bars, angles, or channels. Levers *F* and *J* are both coupled to the piston rod *I*.

The power requirements of the machine for different capacities vary somewhat. A 30-foot machine, for example,

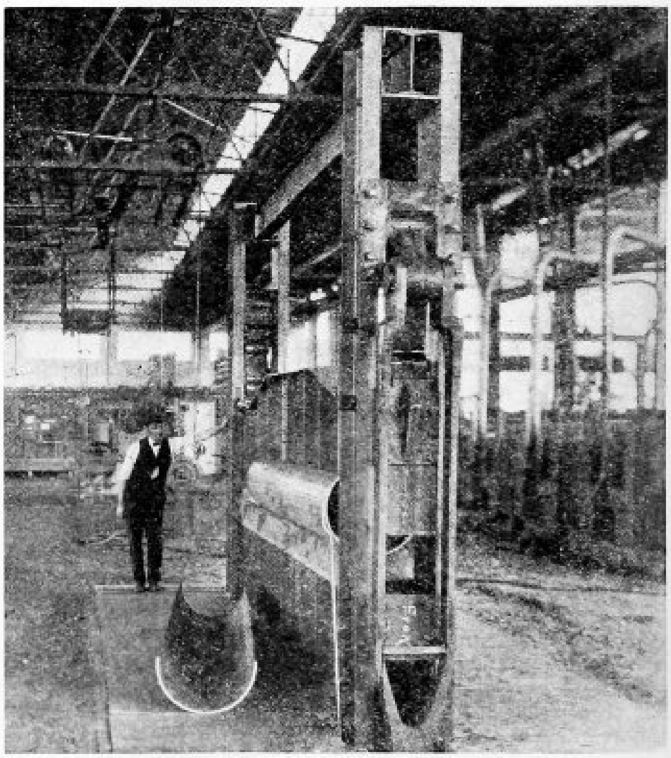
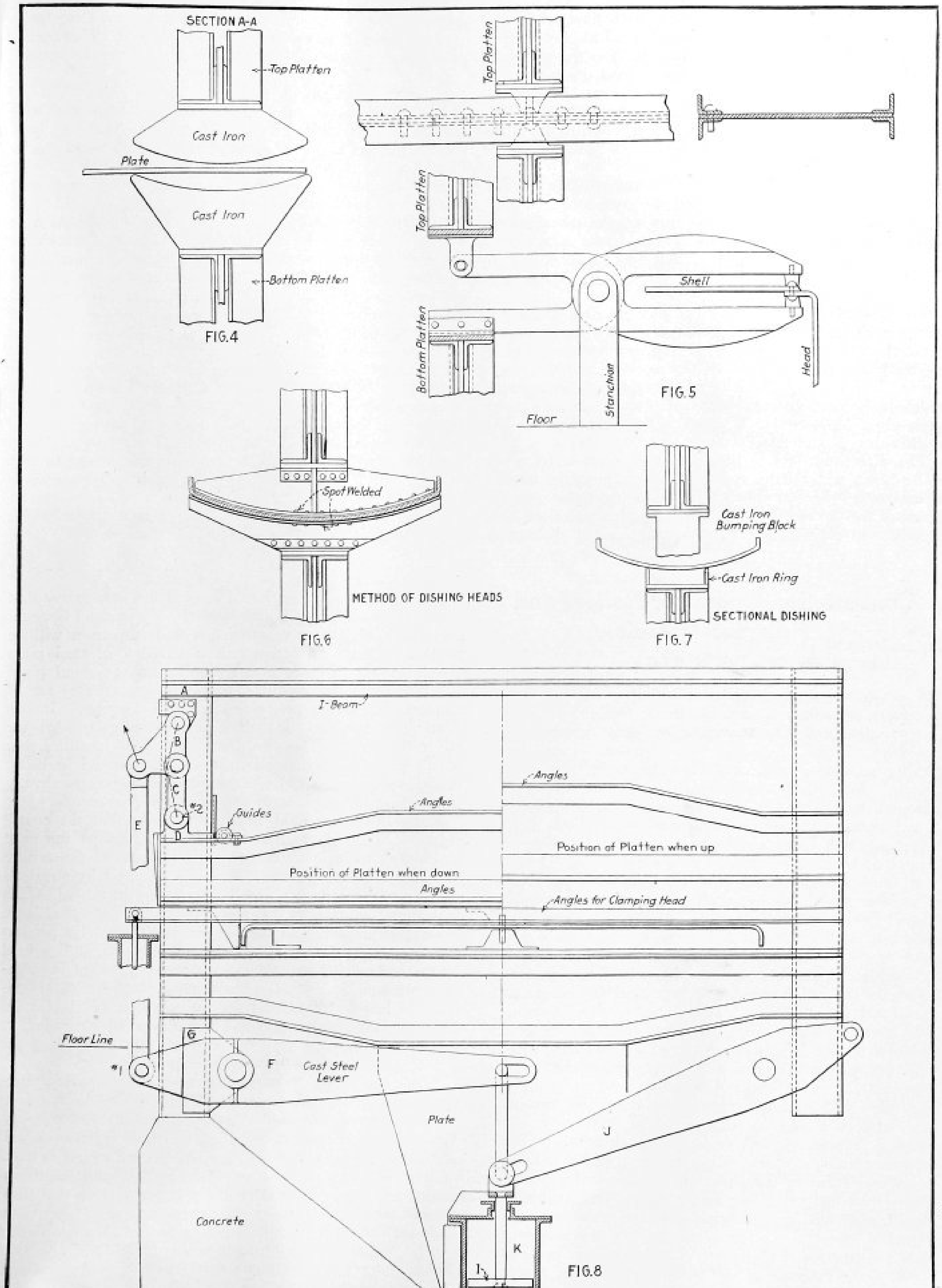


Fig. 3.—Two Sections of ½-Inch Plate Pipe Formed in Press

would require a 30-inch diameter cylinder with a pressure of 100 pounds of air, or if water is used, a cylinder large enough with the pressure of water available to produce 35 tons applied to the piston *I*. The machine is controlled by means of a single lever attached to a four-way valve, which admits the fluid at one end and allows it to flow out at the other.

Fig. 4 shows the manner in which the forms are fastened to the platten for forming long circular plates, butt straps for boilers and the ends of rings to be rolled. In Fig. 5 is shown the method of using the machine in riveting operations, while Figs. 6 and 7 show how heads are dished and flanged. The old method of carrying out this latter operation per-




Details of Press Used for Forming, Flanging, Dishing and Riveting Plate Work mitted the flanging of only one section at a time, while on this forming machine two sections are flanged at once in the following manner: The head is first put into the machine and held centrally by the bracket shown with the pin in it. The head is then clamped by means of the small cylinders indicated at each end. The top platten then moves downward flanging two sections, while the succeeding upward stroke of the platten revolves the head, it being provided with a feed mechanism.

The small cylinders are set on brackets outside of the frame channels of the machine and are detachable, so that when heads are not being flanged they can be taken down. These cylinders, the feed and the main cylinder *K* are controlled from one lever actuating a four-way valve.

### Riveting Operation

Two methods are possible for carrying out rivet operations on the machine, Fig. 5. In the case of riveting for structural parts, the dies are fastened to the top and bottom plattens, the work being passed through the machine and the rivets driven. The riveting of shells requires an extra attachment which is fastened to the bottom platten by means of two angle clips. A stanchion fastened to the floor supports the overhanging part of this device.

The dies shown for dishing heads were made from old boiler heads stiffened by spot welding plates to the outside of the bottom die and spot welding additional plates to the inside of the top die, Fig. 6. This operation was done very rapidly and satisfactorily. Another method of dishing is shown in Fig. 7. By this means, the gores of bottom tanks have been dished as well as various size heads. This operation is done by sections and the dies are not very expensive.

### Machine Has Wide Range of Usefulness

In railroad shops, the forming press has been used with success for straightening sections of steel cars that have been wrecked; it has also been found useful in ship repair yards. Bars, angles, channels and beams of any length may be inserted in the ends of the machine which are open and straightened and bent as desired.

Probably the most advantageous use to which the machine can be put in a boiler manufacturing plant is for forming the ends of drums and butt straps and similar operations that cannot be carried out on the bending rolls. An example of this is given in Fig. 3, where two plates of a tapered steel pipe are being worked. Fourteen steel tapered pipes 80 feet long, 20¾-inch diameter at one end and 28-inch diameter at the other, were formed in the machine for this particular job. Twenty ½-inch plates were used in the fabrication of each pipe. In the machine, the sheets are formed to their true curvature out to the extreme edge of the plate which is not possible on the rolls.

In car tank manufacturing plants this machine has been used for forming long tank bottoms. At the present time it is being built by the Jahncke Dry Dock & Ship Repair Company, New Orleans, La., in sizes 6 feet to 30 feet between housings. The top platten has an 8½-inch stroke which allows ample capacity for all ordinary plate work.

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## Construction Codes for Boilers and Pressure Vessels

### By Donald M. McLean

In designing, manufacturing and selling boilers, air receivers, pressure tanks, etc., for use in Canada, the various regulations and rules governing the construction and installation of such apparatus vary somewhat according to locality and have to be carefully considered. In certain provinces the Canadian inter-provincial regulations are being followed, while in others such regulations have not, as yet, been adopted, although, as a rule, all such provinces have boiler acts and codes of rules of their own, varying in a greater or lesser degree from the inter-provincial standards.

In some cases these provincial acts govern the construction of pressure vessels of nearly all kinds, while in others they control the construction and installation of steam boilers only. In addition, we may have to take into account the rules of the boiler insurance companies when the work is sold subject to their inspection. In some cases, as for example the city of Montreal, there are local regulations to be considered.

Progress is being made, however, towards the general adoption of the inter-provincial regulations which will insure uniformity of legislation and construction practice throughout Canada. It is likely that eventually all such legislation will establish control over the design, manufacture, inspection and installation of all classes of vessels carrying pressure as well as boilers, such as air receivers, rendering tanks, stills, etc. It is not at all probable that any future legislation in this direction will be of a more lenient nature than that prevailing at the present day in those districts having well-defined boiler acts and codes, as there is a general tendency to adopt higher factors of safety in steel plate construction than formerly. This is due in part, no doubt, to the influence of the American Society of Mechanical Engineers' Boiler Code which may be considered as representing the best modern practice.

Taking a broader outlook, it is probably safe to say that at no far distant time, in both the United States and Canada, some form of legislative restriction and inspection will be applied to the construction and installation of steel plate vessels subject to static pressure only, such as stand pipes and large steel storage tanks, particularly when they are of unusual dimensions or possess unusual features. It has often been assumed that these were amply provided for under the building laws in force in various localities, but it will be admitted that all such structures would be better placed under the control of engineers and inspectors already specializing in problems of vessels under pressure.

Many instances could be cited to show that the course suggested above is really necessary, but perhaps the most striking example is afforded by the incident of the failure of a molasses storage tank, 90 feet in diameter by about 50 feet deep, belonging to a distilling company in Boston. This tank burst a number of months ago, wrecking a large amount of property and causing the death of twelve persons and injuries to forty others. On investigation, it was held by the court that the tank was "wholly insufficient in structural strength." Yet, as is well known, the State of Massachusetts has been a leader in the adoption of rigid rules governing the construction and installation of steam boilers and air receivers and has always aimed at guarding the public safety in the most thorough manner.

While much less frequent, instances occur at times where the failure of vacuum tanks by collapse would have serious results as regards probable loss of human life and property. While the principles of good construction are not as well defined in this class of work, particularly with vacuum tanks of large diameter, as they are in connection with vessels intended to contain internal pressure, it would seem that those vessels which are subject to external pressure should be included eventually in the construction and inspection codes of the future. Such structures should include penstocks which under some conditions would be subjected to collapsing pressure and the failure of which might cause considerable loss and inconvenience.

# Principles of Riveted Joint Design—VII

## Danger of Using Lap Seams in Boiler Construction and Proper Reinforcing of Shell Openings

**By William C. Strott***

IN the case of very thick plates, it is difficult to tuck cover plates under overlapping courses of the shell. To eliminate this condition, the construction illustrated in Fig. 44 may be satisfactorily used. No explanation should be required in connection with the drawing, other than that the calking pitches are uniformly spaced between the center lines of the ring seams as usual and that an extra rivet is located in each inner row as shown.

These two rivets are located as near as possible to the girth seam, with only sufficient clearance to permit calking. A soft steel plug about ⅞ inch in diameter fitted with pipe threads is screwed into the gap created by the abutting edges of shell plate. The plug is then riveted over and the edges calked to prevent leakage.

### Scarfing the Ends of Butt Straps and Laps

The purpose of scarfing the ends of butt straps and laps where they merge with the girth seams may best be explained

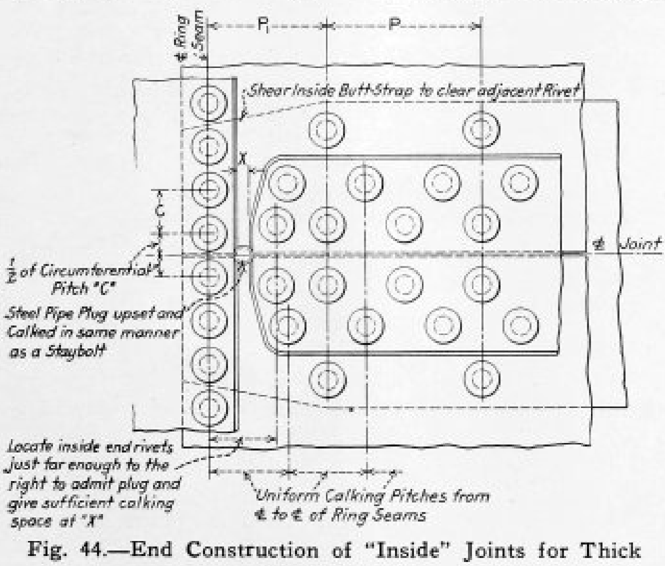


**Fig. 44.—End Construction of "Inside" Joints for Thick Plates**

by a careful study of Fig. 45. In this illustration, it has been assumed that the shell is rolled and the laps formed without scarfing. It should be quite clear from the above that, in addition to creating an open seam, it also forms clumsy "off-sets" in the seams which would throw the shell severely "out of round" and present a crude and unworkmanlike appearance.

If the ends of such underlying plates be scarfed out gradually just beyond the end rivets into very thin edges where they are tucked in between the overlapping plates, then the final result will be as shown in the sectional view *B-B* of Fig. 46. Here it will be seen that there is no possibility of leakage since the calking edge of the longitudinal seam gradually thins out and disappears into the calking edge of the girth seam.

### Advantages of Butt Strapped Joints Over Lap Joints

The practical advantages of butt strapped joints over simple lap riveted joints for the longitudinal seams of boilers, other than their greater strength, are not usually appreciated.

In a plain lap joint, such as illustrated in Fig. 47, the plates are eccentric to each other, the eccentricity being equal

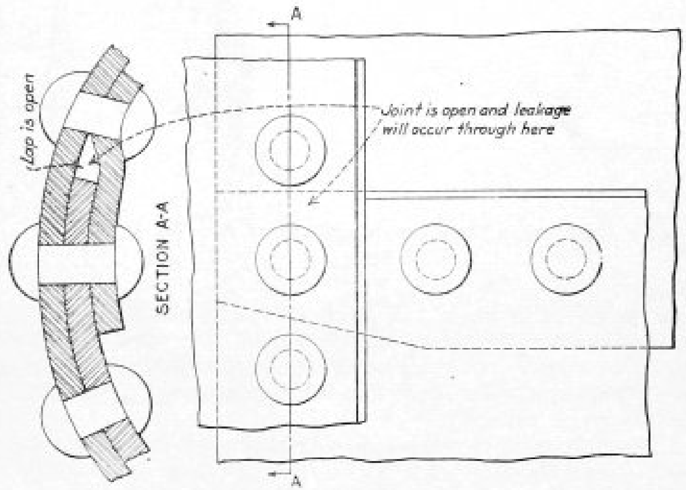


**Fig. 45.—Effect at Seam Juncture When Corner of Underlying Plate Is Not Scarfed**

to the dimension *X* as indicated on the cross-sectional view (a).

A load pulling across the joint in the direction of the arrows, has a tendency to destroy the eccentricity and bring the plates into line. The result is that the plates assume, or tend to assume, the distorted form shown in section (b).

It should be quite evident that the rivets are thereby subjected to considerable tension in addition to their usual shearing stress, because they are true cantilever beams of length

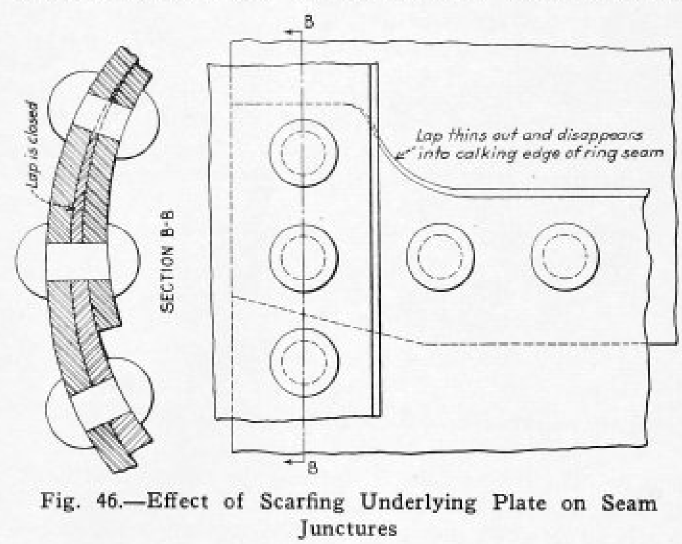


**Fig. 46.—Effect of Scarfing Underlying Plate on Seam Junctures**

*X*. Such bending action eventually opens the seam, causing leakage, with cracked plates as the ultimate result.

### Failure of Lap Joints Due to "Grooving"

Lap joint failures frequently result from what is termed "grooving." The condition illustrated at (b), Fig. 47, is

*Engineering department of The Koppers Company, Pittsburgh, Pa.; formerly designer, Blaw-Knox Company, Pittsburgh, Pa., and Union Iron Works, Erie, Pa.

properly designated as a *physical* action which commences as an incipient crack in the shell just under the edge of the inside lap. The next step towards ultimate failure of the joint occurs by the impurities in the boiler feed water entering this crack and setting up a corrosive action on the metal. This latter process may be termed the *chemical* action. Further distortions of the seam due to the physical action magnify these initial cracks, thereby laying the metal open to further chemical action. Finally a condition is reached sim-

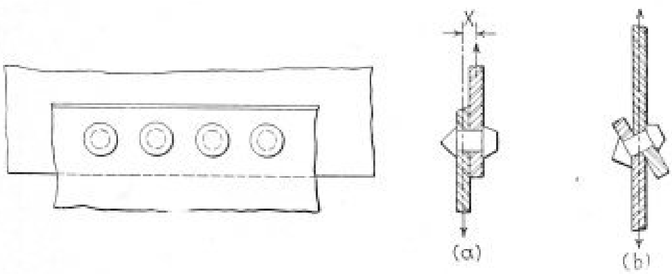


**Fig. 47.—Showing How Bending Stresses Are Set Up in Lap Seams**

ilar to that illustrated in Fig. 48. When this stage of corrosion has been reached, the material has been eaten away to such a depth that the plate is no longer thick enough to resist the tensile stress in the shell, when sudden rupture of the vessel will occur.

The "Locomotive" (the Hartford Steam Boiler Inspection and Insurance Company of Hartford, Conn.), published some years ago a photograph of an exploded horizontal return tubular boiler having a double riveted lap joint for the longitudinal seam. This boiler failed from the cause cited above and the photograph showed the shell plate to have ripped along the edge of the lap, leaving the rivets in the joint intact.

Unfortunately, grooving occurs on the interior of the shell, and usually at a point inaccessible for thorough inspection, as when a portion of the longitudinal seam lies below the tubes. For this reason, a seam in apparently good condition externally may become dangerously affected from this cause before the trouble is discovered, and with fatal results

So many boiler explosions have been traced to lap cracks that in modern practice the lap joint (regardless of the number of rows of rivets) has been condemned for use on boilers designed to carry pressures exceeding 100 pounds per square inch. Examination of the sections of any of the double butt strapped joints previously illustrated will show that the abutting edges of the shell plate are exactly in line and that there can possibly be no distortion of the joint as in (b), Fig. 47.

The eccentricity of cylindrical shells, caused by lap seams,

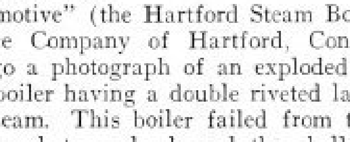

**Fig. 48.—Corrosion of Shell Plate at Edge of Lap Seam**

may be partially overcome by forming the laps as illustrated in Fig. 49. In this way, the shell may be rolled to very nearly a true circle which largely eliminates the strain otherwise thrown on the seam.

The ultimate purpose of this construction is to create an initial distortion by slightly bending the edges of the plate so that the rivets will lie within the mean diameter of the shell. It is evident that this very largely eliminates the bending stress to which the rivets would otherwise be subjected.

It is, however, too costly a practice to bend and fit such laps for simple shell boilers where lap seams are permitted and so this construction is but little used for that purpose. It does, nevertheless, find almost exclusive application in high grade locomotive boilers for the seams of fireboxes and "wagon tops."

### CIRCULAR SEAMS

Numerous openings of considerable size must be provided in every boiler shell, such as for steam pipe and safety valve connections and manhole openings. It is evident that this removal of metal from the shell greatly reduces the strength of the plate in identically the same manner in which the rivet holes of a boiler joint reduce the strength of the plate.

Fig. 50 illustrates the usual elliptical manhole cut in the shell of a boiler. Such openings may be circular, but since a body will pass through an elongated hole with as much ease as though a circular one, it is therefore more economical and at the same time conducive to greater strength to employ oval or elliptical openings for that purpose.

We know that in a cylindrical pressure vessel the *hoop stress* or that which tends to cause rupture of the shell is just twice as great as the *end stress,* or that which tends to force out the heads. Therefore, we make large openings either oval or elliptical in shape and locate them so that their short, or minor axes, will lie in a direction at right angles to the line of greatest stress. This method will remove the least amount of metal from the shell in the direction of its greatest stress.

Suppose that the width of metal removed through line *X-X* of Fig. 50 is 16 inches; that the thickness of the plate

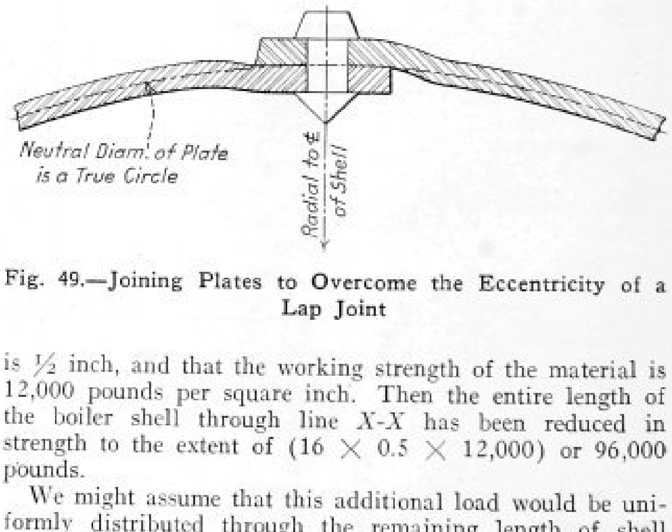


**Fig. 49.—Joining Plates to Overcome the Eccentricity of a Lap Joint**

is ½ inch, and that the working strength of the material is 12,000 pounds per square inch. Then the entire length of the boiler shell through line *X-X* has been reduced in strength to the extent of $(16 \times 0.5 \times 12{,}000)$ or 96,000 pounds.

We might assume that this additional load would be uniformly distributed through the remaining length of shell plate, which for a comparatively long course of plate would not be greater than a few additional pounds per square inch. Practically, however, such an assumption would be erroneous, since actual tests have shown that the load represented by the strength of the shell plate removed is then concentrated in the plate at the edges of the hole and failure by tearing of the plate occurs at these points identically as illustrated in Fig. 51.

It is obvious, therefore, that the edges of all large openings in shell plates must be reinforced in order to prevent such failure. This is accomplished by riveting one or two reinforcing rings (one on the inside, or the outside or on both) to the edge of the hole, as in Fig. 51. The riveting of reinforcing rings for either style may be single or double riveted as required to give the necessary strength to withstand the stresses set up in service.

The combined net sectional area of the ring or rings through lines *B-B* must evidently equal the cross-sectional area of the shell plate removed, and the thickness of any ring shall not be less than that of the shell plate removed.

The following formulæ are quite simple in theory and should require no additional explanation:

Notations employed in all calculations:

W = Width of reinforcing ring in inches.
t = Thickness of shell plate in inches.
$t_1$ = Thickness of reinforcing ring in inches.

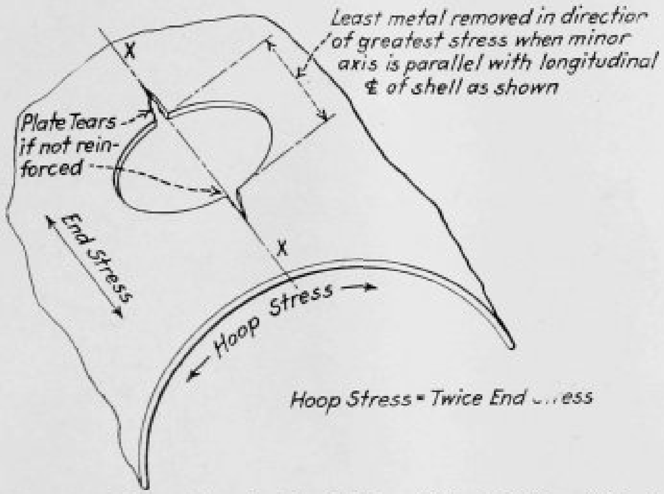


**Fig. 50.—Illustrating the Possibility of Plate Failure Due to Shell Opening**

d = Diameter of rivet holes in inches.
$T_s$ = Ultimate tensile strength of reinforcing ring in pounds per square inch.
C = Crushing strength of the plate in pounds per square inch.
A = Combined net sectional area of one side of the ring or rings in square inches.
a = Cross sectional area of one rivet hole in square inches.
S = Ultimate double shearing strength of the rivets in pounds per square inch.
s = Utimate single shearing strength of the rivets in pounds per square inch.
1 = Length of shell plate removed in a line at right angles to the line of maximum stress.

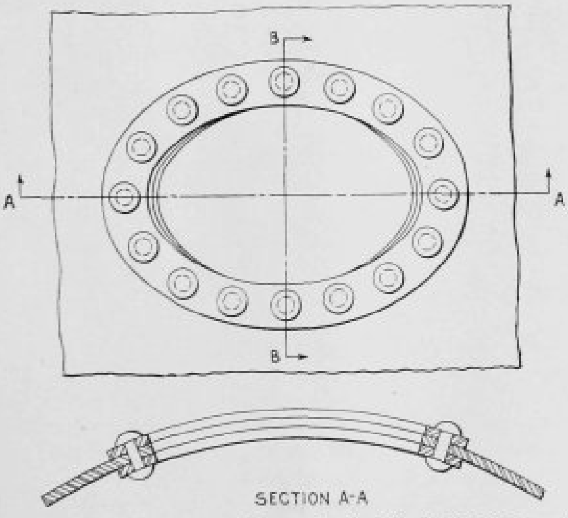


**Fig. 51.—Reinforcement for a Cylindrical Shell Opening**

N = The total number of rivets on one side of the ring or rings.
n = Number of rivets in a unit length of circular seam.

The formula for "W", for one single riveted ring is:

$$W = \frac{1 \times t}{2 \times t_1} + d.$$

For two single riveted rings:

$$W = \frac{1 \times t}{4 \times t_1} + d.$$

For one double riveted ring the width for the reinforcement is:

$$W = \frac{1 \times t}{2 \times t_1} + 2d.$$

For two double riveted rings:

$$W = \frac{1 \times t}{4 \times t_1} + 2d.$$

In some cases it is frequently desirable to assume the least width of rings practicable and then solve for their required thickness. The following formulæ are presented for convenience, and were simply arranged from the preceding formulæ.

The formula for $t_1$ for one single riveted ring is:

$$t_1 = \frac{0.5 \times 1 \times t}{W - d}$$

For two single riveted rings:

$$t_1 = \frac{1 \times t}{W - d}$$

For one double riveted ring:

$$t_1 = \frac{0.5 \times 1 \times t}{W - (2d)}$$

For two double riveted rings:

$$t_1 = \frac{1 \times t}{W - (2d)}$$

Obviously, the rivets attaching the reinforcing ring or rings to the shell must be of such size and number that their combined shearing strength on one side of the hole will be at least equal to the combined net cross sectional area of the rings.

The diameter of the rivets employed is usually the same as in the other joints of the boiler. The number of rivets required may then be found from the following formula:

$$N = \frac{5.1 \times T_s \times A}{(S \text{ or } s) \times d^2}$$

Note—In the above formula, the rivets are in double shear when two rings (one upper and one lower) are employed; single shear when only one ring is used.

Figs. 52 (a) and (b) are very plainly single riveted, and Figs. 53 (a) and (b) are of course double riveted.

In a circular seam there is evidently no positively defined unit length, as in the case of the straight seams we have heretofore dealt with. However, experience and actual tests have borne out that for openings not exceeding 16 inches in any direction, a unit length may be considered as one-half the span of the bolt circle measured at right angles to the line of maximum stress. The number of rivets should be even and arranged symmetrically about the centerline of the opening. The spacing should be such that dimension $\frac{D}{2}$ will either cut the rivets or bisect the rivet space, which is very clearly indicated in the illustrations.

The efficiency of the plate ligaments in these unit lengths is calculated in the same manner as for a straight seam. The following equations should by this time be thoroughly familiar, and their application to practice necessitate no difficulty:

Strength of solid plate in a unit length:

$$W = \frac{D}{2} (t \times S)$$

Net strength of plate in a unit length:

$$T = (\frac{D}{2} - nd) \times t \times S$$

(*Continued on page 28*)

# Cleaning Boiler Tubes With Modern Equipment

## Dry and Wet Rattlers Have Charging Capacities Up to 350 Standard Size Locomotive Tubes

RECLAMATION of locomotive boiler tubes and flues has grown to be an important feature in the maintenance of locomotive boilers and requires the use of highly developed equipment. Practically the entire success of the reconditioning, however, depends on having the tubes absolutely clean from scale and grease to start with, and this phase of the tube reclamation process is discussed below. Not only for safe ending, but also where a set of tubes is to be reinstalled in an engine undergoing repairs is it necessary to have clean tubes, because the operating efficiency of the boiler largely depends on their condition.

Special machines have been developed to speed up the tube cleaning operation in the shop and these machines are located where they will fit most conveniently into the scheme of shop production. The cleaner is generally placed where the shop crane can be used to load and unload it and so that the clean tubes may be carried directly to the racks for safe ending, if they are intended to go through this process. Tubes are handled by members of the flue shop crew during the cleaning process, but so well does the work fit in, that the normal production of this department is in no way interfered with.

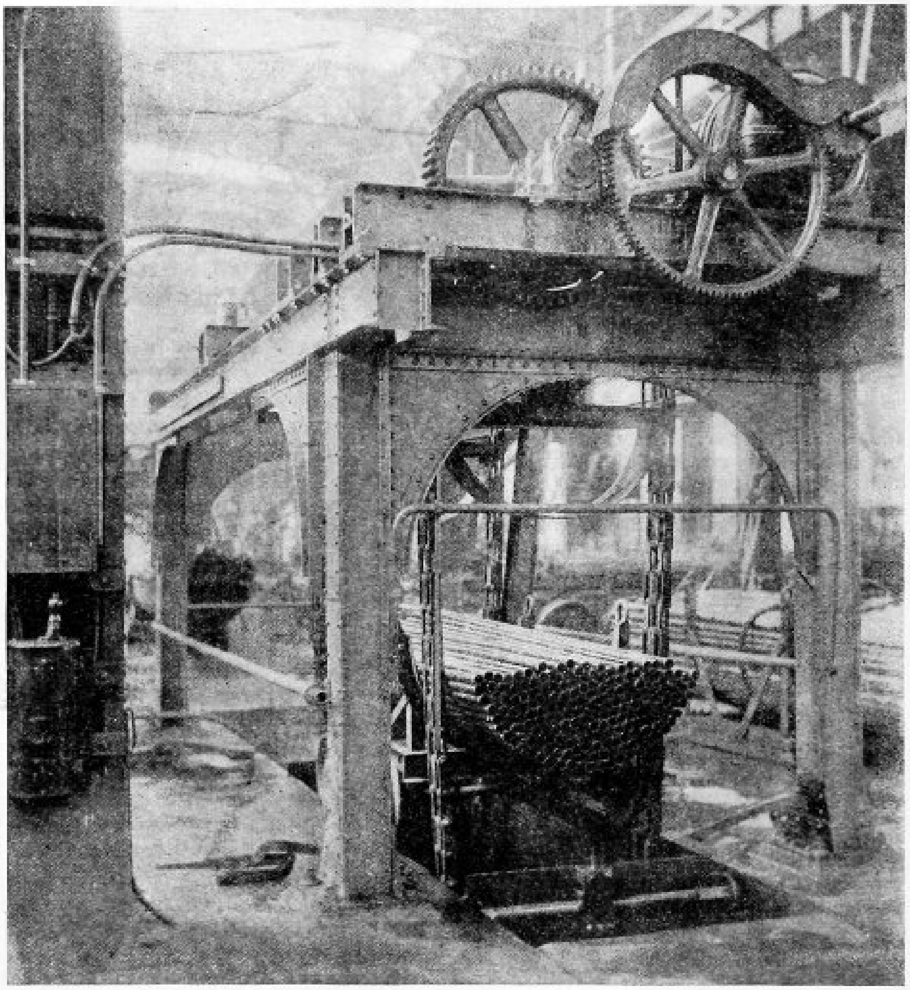

Fig. 1.—Overhead Framework Type Submerged Tube Cleaner, Charged and Ready to Begin Operation

Formerly where the cleaners were located outside the shop at some distance, tubes were handled with considerable inconvenience, and it was necessary to keep at least two men busy loading and unloading the machine.

Tube cleaners in general may be divided into three classes —rotary single tube cleaners, dry rattlers and wet rattlers.

### Rotary Type Single Tube Cleaner

For shops having a small number of tubes to clean daily the rotary single tube cleaner has sufficient capacity. The larger shops find it more economical to use one of the other types. The rotary cleaner is particularly useful for handling tubes incrusted with heavy scale which cannot be readily removed in the rattler.

The rotary type machine illustrated has been designed for a capacity of tubes from 1½ inches to 6½ inches outside diameter. This capacity makes possible the cleaning of both standard size and superheater tubes in the same machine.

The machine consists substantially of a cast base on which the cleaning mechanism and driving attachment are mounted, the latter arranged for either belt or motor drive. While the tube is being cleaned an automatic feed mechanism carries it through the cleaning rolls, the speed of feeding being proportionate to the diameter of the tube. For superheater flues this speed is about 10 feet per minute, while for standard 2-inch sizes it is about 18 feet per minute.

### Dry Rattler

The dry type rattler has the advantage of cheapness and simplicity while its chief advantages are noise and dirt which usually result in locating it in a separate building or in the open.

The cylinder or barrel of the machine is made of boiler steel, usually having shelves or projections inside to lift and drop the tubes rather than to allow them to roll about freely at the lowest point of the shell. The barrel is supported on trunnions and is revolved by gears. Charging and discharging is carried on either through an opening in the end, one tube at a time, which requires the service of one man inside and at least one outside, or through a long narrow opening in the side closed by a hinged boiler steel door. This type can be charged with practically no hand labor if an overhead crane is available and can always be discharged through the hinged door by rotating the drum until the door is at the bottom when the tubes will roll out as the door is opened.

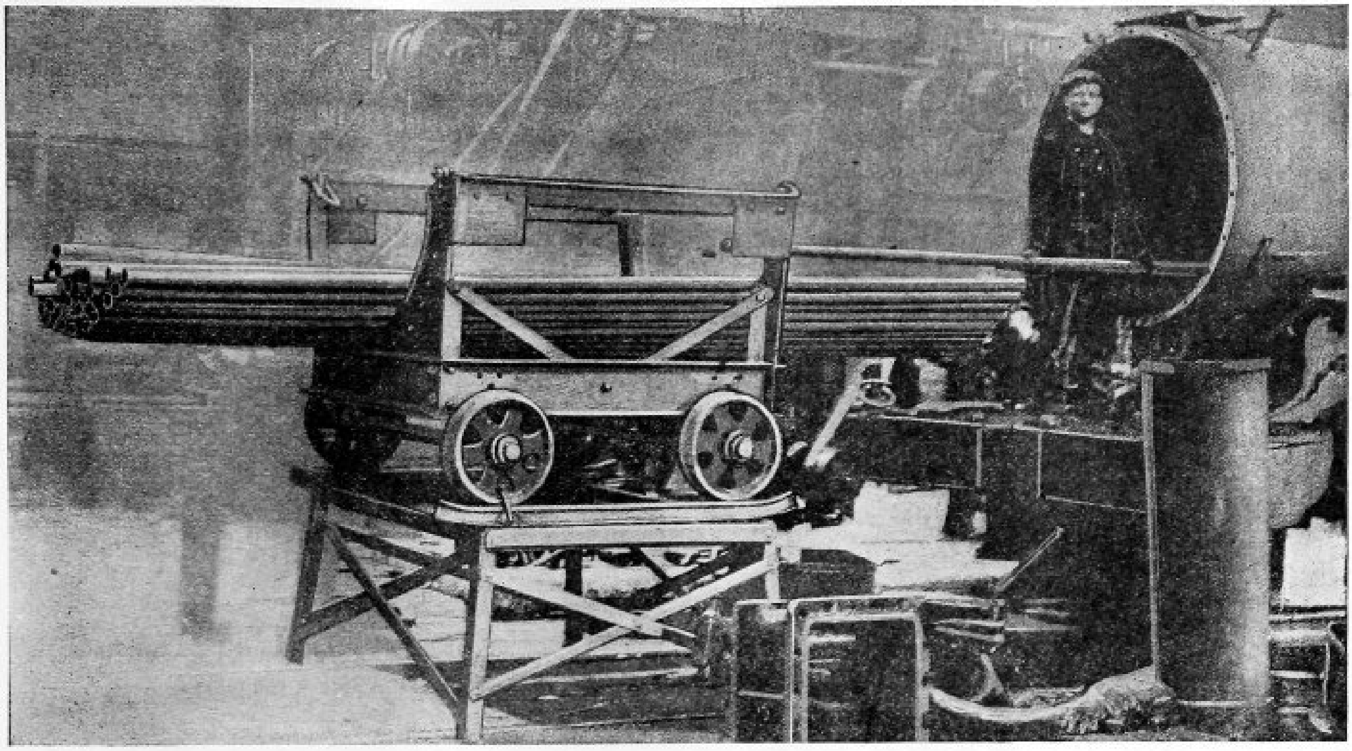

Fig. 2.—Loading the Tube Truck Which Is Used for Charging the Overhead Framework Type Cleaner

For these reasons it is decidedly preferable to the machine with end openings.

### WET RATTLER TUBE CLEANERS

There are three types of wet rattler tube cleaners, the roller barrel similar to the dry type, it having in addition a flow of water to soften the scale and keep down the dust, the submerged revolving chain type with a superstructure and the submerged revolving chain pit type. The operation of the submerged superstructure type is carried on with the tubes partly submerged in water which softens the scale and keeps down the dust and noise. During the process the tubes are made to rub and drop against one another, thus scraping and knocking off the scale.

The latest type machine for this work consists of a heavily constructed overhead steel frame work which carries the driv-

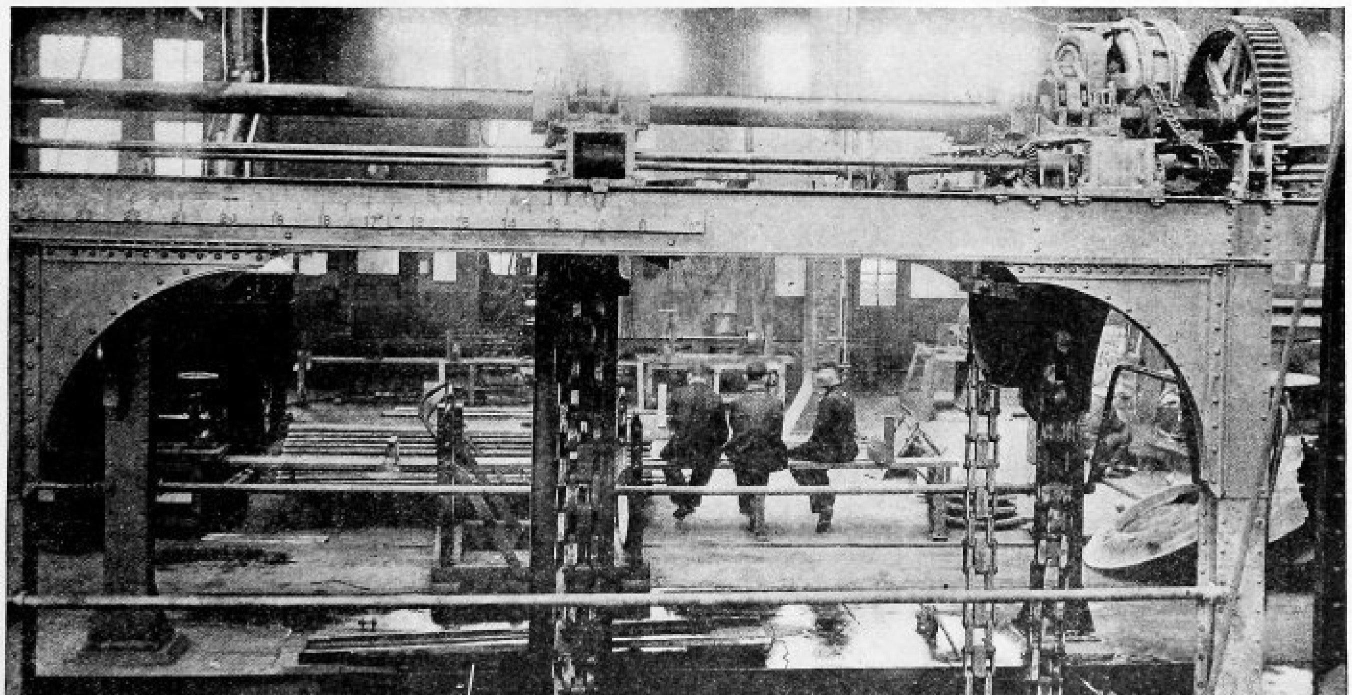

Fig. 3.—General View of a Revolving Chain Cleaner, the Capacity of Which Is 350 Standard Size Tubes at a Time

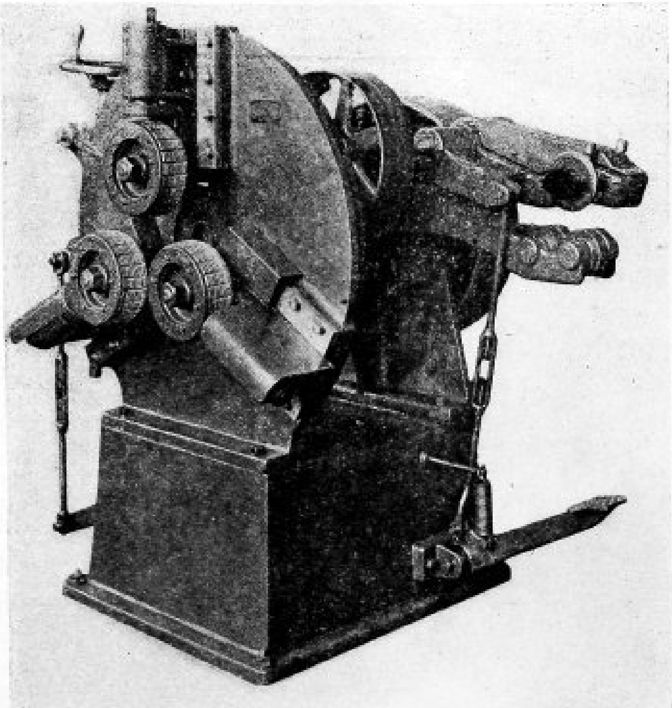

Fig. 4.—Rotary Single Tube Cleaner for Standard Size and Superheater Tubes

ing mechanism and two heavy case hardened chains which hang down into a pit set into the shop floor. The chains form two loops for supporting the tubes to be rattled. These chains are actuated by four heavy sprocket wheels which are geared to driving motors. While the chains are in motion the tubes are caused to roll over and over upon themselves in the cradle formed by the loops. Adjusting screws make possible the setting of the outer chain to accommodate tubes from 10 feet to 24 feet in length.

A special arrangement of the driving mechanism allows the tubes to be raised from or lowered into the pit, which facilitates handling, for with this system they can be run onto the machine or removed from it on a push car.

The pit is of concrete construction and is set with its top level with the floor line. While the cleaning operation is

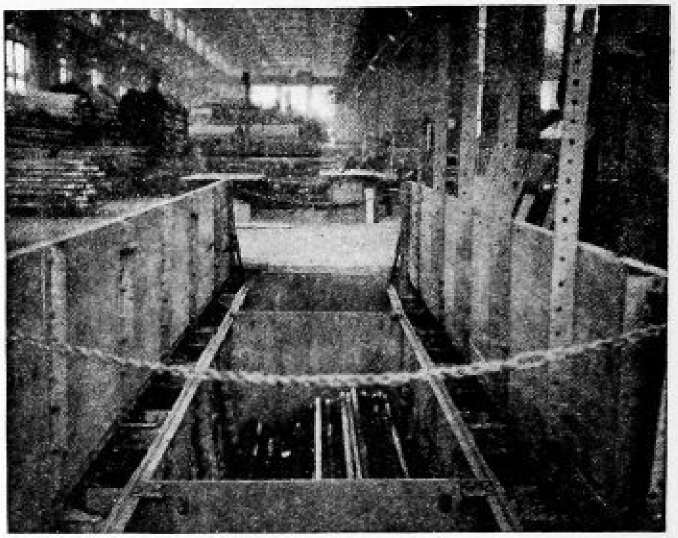

Fig. 6.—Underground Pit Type Cleaner

going on, steel doors are used to cover the pit which cuts down noise and dirt. The capacity of the machine is about 350 two-inch tubes, almost twice the number that can be accommodated in the roller barrel type.

UNDERGROUND PIT TYPE CLEANER

The submerged pit type cleaner is similar in principle to the type described above except that there is no superstructure and so the metal chains cannot be used to load or unload the rattler which necessitates the use of a shop crane or hoist of some description. Both these latter types have the advantage of large capac ty and speed with less power requirements for driving and the advantage of adjustability to any required length up to 24 feet.

(Continued on page 28)

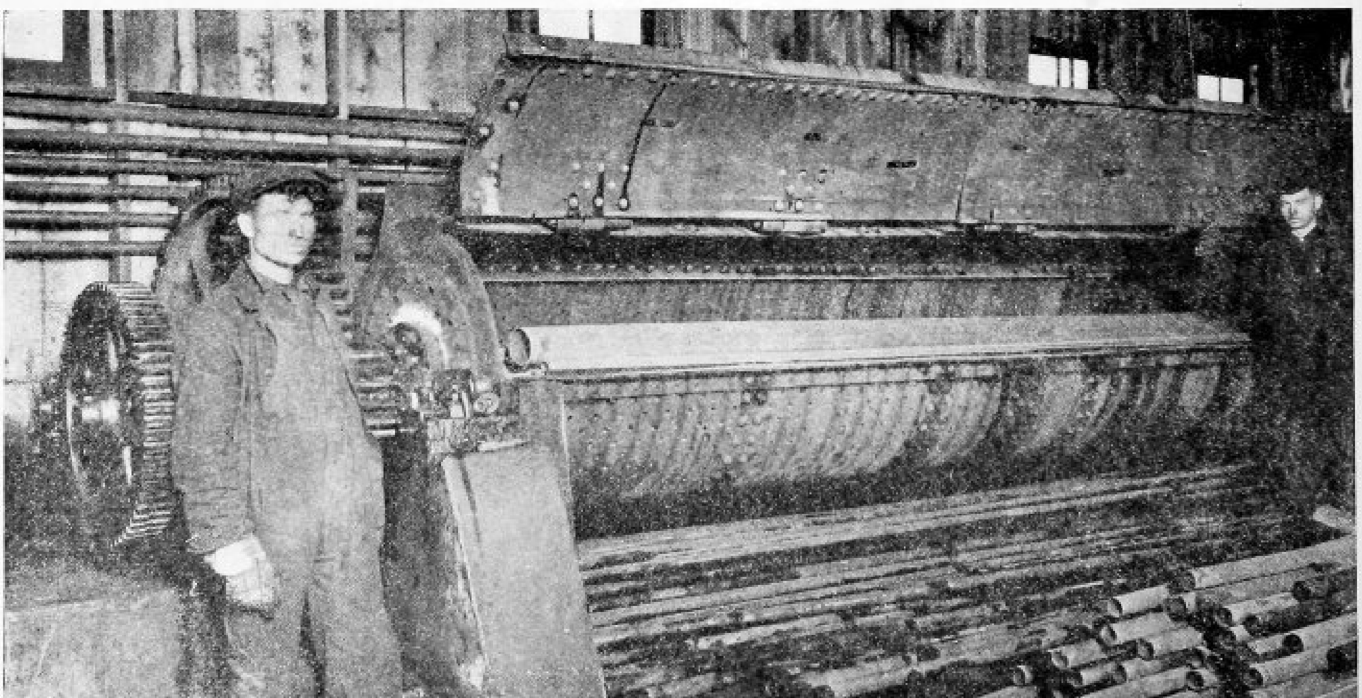

Fig. 5.—Barrel Type Rattler Charged With a Set of Superheater Flues

# Carrying Out Shop Inspections on Steam Boilers

## Methods of Building Boilers to Conform to the American Society of Mechanical Engineers' Boiler Code

**By D. R. Long**

A GENERAL appreciation of the necessity of building boilers right has resulted in legislation affecting boiler design, construction, installation and operation in many states. At the present time, most of the states which have adopted the American Society of Mechanical Engineers' Boiler Code require the inspection of boilers during their construction. Boiler manufacturers, as a body, never wished to build inferior boilers, but before they had the protection of the law they were forced to build boilers by methods which might have been improved upon, due no doubt to competitive conditions. Under these circumstances the boiler manufacturer who had the lowest price made the sale and inspection was practically unheard of until the insurance inspector examined the boiler after it had been installed.

Later a number of manufacturers, appreciating the desirability of good workmanship, took advantage of the service provided by the insurance companies by having their boilers inspected during construction. At the present time, practically all of the large boiler manufacturers employ this inspection service to safeguard their patrons, as well as to comply with the various state laws.

The American Society of Mechanical Engineers' Boiler Code was drafted to provide a set of rules for the construction of safe boilers. An inspector making a shop inspection of a boiler makes the necessary examination to determine whether the boiler complies with the American Society of Mechanical Engineers Code. While the application of the Code to boiler construction is broad, at the same time it specifies materials and methods of manufacture specifically enough to insure safe boilers.

### Machinery Required to Make a Standard Boiler

When an inspector visits a boiler shop for the first time, he is concerned with the shop equipment, because it is evident that certain equipment is necessary to produce a standard boiler. Generally speaking, the equipment required is as follows:

1. Plate rolls capable of rolling butt straps and the ends of sheets or ordinary plate rolls supplemented by some apparatus, making it possible to form the ends of sheets and narrow strips by the application of pressure.
2. Plate planer or miller for removing sheared edges.
3. Equipment for drilling or reaming rivet and tube holes.
4. Hydraulic riveters.
5. Round nosed calking tools.
6. In addition to the above, of course, there will be the usual punches, shears, lathes, drill presses, power hack saws, forges, etc., and machinery incidental to a manufacturing operation of this kind.

In addition to paying particular attention to the shop equipment, the inspector usually is interested in the man handling the equipment, because it is a well recognized fact that no matter how good the equipment provided, poor boilers will be produced if the workmen are careless or ignorant of their business.

The inspector usually makes three visits to check up the work on a given boiler. Of course, the inspector can follow the construction of several boilers equally as well as one if a number of boilers are being built at the same time. In performing this work, the inspector is interested in the character of the workmanship on the boiler and whether it complies with the Code.

### First Visit to the Shop

The inspector is usually informed by his office that a boiler is in the course of construction and frequently calls at the shop before work is commenced to ascertain the particulars in regard to the construction of the boiler. At this time he usually identifies the sheets which will be used in the construction of the boiler and locates the manufacturer's stamps and heat numbers. It is very important that he identify each sheet, butt strap, head or other piece of plate entering into the construction of the boiler and for this reason he is apt to ask whether butt straps will be sheared from the plates, or if other narrow pieces are available and he will want to locate the stamps on each of the plates. The identification of the various sheets, butt straps, heads, etc., is sometimes made after the sheets have been rolled and are being drilled or reamed.

After the identification is made, the physical and chemical properties of the plates are copied from the mill test report, in order that a record of them will be available for the official inspection report. After the inspector has identified the plates and been satisfied of their acceptability, he will examine the method of drilling or reaming the rivet holes.

He will also wish to convince himself that all burrs have been removed after the plates have been drilled or reamed in position.

The calking edges will also be carefully examined, because it is necessary that these edges be planed or milled sufficiently to remove any of the metal injured by shearing.

The curvature of shell plates and butt straps is also very carefully observed, because it is of extreme importance that plates and butt straps be rolled to a true and regular curvature. The methods employed by the inspector in determining this feature will be largely contingent upon the equipment in the shop. In this connection attention is called to the fact that the old practice of forming butt straps and ends of plates by blows from wooden mauls, or a practice, which was worse, of letting them go unformed, has been, without question, responsible for many of the boiler explosions reported during the past 20 years. The lap joint, which is now considered obsolete for high pressure boilers because of the danger from the well known lap joint crack, caused by a "breathing action," no doubt developed this defect, because of the fact that sheet ends were very rarely formed in a satisfactory manner 20 years ago.

The inspector will insist that when riveting is being done, plates and butt straps be held firmly in place by barrel pins and tack bolts. The usual procedure, of course, is to drive a rivet on each side of a tack bolt before the bolt is removed. Riveting must be done wherever possible on hydraulic riveters and it is important that the operators permit the rivets to cool under pressure.

### Inspector's Second Visit to Shop

Before leaving the shop on his first visit, the inspector ascertains when the riveting will be completed and arranges to make another inspection of the boiler when the tubes are being installed. He will insist that the tubes be drilled or reamed to size, and also that all sharp edges be removed.

Some manufacturers chamfer both sides of the tube holes with a special tool. This practice is desirable, because it gives the tube an excellent bearing. Tubes must be rolled or expanded and beaded in horizontal tubular boilers, and must be rolled and flared in watertube boilers.

### Annealing Plates After Flanging

On work where flanging is necessary, the inspector will usually be found to favor machine flanging and will insist, in cases where more than one heat is necessary, that the plate be annealed after the flanging is completed. The inspector usually has an opportunity to examine flanging operations on his second visit, depending of course upon the type of boiler being built.

The third visit is made after the boiler has been completed. The boiler by that time is usually on the testing floor filled with water. A hydrostatic pressure test of 150 percent of the working pressure is applied to the boiler.

At this test the safety valve connection is usually covered with a blank flange, but if the safety valve is in place the inspector will insist that it be gagged, no adjustment of the safety valve spring being permitted for a hydrostatic pressure test. After this test has been completed, the inspector will carefully examine every part of the boiler internally and externally. All of the measurements required on the American Society of Mechanical Engineers' shop data report are taken with an accurate steel tape or rule. The workmanship on the boiler is carefully observed both internally and externally and any imperfections or serious leaks are corrected.

In the important work of correcting defects the boiler shop people and inspectors usually get along well. Occasionally, however, there may be slight disagreements in regard to calking leaks or other minor imperfections. It is generally conceded that it is unwise to calk rivets or tubes, which are weeping slightly at the hydrostatic test in the shop, because of the fact that leaks very frequently develop after the boiler has been shipped. Serious leaks, however, must have attention in the shop, because it may be necessary to cut out a rivet or in some cases several rivets to correct the evil.

As stated above, such defects while they frequently cause good natured arguments are usually agreed upon without reference to the head office of the insurance company or state department because both manufacturer and the boiler inspector should have one purpose, that being to produce boilers which are safe and satisfactory.

After the boiler is completed, it must be stamped with the required numbers. Most state laws require the following:

1. The manufacturer's serial number.
2. A state number.
3. The A. S. M. E. standard number.
4. The insurance company's serial number.

It is very important that before stamping numbers on boilers, the person who is to do the work familiarize himself with the state law in regard to this important matter and, if any question arises, the inspector should be asked for information.

### The American Society of Mechanical Engineers' Data Report

This report is now accepted as the standard by all boiler manufacturers and most states. The report may be made out either by the shop people or by the inspector. If made out by the shop people, it will be checked by the inspector before he signs it, and naturally if made out by the inspector the shop people will be inclined to check it before their signature is placed upon it. Five copies of this report are usually necessary: one for the shop people, one for the party for whom the boiler is built, one for the state department and two for the insurance company's files.

### Boilers in General

The life of a properly designed and constructed butt joint boiler is indefinite and apparently is limited only by the care given the boiler after installation, because serious defects due to structural faults do not develop frequently. The careful construction of boilers now means safe boilers for the next generation. It therefore behooves all concerned to use every precaution to prevent any structural weaknesses or faults which may tend to make boilers unsafe.

# Avoidable Waste in Locomotive Operation as Affected by Design*

**By James Partington†**

IT SEEMS advisable to consider this subject from the constructive standpoint of indicating what constitutes good design as demonstrated by locomotives in actual service, rather than to attempt to point out the defects in locomotives which do not show maximum efficiency. If any power plant or engine is not properly proportioned for the work it has to do, the most expert skill in operation can reduce only in part the waste resulting from having such equipment in service.

First, considering the design of steam locomotives from the standpoint of new equipment, when a railroad company is in the market for new locomotives its requirements may be met sometimes by duplicating locomotives in service on their road, but adding newly developed attachments which make for increased efficiency and economy. More frequently, however, it will be found that increased traffic, change from wooden to steel cars, improvement in track, roadbed and bridges, etc., will justify and make advisable the adoption of locomotives of a larger and more powerful type.

Then careful consideration must be given to service requirements—maximum loads to be hauled, capacity of cars, approximate proportion of loaded to empty cars per train, grades, curves, running time over divisions, maximum allowable load per axle, location of coal chutes and water tanks, clearances, conditions under which trains must be started, and any other special requirements of the service.

### Fuel Economy

As standard practice in modern locomotives, a sectional brick arch in the firebox and a firetube superheater should be applied as a means of saving fuel in any class of service. A sectional brick arch is low in first cost, easily applied and easily renewed. It usually accomplishes a fuel saving of from 10 to 12 percent in coal-burning engines, and about 5 percent in oil-burning engines.

The very general use of superheaters has gradually brought about improved conditions of cylinder lubrication which now make it possible and desirable for the greatest economy to

*Abstract of paper presented at the meeting of the railroad division of the American Society of Mechanical Engineers, New York, December, 1921. This abstract includes such sections of the general subject of locomotive design as affect the construction of the boiler.

†Estimating engineer, American Locomotive Company.

use a high degree of superheat, 250 to 300 degrees F. now being considered the best practice. A saving of 25 to 30 percent can be obtained.

The use of feedwater heaters will further conserve fuel, and these are now in general use in continental Europe and are gradually being applied to locomotives in the United States. The saving that can be realized is as much as 12 percent. The initial cost is considerable, but the effect of the feedwater heater in operation, aside from fuel economy, will be to help reduce other boiler maintenance charges.

The general proportions of the boiler should also receive careful consideration. For the best results with bituminous coal, the length of the boiler tubes should be approximately within the following limits:

| Size of tube, inches | Distance over tube sheet |
|---|---|
| 2 | 18 feet 0 inches to 19 feet 6 inches |
| 2¼ | 22 feet 6 inches to 24 feet 6 inches |
| 2½ | 28 feet 0 inches to 30 feet 0 inches |

For many designs of locomotives, a combustion chamber can be provided, and this will help further in the economical production of steam. A generous steam space should be provided and the throttle designed and located to secure dry steam. The evaporative capacity of the boiler should be as nearly 100 percent of the maximum steam requirements of the cylinders as the type of locomotive will permit. Based on 100 percent boiler, the grate area should be sufficient to prevent the maximum coal consumption per square foot of grate per hour from exceeding, for bituminous coal, 120 pounds, and for anthracite coal, 55 to 70 pounds, depending on size.

When the total coal consumption exceeds 6,000 pounds per hour, it is generally necessary to apply an automatic stoker. These have now been so adapted to locomotive requirements that a properly designed stoker will show economy over hand firing, aside from the necessity of its use on account of the coal consumption being greater than the physical capacity of one fireman if the boiler were hand-fired.

The arrangement of deflector plates and netting in the smokebox should be carefully adapted to the fuel and combustion conditions, to provide minimum fuel waste and minimum back pressure in the cylinder exhaust passages with proper provision against fire hazards which might obtain by the throwing of sparks.

### Cost of Repairs

It has been pointed out that locomotives and tenders should be designed to produce the required drawbar horsepower with as little excess weight as possible. In this connection, however, due consideration must be given to the question of repairs.

The design of boilers from the standpoint of weight is practically fixed by existing boiler regulations, which provide that locomotive boilers must be operated with a factor of safety of not less than four. Practically all boilers at the present time are designed with a factor of safety of 4½, which leaves a comfortable margin between this and the minimum allowable operating factor.

The maximum stresses in other parts of the locomotive must also be carefully considered, and the parts must be designed to keep these stresses within limits which will eliminate costly failures in service.

Aside from the consideration of stresses, much repair cost can be avoided by adopting designs which reduce the number of parts, as far as reasonably may be, especially where these parts must have bolted connections. Here, however, care must be taken to avoid construction which cannot readily be removed for repairs or renewals or repaired in place with reasonable facility.

The repair shop facilities must, of course, be kept abreast of the requirements; *i.e.*, as new and larger locomotives are put in service, turntables, cranes, machine tools, etc., must be of sufficient capacity to handle the larger equipment economically.

The repairs of locomotives can often be facilitated and the necessary shop equipment kept down to the minimum by securing from the locomotive builder many parts which he is able to turn out more accurately and more economically than the average railroad shop would be equipped to do. Such parts include: flanged sheets for boiler repairs; flexible and ordinary staybolts; finished bolts and nuts; drop forgings; packing rings for pistons and piston valves and special equipment which requires special tools for its production.

Without attempting to pursue further the design of new locomotives it may be remarked that a study of the special conditions of individual railroads is necessary to secure equipment best suited to the needs of each.

### Old Motive-Power Equipment

Much waste in locomotive operation can be avoided by making a careful survey of present motive power equipment which is not giving as economical or efficient service as could be obtained if the engines were modernized. This applies particularly to locomotives where the service conditions demand more power than the present equipment can economically produce. All the suggestions made in regard to the design of new equipment are applicable to a greater or less degree to old equipment, providing the old equipment is not meeting the demands of the service from a power standpoint, or is not furnishing this power economically.

In making a survey of this character care should be taken to determine accurately whether the old equipment will warrant the additional cost of changes and betterments necessary to convert it into up-to-date power. This can be decided by taking the number of years the engines will be retained in service and the increased net return or saving for this period as against the cost involved for changes, interest on the additional investment, increased maintenance, etc.

A comparison should also be made with the results that could be realized by the purchase of new equipment best adapted for the service, as against the cost of contemplated changes in the old equipment. If these comparisons show a saving in favor of modernizing the old equipment or the purchase of new equipment, every month that the engines are kept in service without doing this will result in a loss that is not recoverable.

A few concrete examples of what has been accomplished in service by locomotives designed to yield maximum efficiency may be of advantage. Notable designs, for which data is available, are as follows:

Pacific type passenger locomotive No. 50000 built by the American Locomotive Company; Decapod type freight locomotive, Class I 1s, built by the Pennsylvania Railroad and heavy Mallet special service locomotive built for the Virginian by the American Locomotive Company.

### American Locomotive Company Engine No. 50000

Locomotive 50000 was built by the American Locomotive Company in 1910. It was designed and constructed at the builder's expense to demonstrate the maximum tractive power with adequate boiler capacity that could be obtained while keeping the adhesive weight below 60,000 pounds per driving axle.

Untrammeled by any outside specifications or the necessity of conforming to any railroad's existing standards, the builders had a free hand to embody in this design their ideas of the best engineering practice. To accomplish the purpose of the design—the maximum capacity per pound of weight—the largest boiler capacity within the predetermined wheel loads was the essential feature.

This end was obtained by eliminating every pound of weight in all the parts that was not necessary to strength and durability, utilizing the weight thus saved to provide a larger boiler and by increasing the capacity of the boiler thus secured by combining in one design the most approved fuel saving devices to obtain the utmost economy in boiler and cylinder performance.

Many of the large Pacific type locomotives with drivers 75 inches in diameter and over in operation today greatly exceed locomotive 50000 in total weight.

An average of all of the important engines of this type including locomotive 50000 shows approximately 1,000 pounds less tractive power with an increase of 17,400 pounds in weight with the very slight advantage of only 1½ percent in boiler capacity.

Locomotive 50000 delivers one cylinder horsepower for every 110.8 pounds of weight and one boiler horsepower for every 120.3 pounds of weight.

In actual tests it developed:

An average rate of 2.21 pounds of coal per indicated horsepower hour.

A low rate on one test of 2.12 pounds of coal per indicated horsepower hour.

An average rate of 16.85 pounds of steam per indicated horsepower hour.

A low rate on one test of 16.5 pounds of steam per indicated horsepower hour.

A maximum indicated horsepower of 2,216 or one horsepower for every 121.4 pounds of weight.

The thought occurred that possibly 50000 was built too light and that later on, in order to keep the engine in service, many of the parts might require strengthening.

Locomotive 50000 was purchased by the Erie Railroad and numbered 2509. William Schlafge, mechanical manager of the Erie, states that since the locomotive was received it has been necessary to make very few changes.

Ten years of service coupled with 350,000 miles of running have demonstrated the strength of the design and the figures given indicate remarkable performance.

### Pennsylvania Railroad Class I1s

While the design of engine 50000 represents the best practice of the present day as measured by the economical operation of passenger locomotives, the development of heavy freight power involves the consideration of other factors that materially affect the design. In 1915 the Pennsylvania Railroad found that for the economical operation of their line a tractive power about 25 percent in excess of the Mikados then in use was desirable. In working on the design for such an engine, an attempt was made to obtain better economy in performance by a radical departure in cylinder proportions. The accepted practice in proportioning cylinders is to arrange for a cut off of nearly 90 percent of the stroke, so that the starting torque may be as uniform as possible.

The thermal efficiency of the locomotive is high and well sustained over a large range, a maximum of 8.1 percent being attained at an output of 1,777 indicated horsepower, and the range being from 6.1 percent at 776 indicated horsepower to 5.3 percent at 3,486 indicated horsepower with an average of over 7 percent for the usual operating conditions.

This design gives a calculated figure of 88.9 pounds per cylinder horsepower, the lowest on record. The weight per boiler horsepower does not compare as favorably, however, as it is 145.4 pounds. The Belpaire firebox contributes materially to this excess.

### Virginian 2-10-10-2 Type Locomotives

The large 2-10-10-2 Mallet engines for the Virginian were designed to meet their unique conditions. This road was built as an outlet to certain bituminous coal fields of West Virginia. The 2-10-10-2 Mallets were designed for this service and their operation has been very successful. They have handled trains of 16,000 tons on a 0.2 percent grade with the lowest consumption of coal per ton mile ever recorded. Unfortunately accurate tests of coal and water per dynamometer horsepower are not available owing to the fact that there is no dynamometer of adequate capacity to be had at present. However, on May 25, 1921, a train of 15,725 tons behind the tender was hauled from Princeton to Roanoke at a rate of 26.9 pounds of coal per 1,000 ton miles, and on May 27 a 75 car train of 12,070 tons showed the same figure for coal per thousand ton miles.

One of these engines has hauled a train of 110 cars weighing 17,250 tons from Victoria to Sewall's Point, which is believed to be the heaviest train ever handled by one engine. The ruling adverse grade was .2 percent.

The principal dimensions of the three locomotives cited and a comparison of the horsepower characteristics—calculated by the American Locomotive Company's method—are embodied in the following table:

Modern Maximum Efficiency Locomotives

| | No. 50000 | | |
|---|---|---|---|
| Road | Erie | Virginian | Pennsylvania |
| Type | 4-6-2 | 2-10-10-2 | 2-10-0 |
| Fuel | Bituminous coal | Bituminous coal | Bituminous coal |
| Boiler, type | Conical connection | Extended wagon top | Conical connection |
| Boiler, diameter | 76¼ in.-87 in. | 105½-118½ in. | 87-90½ in. |
| Weight on drivers, lb. | 172,500 | 617,000 | 342,050 |
| Weight on truck, lb. | 49,000 | 32,000 | 29,750 |
| Weight on trailer, lb. | 47,000 | 35,000 | .......... |
| Weight, total, lb. | 269,000 | 684,000 | 371,800 |
| Driving wheel diam. | 79 in. | 56 in. | 62 in. |
| Cylinders | 27 in. by 28 in. | 30 in. and 48 in. by 32 in. | 30½ in. by 32 in. |
| Boiler pressure, lb. per sq. in. | 185 | 215 | 250 |
| Tractive power, lb. | 40,600 | 147,200 | 90,000 |
| Factor of adhesion | 4.25 | 4.08 | 3.80 |
| Cylinder horse power. | 2,427 | 5,040 | 4,182 |
| Grate, length and width. | 114 in. by 75¼ in. | 144 in. by 108¼ in. | 126 in. by 80 in. |
| Grate area, sq. ft. | 59.7 | 108.7 | 70.01 |
| Tubes, number | 207 | 381 | 244 |
| Tubes, length | 22 ft. 0 in. | 25 ft. 0 in. | 19 ft. 1 in. |
| Tubes, spacing | ¾ in. | ⅞ in. | ⅝ in. |
| Tubes, thickness | No. 11 B. W. G. | No. 11 B. W. G. | .125 |
| Tubes, diameter | 2¼ in. | 2¼ in. | 2¼ in. |
| Flues, number | 36 | 70 | 48 |
| Flues, diameter | 5½ in. | 5½ in. | 5½ in. |
| Flues, thickness | $\frac{5}{32}$ in. | No. 9 B. W. G. | .18 |
| Combustion chamber—length. | None | 36 in. | 42 in. |
| Brick arch | Security | Gaines | Security |
| Heating surface—firebox, sq. ft. | 248 | 532 | 290 |
| Heating surface tubes—water side, sq. ft. | 2,672 | 5,592 | 2,731 |
| Heating surface flues—water side, sq. ft. | 1,136 | 2,511 | 1,313 |
| Heating surface total, sq. ft. | 4,056 | 8,635 | 4,334 |
| Boiler horse power | 2,250 | 4,800 | 2,553 |
| Steam rate, lb. per hp. hour. | 20.8 | 19.7 | 20.8 |
| Coal rate, lb. per hp. hour. | 3.25 | 3.1 | 3.25 |
| Superheater, number of units. | 36 | 70 | 42 |
| Superheater, diameter | 1½ in. | 1½ in. | 1½ in. |
| Superheater, heating surface. | 879 | 2,120 | 1,418 |
| Tender weight in running order, lb. | 161,500 | 214,300 | 182,000 |
| Tender capacity coal, tons. | 14 | 12 | 17½ |
| Tender capacity water, gallons. | 8,000 | 13,000 | 9,000 |
| Weight of locomotive in lb. per cylinder hp. | 110.6 | 135.7 | 88.9 |
| Weight of locomotive in lb. per boiler hp. | 119.6 | 142.5 | 145.4 |
| Best actual performance— | | | |
| Steam rate—lb. per hp. hour. | 16.5 | .......... | 15.4 |
| Coal rate—lb. per hp. hour. | 2.12 | .......... | 2.0 |

## American Boiler Manufacturers' Meeting

A special winter meeting of the American Boiler Manufacturers' Association will be held at the Fort Pitt Hotel, Pittsburgh, Pa., February 13. Since the annual meeting in June, a number of important matters dealing with boiler design have come up for settlement and these as well as committee reports will be discussed at this meeting.

# The Boiler Maker

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In making our plans for the coming year, we are counting on close cooperation from every reader of THE BOILER MAKER. To be of the greatest assistance to all members of the boiler manufacturing industry and those allied with it, we need help from the men doing the actual production, whether it is designing, laying out, shop work, welding, inspection or any one of the other numerous branches of boiler and tank work.

By sending in the details of new and interesting features of shops or special methods of carrying out production operations, telling us of events having news value, that may occur in the field, describing new designs and machines that prove efficient in boiler construction—all these will aid us materially in giving the best service to our readers.

In addition, we want discussions on the subjects that are dealt with in the magazine; for no better way exists of getting at the facts of a case than in the debate of a subject by interested individuals.

Our object is to have every reader a correspondent, who will tell us in his own words of the things that most interest him in his work. From the information thus obtained, the editorial staff will be able to prepare for publication articles of value to the whole industry.

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Although the regulation of construction and inspection of storage or other tanks, subjected to static pressure hardly seems necessary yet, in the past few months, the number of failures of these vessels has brought the matter to the attention of the authoritie of several states.

Boiler and tank manufacturing concerns are vitally interested in making storage tanks safe for service since practically all have occasion at one time or another to build vessels for storage purposes, as well as those intended for pressure service. Little trouble is experienced in designing, constructing and erecting tanks so that they will be safe, but when they are exposed to corrosive action and weather, frequent inspections should be maintained to prevent failures.

This matter has received the attention of at least one state legislature, for in Massachusetts the construction of tanks and containers for the storage of fluids other than water is controlled by a law which requires that permits for building, maintaining or using any such tanks must be obtained from the chief of the district police (in the Metropolitan district, from the fire commissioner). This regulation was brought about mainly by the molasses tank failure in Boston, in 1919, in which twelve persons were killed. The law does not apply to tanks under 10,000 gallons capacity.

Similar legislation will no doubt be adopted in other states as the need for the control of tanks is better understood.

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Due possibly to the greater activity of the designing departments in the past few years, progress has been made towards increasing the efficiency of the locomotive. In the development of the boiler the aim has been to obtain a maximum capacity with the least increase in weight and size.

The practice of providing a grate large enough to burn the amount of coal theoretically required and putting in as large a heating surface as possible has been replaced by the scientific proportioning of the firebox combustion chamber and tubes to obtain the greatest evaporation. The value of combustion chambers is fully realized and practically all of the later locomotives include them in the boiler design.

The proper relation of length between combustion chamber and tubes has not been definitely determined. For example, in the case of one design the combustion chamber was shortened 15 inches and the tubes lengthened a like amount with an increase in evaporation per pound of coal ranging from 6.6 to 9.8 percent.

In general, to obtain the best results, the length of tubes should not be more than 120 times the inside diameter; for with this length, ample space is allowed on long wheel base engines for combustion chambers.

The better utilization of the heat from waste gases and exhaust steam is receiving greater consideration than ever before. Heating feed water with waste gas and the use of exhaust steam injectors offer possibilities for economy.

All reports on the subject of locomotive design indicate that real progress has been made, but there is still need of further experimental work and investigation to produce the most economical proportions of boilers.

# Engineering Specialties for Boiler Making

**New Tools, Machinery, Appliances and Supplies for the Boiler Shop and Improved Fittings for Boilers**

## Portable Electric Rivet Heating Devices

Electric rivet heaters in general embody advantages of cleanliness, ready movement from place to place in the shop and rapidity of heating. The United States Electric Company, New London, Conn., appreciating the need for this equipment in boiler, railroad, and structural working shops has developed the rivet heating devices illustrated.

The heater shown in Fig. 1 has a capacity of rivets from ¼ inch to 1½ inches in diameter by 6 inches long. The time required for heating a rivet of the largest size is about 30 seconds.

The device is built in three types A, B and C with electrodes arranged to heat two, four or six rivets at one time.

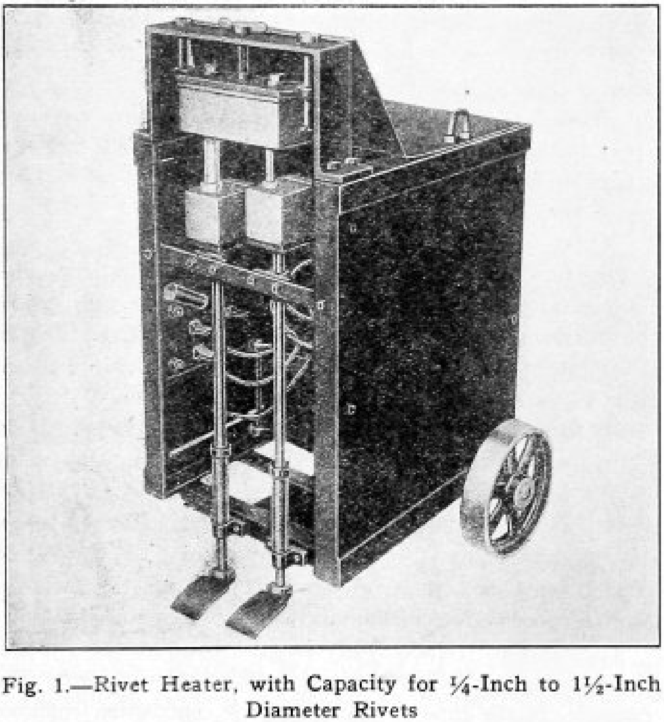


Fig. 1.—Rivet Heater, with Capacity for ¼-Inch to 1½-Inch Diameter Rivets

The large type C machine can heat twelve pin rivets per minute, which is as fast as they will ordinarily be required. Ten, 15 and 20 kilowatts, respectively, is the power consumption of the machines, depending upon the diameter of rivets to be heated.

A pan is supplied with the heater when it is desired to hold a quantity of rivets in front of the operator or heater, and the rivets are easily placed by hand in the electrodes and removed with the tongs when heated. The operation is simple. The control switch being set for the size of rivets to be heated, the operator presses down on the foot lever and places a rivet between the electrodes until the desired heat is obtained. By heating in series after the first two rivets are heated, there is always a hot rivet ready for the riveter, and the operator always can control the current by removing one rivet, eliminating the pulling of a switch. The switch will be supplied if specified so that it will not be necessary to remove the rivet. The machine operates on 60 cycles and 220, 440 or 550 volts, single phase.

The automatic rivet heater, illustrated in Fig. 2, is built to heat rivets when making long runs on one size of rivet, heat-

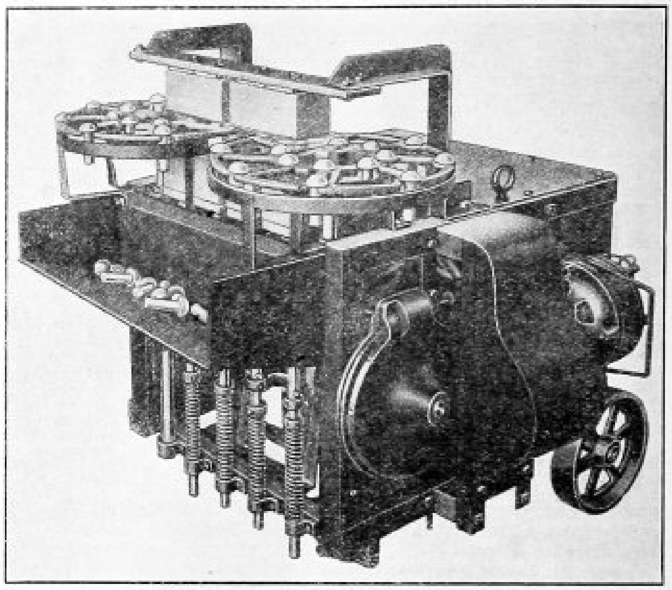
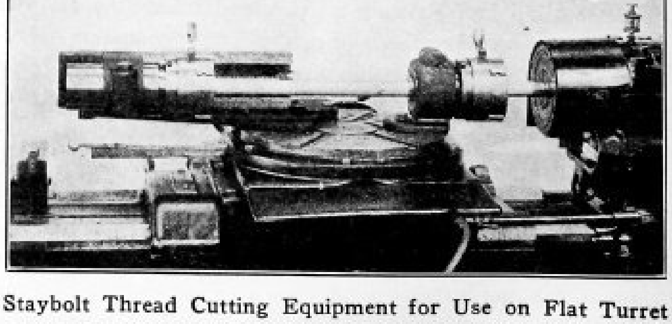


Fig. 2.—Automatic Electric Rivet Heater for Use When Making Long Runs on One Size of Rivet

ing as high as 12¾-inch by 2½-inch rivets per minute. The machine is equipped with a control switch, the disks being arranged to hold any size rivet and accommodating 32 at one loading. The electrodes can be adjusted for any length of rivet up to five inches long and timed to give the desired heat in the rivet.

## Staybolt Equipment for Flat Turret Lathes

The principal object of new staybolt equipment designed for attachment to flat turret lathes by the Acme Machine Tool Company, Cincinnati, Ohio, is to produce accurate



Staybolt Thread Cutting Equipment for Use on Flat Turret Lathes threads of the same concentricity and lead on both ends of staybolts.

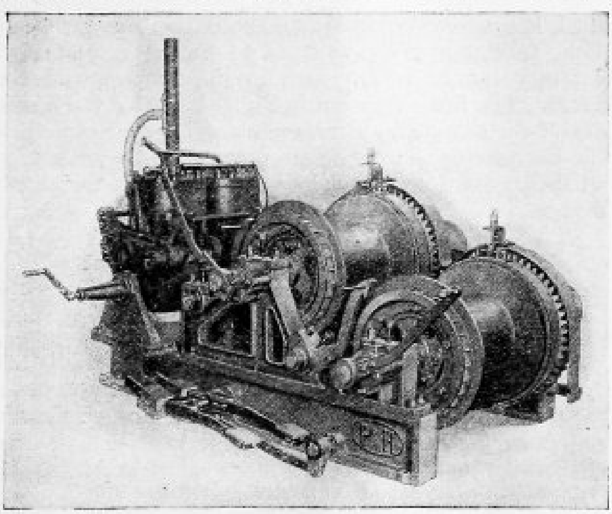
It is essential to have both die heads cutting simultaneously so that the leads will correspond exactly with that of the master staybolt tap. The rear die-head is made adjustable, as shown in the illustration, so that any length of bolt within the range of the machine can be handled.

In operation the staybolt is first turned complete with a multiple cutter box tool provided with an adjustable tool for recessing the blank space between threaded ends. (This box tool is not shown in the illustration which gives a rear view of the thread cutting equipment.) After the staybolt has been turned the die heads are brought into position as shown. The front tool holder carries one die head while a special adjustable holder carries the rear die head. A micrometer collar is provided on the screw for accurate adjustment so that both die heads have the same relative lead.

Regular staybolt equipment can be provided for the 2½-inch by 26-inch. Cincinnati Acme flat turret lathe to thread staybolts 1¼ inches in diameter by 14 to 24 inches long. On the Universal or 3¼-inch by 36-inch flat turret lathe, bolts up to 1½ inches in diameter can be threaded and lengths from 14 to 25 inches. With special turners, work from 8 inches to 14 inches long can be accommodated in one chucking. Work less than 8 inches long can be threaded before releasing.

## Electric, Gasoline and Belt Drive Hoists

The Pawling and Harnischfeger Company, Milwaukee, Wis., has standardized a line of stationary hoists which may be driven by electric power, gasoline or by belt. These hoists



Pawling and Harnischfeger Stationary Type Hoist

are in sizes ranging from 8 horsepower with an 8-inch by 12-inch drum up to 115 horsepower with an 18-inch by 28-inch drum.

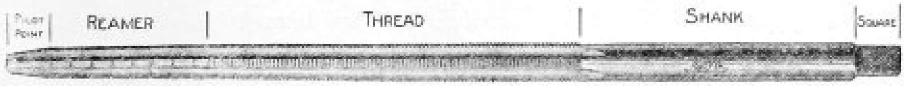
For the gasoline driven type hoist, the same type motor is used that is provided on P. & H. excavators, cranes and gas shovels. The engine is a heavy duty, four cylinder vertical tractor type with a Bosch magneto, Stewart Vacuum system and air cleaners. Automatic throttle governors and conveniently located hand throttles are provided.

The belt-driven types are similar except that the rear end of the bed frame is left off, and a large size driving pulley is provided on the side opposite the operator.

The friction mechanism is of the standard V design; the friction blocks are of specially seasoned maple, accurately turned. Brakes are operated by means of foot levers. Full contact of the brake bands is insured because they are worked-in on drums and peened to conform to the drum surface before being placed on the hoist. Counterweights are provided for all brakes, insuring a quick release.

## Boiler Staybolt Tap

The "Maxitap" for staybolts, being produced by the Greenfield Tap and Die Corporation, Greenfield, Mass., has a number of special features intended to preserve the size




Details of New Staybolt Tap

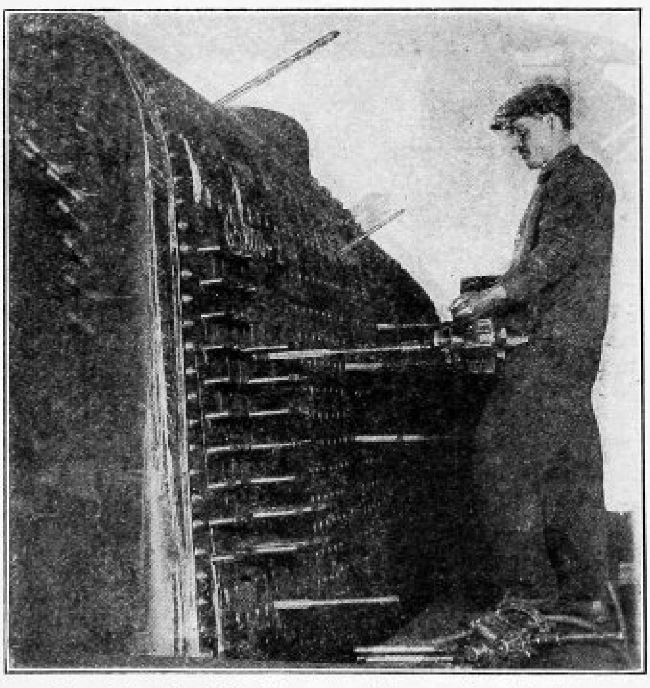
and lead of the threads it is cutting. These features include a pilot point, a chip breaker, a special hook, a long taper and special relief.

In tapping staybolt holes, the first operation, that of reaming the outer plate, is comparatively simple and usually offers no difficulty to the operator. Until the inner plate is reached no trouble is experienced, but then, unless the holes happen to line up properly, the staybolt tap is apt to butt against the inner plate and requires more or less manoeuvering before it will enter the second hole. The pilot point on the "Maxitap" is designed to eliminate this trouble and acts as a guide for the tap in alining the holes.

This tap is made with lands of a special form having a decided hook which allows the reamer section to cut easily even with a small amount of lubricant and at the same time offers slight resistance to the tapping of the first hole while the second hole is being reamed.

A left hand spiral groove is turned on the outside of the reamer section and acts as a chip breaker, preventing the chips from accumulating and wedging, tearing the threads and hindering the progress of the tap. With this reamer section the chips are broken up fine and pushed out ahead as the tap comes through the inner plate.

Friction of the tap against the thread wall is reduced by giving the tap thread a special relief.



The "Maxitap" in Use on a Locomotive Firebox

# Questions and Answers for Boiler Makers

## Information for Those Who Design, Construct, Erect, Inspect and Repair Boilers—Practical Boiler Shop Problems

**Conducted by C. B. Lindstrom**

*This department is open to subscribers of* THE BOILER MAKER *for the purpose of helping those who desire assistance on practical boiler shop problems. All questions should be definitely stated and clearly written in ink, or typewritten, on one side of the paper, and sketches furnished if necessary. 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 permission to do so.*

### Tube Welding Furnace

Q.—Would you kindly publish in THE BOILER MAKER information relative to a type of furnace and burner for welding flues, oil being used for fuel. Kindly give dimensions and diagram for same.—A. G.

A.—There are a number of oil furnaces and burners on the market for welding tubes. One of these is shown in Fig. 1. This furnace will serve any flue welding machine, and it can be used either for scarf or butt welds on tubes from 2 inches to 4½ inches in diameter. There are in this type three charging openings making it possible to have three tubes in the fire at a time, thereby expediting the heat-

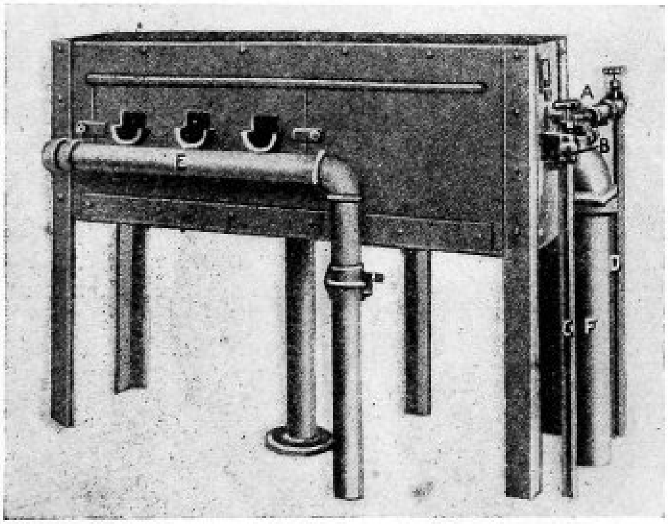



Fig. 1.—Oil Fired Tube Heating Furnace

ing and welding of the tubes. The welds are clean as a result of using oil as a fuel, and it is unnecessary to turn the tube in the furnace while heating. No borax or other flux is needed in the welded joint, as the weld can be made without it.

The oil burner is shown at *A*, the regulating cock at *B*, the oil pipe *C* and *D* the air pipe, *E* the deflection blast and *F* the auxiliary blast. A burner suitable for fuel oil, not crude oil or tar is shown in Fig. 2. It is of the low pressure type requiring an air pressure of from 1 to 5 pounds per square inch. The oil connection *A* is ¼-inch in diameter and the air connection *B* is 1 inch in diameter, the air supply is regulated at the mouth of the furnace by raising or lowering the gate *C*. The flame from the torch is straight and not fan shaped which arises in the use of the high pressure burners. Therefore if the type shown in Fig. 2 is used, it would be necessary to install one or more burners depending on the size and requirements of the furnace.

A furnace of your own design can be made and equipped with these burners. A home made furnace would first be made of steel plate to the size required. Close in three sides, top and bottom, excepting the openings for the burners, which are set in place. Then line the metal box with refractory brick, that is, brick having a high melting point

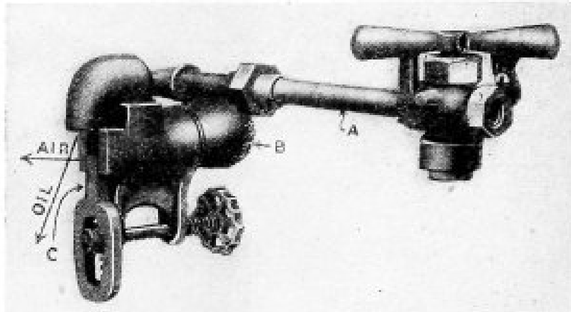



Fig. 2.—Fuel Oil Type Burner for Welding Furnace

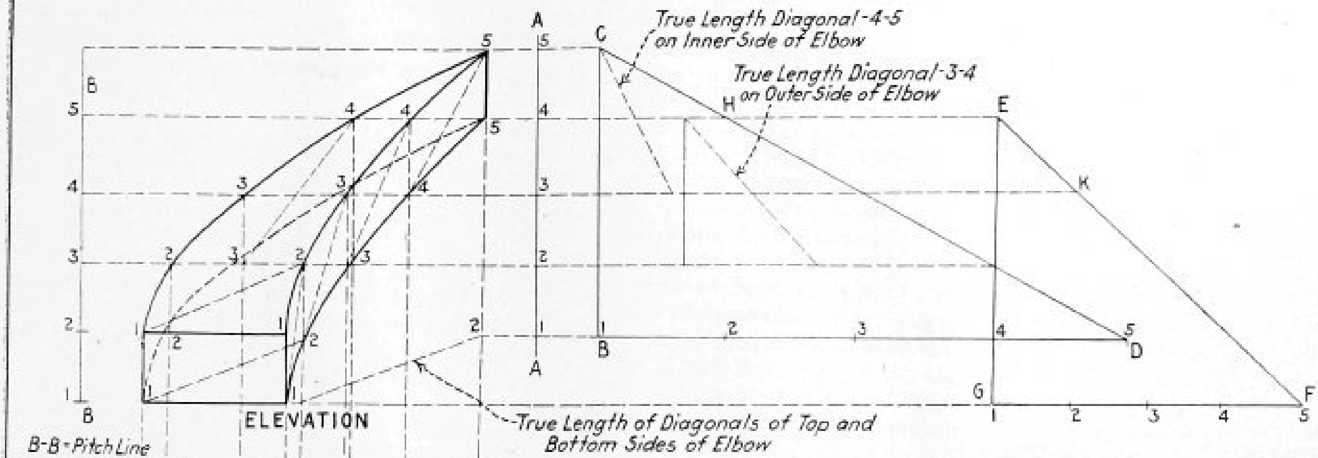
which is necessary to withstand the intense heat. The front of the furnace should be shaped to receive the tubes and so that they can be readily seen in the furnace while being heated. The furnace shown in Fig. 1 will give you a general idea of the shape and arrangement of the steel plate casing. The low pressure burner would not require the blast pipe *F*, but the pipe *E* for air should be placed at the mouth of the furnace.

### Compound Elbow Development

Q.—Will you kindly supply me with the information for the development of a compound curve elbow similar to that shown in Fig. 1. Any measurement will be suitable as long as the general outline is clearly shown. An early reply will oblige.—G. C.

A.—The sides, bottom and top of the elbow, Fig. 1, form a double or compound curve and constitute warped surfaces. The plan and elevation, Fig. 2, show the nature of the curved sections of the elbow and indicate the method of laying off the two views. The pitch or rise for a quarter turn or through a 90-degree angle is equal to *A-A* and *B-B*. The pitch *A-A* is for the curved lines on the top edges of the elbow and *B-B* for the curves of the bottom edges. Divide the pitch into the same number of parts as in the quadrant plan view. Where the horizontal lines drawn from the points *1-2-3-4* and *5* on the pitch lines intersect the corresponding vertical projection lines, drawn from the arcs in the plan view, locate points on the compound curves. The length of the curve *1-5* on the outer edge of the elbow, either top or bottom is equal to length *C-D* of the right angle triangle *C-B-D*. The base *B-D* equals the arc length of the outer curve plan view and *B-C* equals the pitch of the elbow. *C-H* on the hypotenuse is the required arc length between points *1-2*, *2-3*, etc.

The length of the curves *1-5* on the inside of the elbow equals *E-F* of the right angle triangle *E-G-F*. The base *G-F* equals the arc length *1-5* of the smaller arc of the plan view. *E-G* is the pitch and *E-K* is the length between the points *1-2* *2-3*, etc., on the inner curves. There are three diagonal lines



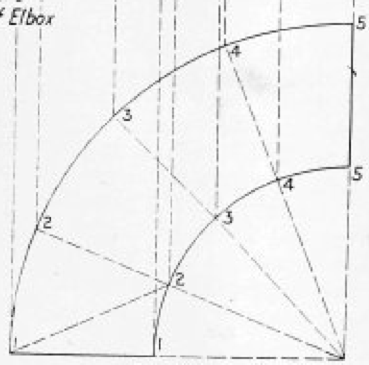




FIG. 2.- PLAN AND ELEVATION OF ELBOW

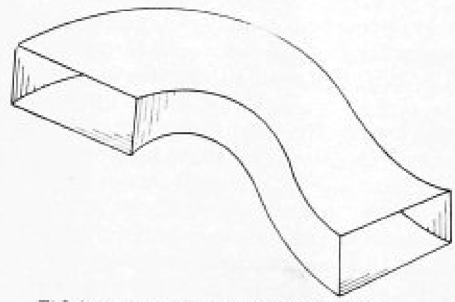


FIG. 1.- GENERAL VIEW OF ELBOW

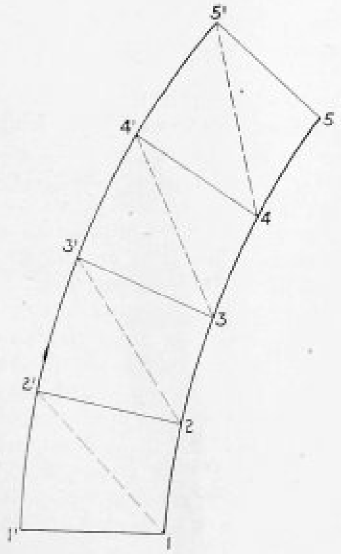


FIG. 3.- PATTERN FOR TOP AND BOTTOM OF ELBOW

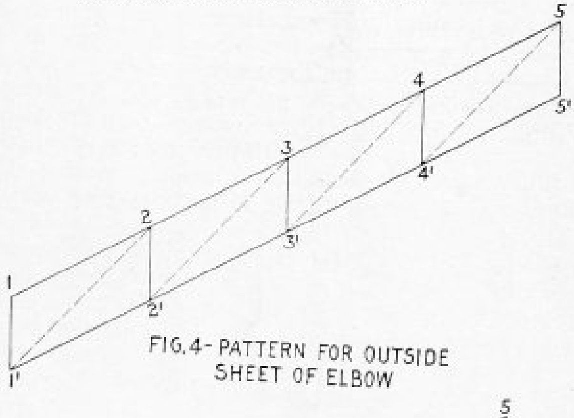


FIG. 4- PATTERN FOR OUTSIDE SHEET OF ELBOW

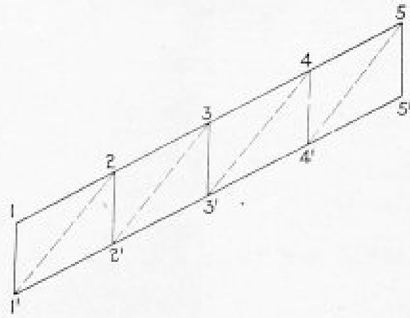


FIG. 5.- PATTERN FOR INSIDE SHEET OF ELBOW

Details of Compound Elbow Layout

which must be laid off in their true length. The bottom diagonal *1-2* is found by drawing a right angle triangle. The base equals *1-2* of the plan view and the height is equal to the depth of the elbow in this case. The hypotenuse is the required true length of the line. With this length the pattern for the top and bottom can be laid off, as shown in Fig. 3.

Lay off a straight line *1-1*, Fig. 3, equal to *1-1* of the plan view, Fig. 2; with point *1* as a center and using the true diagonal length *1* to *2*, draw an arc. With *C-H* as a radius and point *1'* as a center draw an arc intersecting as shown at point *2'*. Using *E-K* as a radius and point *1* as a center draw an arc then with *1-1* of the plan as a radius and point *2'* as a center draw an arc intersecting point *2*. This completes ¼ of the pattern, the remaining sections are laid off in the same manner.

The true diagonal length as between points *3-4* must be established. This may be done by drawing a right angle triangle with its base equal to *3-4* of the plan and the height equal to the vertical distance between these points of the elevation. The true length of the diagonal is shown in the development to the right of the elevation. In Fig. 4, a straight line *1-1* is drawn which is equal to the depth *1-1* of the elbow. With *1'* as a center and a radius equal to the diagonal *3-4* draw an arc. The arc length for top and bottom equals *C-H* and using points *1-1'* as centers and with *C-H* as a radius draw arcs. From the point *2* and with *1-1'* as a radius draw an arc to intersect at *2*. This completes the outline for ¼ of the pattern for the outer side. The remaining sections are laid off in this way until the pattern is completed.

In Fig. 5 is shown the pattern for the inside sheet. The layout work is carried on as explained for the outside sheet, except that the diagonal equals *4-5* as obtained in the right angle triangle construction shown to the right of the elevation. Use the arc length *E-K* for the upper and lower edges of the pattern. Allow for laps and the patterns must be shaped to form the warped surfaces. If the plate is heavy the patterns should be made in several sections so that they can be formed to better advantage by bending and hammering.

## Conical Ventilator Types

Q.—How are ventilators made, when the top section is in the form of a cone and the lower section is a cylindrical pipe?—O. F.

A.—There are two methods either of which produces a very good means of admitting air into buildings or holds of vessels. In the form, Fig. 1, the connection is made so that

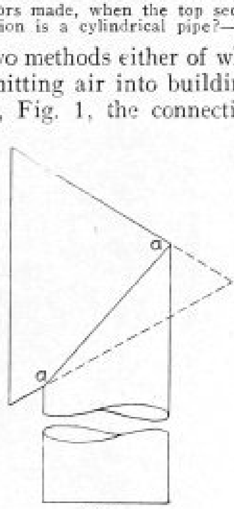


FIG. I

**Ventilator in Common Use**

the line of intersection, *a—a* is a straight line. The section of the cone on this line and also of the cylinder is an ellipse. The development of Fig. 2 will be given, illustrating the method of developing the intersection between the cone and cylinder when the cylinder's axis is at right angles to the axis of the cone.

The construction in Fig. 2 shows an elevation of the ventilator, in which no plan view is required for making the development of the miter between the cone and cylinder. This procedure simplifies developments of this kind, although the principles applied involve the use of the plan construction. Consider a number of planes to be passed through the cylinder and cone. The edges of these planes are shown at *2-2*, *3-3* and *4-4* and they pass through the cone. The intersection of these planes and the cone are circular in shape. The sections of the cylinder on these planes are rectangles having widths equal to the distances *2-2*, *3-3* and *4-4* of the circle, which represents an end view

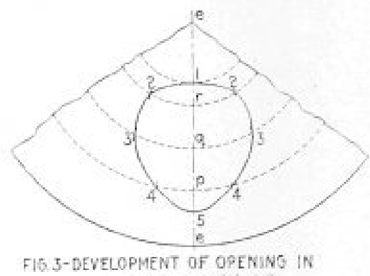


FIG. 3—DEVELOPMENT OF OPENING IN PATTERN OF CONE

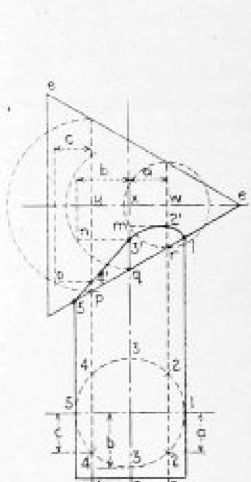


FIG. 2—ELEVATION OF VENTILATOR

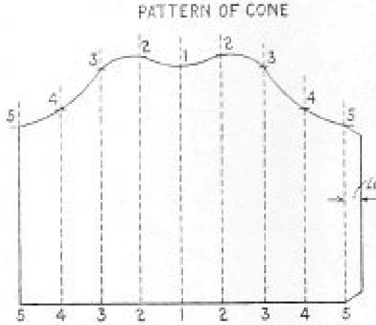


FIG. 4—LAYOUT OF PATTERN FOR CYLINDER

**Conical Ventilator Development**

of the pipe. The problem consists of finding where the rectangular edges intersect the circular sections of the cone as shown at *2'*, *3'* and *4'*. To establish these points which lie on the miter, lay off from the line *2-2'* the distance *a*, from the line *3-3'* the distance *b* and from the line *4-4'* the distance *c* equal respectively to the corresponding distances indicated in the circle.

The sections of the cone are drawn from points *w*, *x* and *y* using the respective radii *w-r*, *x-q* and *y-p*. Lines are then drawn perpendicular to the axis of the cone from the extremities of distances *a*, *b* and *c*, intersecting the sections of the cone in points *m*, *n* and *o*. These points are then projected to the edge lines of the planes to intersect as shown at *2'*, *3'* and *4'* thus locating points lying on the miter line.

From these data in Fig. 2 the patterns, Figs. 3 and 4 can be made. Lay off line *e-e*, Fig. 3, equal to the slant height of the cone *e-e*, Fig. 2. Draw an arc with this distance as a radius and with the traveling wheel set off the stretchout of the cone. Make *e-1*, *e-r*, *e-q*, *e-p* of the pattern for the cone equal to the corresponding distances on the side of the cone, Fig. 2. Draw the arcs in Fig. 3 through these points using point *e* as a center. Set off from points *r*, *q* and *p* on the arcs the points *2*, *3* and *4* making the arc lengths equal respectively to the arcs from *r* to *m*, *q* to *n* and *p* to *o* of Fig. 2.

The development of the cylinder connection is given in Fig. 4. The line *5-5* equals the circumference of the circle, Fig. 2, and the length is divided into as many equal parts as in the circle. Draw the lines *1-2-3*, etc., perpendicular to the line *5-5* and number them so as to correspond with the figures in the illustration, Fig. 2. Transfer the lengths of the cylinder, Fig. 2, as from *1-1'*, *2-2'*, *3-3'*, *4-4'* and *5-5'* and set them off as shown in the pattern. Make the necessary allowances for seams.

# Letters from Practical Boiler Makers

**This Department Is Open to All Readers of the Magazine —All Letters Published Are Paid for at Regular Rates**

## On Bemoaning Our Fate

"Say, but I made an awful mistake in taking up this kind of work," is as well known a saying among boiler makers as it is in all other trades and professions with which we come in contact. Doctors, lawyers, actors and even ministers of the gospel make bitter complaints about their lot.

To hear anybody complain about hard luck, though, is usually a bad sign; the cause of the hard luck can almost invariably be traced squarely back to the complainant himself. We don't hear the "best men" complain, because they haven't time for such things; they are too busy progressing and keeping above those who have time for foolish mutterings.

The owner of a boiler plant made this remark recently: "The next time I employ a man, I certainly will not select one who is 'sick of his job!' I want one who is alive every minute and who loves his work as much as his religion. If he has no religion, I want him to love his work as much as he loves his mother, wife, or sweetheart. If he doesn't love anything, he is hopeless and I would not even consider him."

To complain is to acknowledge that you are weak—that you are not the best in your line, nor even successful. And every time you air your weaknesses you grow weaker.

We do not mean that one should bluff and pretend that he is more than he is. It is permissible to admit that you are unacquainted with a detail here and a detail there, but don't keep on admitting it forever, thus advertising your weakness. Study the detail until you understand it. By thus plodding along, keeping yourself interested in your work, studying, progressing, you will soon find yourself out of the "admitting and complaining class" and you will find many opportunities ahead.

Ever hear of a man who worked hard and who concentrated his mind upon his work, who did not progress? I never have. Such men do not complain.

The non-complaining man is the man who generally gets the best results out of his work. He is a natural economizer. To waste time, money and words would be painful to him.

Newark, N. J. N. G. Near.

## Acceptable Methods of Patching Boilers

On page 242 of the August, 1921, issue a "Subscriber" relates a boiler patching experience and asks for suggestions from readers as to the best manner of handling such matters. Having followed the occupation of boiler inspector for some years in about 15 widely scattered states, it is needless to say that the writer has been up against the patching proposition many times and under a variety of circumstances.

Generally speaking, the placing of a patch in the shell of a horizontal tubular boiler, where it is exposed to the products of combustion, is purely a makeshift repair. However it is one which recommends itself to many owners because of the small comparative cost. In the majority of cases, when an experienced insurance inspector recommends such a patch, it is because he realizes that there will be more likelihood of his recommendation being complied with and a bad condition at least temporarily removed, than if he should insist on a three-quarter sheet, which, after all, is the only worth while repair in the majority of cases.

The writer has recommended crescent patches for badly bagged or severely fire-cracked sheets many times. However, such recommendations have almost invariably been in plants supplied with reasonably pure water or in charge of high grade attendants, or both. Experience has shown that even an inside patch (first course patches should always be inside) seems to have a particular attraction for the impurities in the water; and even when design and workmanship are of the best, unless the patch seam and rivet heads are kept scrupulously clean, the seam will leak and frequently leaking fire cracks will develop from rivet hole to edge of plate.

In deciding as to the advisability of installing a patch on a horizontal tubular boiler, the first item to be considered is the quality of the water, which in most cases can be approximately determined by an examination of the internal surfaces. If it is apparently difficult to prevent a rapid and heavy incrustation, there is slight hope for the success of the patch. The furnace design and the demands made upon the capacity of the boiler are also important factors. It is seldom possible to have success with a patch when the boiler is set low with a high bridge wall and is required to generate at or beyond rated capacity. Forced draft is a well known enemy of girth seams and patches and a case comes to mind which clearly demonstrated this fact.

Early in 1917 the writer made several inspections of a battery of large horizontal tubular boilers which were installed in a drop forge shop. These inspections covered the installation and connecting up and one or two inspections were made after the plant had been in operation for two or three months. Everything seemed to be going along fine and the plant was in charge of a university engineer who was really good, considering his length of practical experience. During my absence on a long trip, war orders began to swamp the little plant and there was increasing demand for steam and no additional boilers available at what the owner considered a reasonable price. Upon my return, I found my presence in great demand at the plant. An inspection showed the first course sheets of the boilers to be bagged and warped from head to girth and up to the fire line. They were heated and straightened out, the girth seam rivets redriven and the boilers (perfectly clean inside) again placed in service. But the sheets bagged again in less than a week's run. After it seemed as if we had been driving back bags all winter, I happened to notice that a fine little forced draft outfit had been installed during my absence to increase the capacity of the boilers.

It was situated so as to be easily overlooked and anyhow I had never been up against a similar proposition before, so perhaps was not sufficiently on the alert, but once it was located it was quickly found to be the cause of the difficulty. New three-quarter courses were installed, the forced draft discontinued and the plant capacity curtailed within the limits of safe boiler operation until an additional boiler could be installed. No further difficulty of this nature was experienced, which goes to prove that even clean boiler plate can be damaged, when a horizontal boiler is improperly handled in an attempt to force it to unreasonable capacity. How much more so would a patch be subject to damage under like circumstances?

San Francisco, Cal. A. J. Lamie.

## Boiler Explodes With Man in Firebox

The writer recently read of a "freak" boiler explosion which occurred near Newark, N. J., while an inspector was in the firebox searching for defects. The boiler which had been out of service for a long time was of the stationary locomotive type.

The inspector had been examining the inside of the firebox for only a very few minutes when he was startled to hear a loud report which sounded as if a stick of dynamite had exploded. He found, however, that the furnace sheet had ripped open directly through a weld for about 36 inches. The rupture extended about equal distances on either side of the part built up by welding.

The defective part was found practically free of scale but the metal was quite badly crystallized. Such failures in pressure vessels emphasize the importance of exercising the greatest care possible in preparing the edges of plates for welding so that the metal from the electrode may be thoroughly incorporated in the parent metal. Crystallization may be avoided by using the proper voltage and amperage for the plate thickness being worked and the diameter of the electrode used. In case the oxy-acetylene method is employed it is essential to have a neutral flame with the correct mixture of gas and oxygen and to manipulate the torch so that the plate is not burned. The application of heat from the welding torch or electrode sets up stresses due to the expansion of the metal and in cooling the welded seam may crack or internal strains may arise, which are detrimental to good welds. To insure good welds only those operators should be employed who understand these conditions and how they may be overcome. This is a matter of training involving the supervision of the employer and in addition rigid inspection.

Scranton, Pa. C. B. LIBBY.

## Principles of Riveted Joint Design

(*Continued from page* 13)

Total shearing strength of the joint:

$$Sh = \begin{cases} \text{For one reinforcing ring}: n \times a \times S \\ \text{For two reinforcing rings}: n \times a \times s \end{cases}$$

Crushing strength of the joint:

$$Cr = n \times d \times t \times C$$

Divide T, Sh, or Cr, whichever is the least, by W and the quotient will be the true efficiency of the joint.

Openings in the shell for pipe connections are usually fitted with forged or cast steel nozzles and flanges, which are generally heavy enough to provide the necessary reinforcement. Nevertheless, they should be "checked up" in this regard, with particular attention being given to the number, size and pitch of the rivets attaching them to the boiler shell.

(*To be continued*)

## Standards of Railroad Shop Welding Practice

(*Continued from page* 7)

so that the weld will come lower than between the first and second rows of staybolts above the mud ring.

The method of applying a butt-welded firedoor patch is shown in Fig. 5. The corrugation to allow for expansion is shown and, as in the previous instance, the patch is beveled to an angle of 45 degrees, the weld being built up an additional 1/16 inch for reinforcement.

When constant reworking of tubes and flues has damaged the flue sheet bridges, but the lower portion of the sheet is in good condition, the method of repair by welding in a new top section is shown in Fig. 6. This method effects quite a saving in time since the top flue sheet section can be more quickly laid out and formed, and the labor of cutting and reapplying staybolts in the lower section is eliminated. If any difficulty is experienced in bringing the edges of the new and old plate in alinement previous to welding, a special clamp, as shown in Fig. 7, can be used.

One of the most successful uses of welding in boiler work has been in the application of side sheets and half side sheets. The application of a full side sheet is shown in Fig. 8 with the corrugation for expansion along line A-B.

## Cleaning Boiler Tubes with Modern Equipment

(*Continued from page* 16)

In the case of the underground pit type a heavy structural frame work supporting a steel semi-circular basin or tank is set in a pit with its doors flush with the shop floor. Shafts are mounted along each side of the frame for the entire length of the tank and on each of these five steel sprocket wheels are mounted which actuate the heavy case hardened sprocket chains. These chains are carried under the tank on idler pulleys and after passing over the sprocket wheels near the top, form cradles or slings in which the tubes are rattled. One of the sprocket carrying shafts is extended and provided with a gear which engages with the gearing of the driving mechanism. The arrangement is such that as the driving shaft revolves, the tubes in the tank are cleaned by contact with the chains and with one another.

The raising and lowering of the tubes into the machine is accomplished by means of sling chains which are left hanging in the tank below the level of the cradle chains. During the cleaning operation these chains are suspended from hooks on either side of the tank. The capacity of this machine is the same as for the frame work type.

With this type installed in a flue shop, the normal activity of the department is in no way interfered with, for once the cleaner is charged with tubes and the covers closed no further attention is required until the tubes are clean.

With the exception of the dry type rattler, the tube cleaners illustrated were built by Joseph T. Ryerson and Son, Chicago, Ill.

## BUSINESS NOTES

The Wilson Welder & Metals Company has moved its general offices and Bush Terminal factory to 132 King street, New York City.

The Keller Pneumatic Tool Company, Grand Haven, Mich., has recently changed its corporate name to William H. Keller, Inc.

Andrew Fletcher, president of the American Locomotive Company, has been elected a director of the American Car & Foundry Company.

## OBITUARY

The death of A. H. Chapman, secretary and treasurer of the Walsh and Weidner Boiler Company, Chattanooga, Tenn., was recently announced by the company. Mr. Chapman was connected with the company for over thirty years.

John W. Duntley, who founded the Chicago Pneumatic Tool Company in 1884 and served as its president until 1909, was killed in an automobile accident December 15, in Chicago, his home city.

## ASSOCIATIONS

### Bureau of Locomotive Inspection of the Interstate Commerce Commission

Chief Inspector—A. G. Pack, Washington, D. C.
Assistant Chief Inspector—J. M. Hall, Washington, D. C.

### Steamboat Inspection Service of the Department of Commerce

Supervising Inspector General—George Uhler, Washington, D. C.

Deputy 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—John A. Stevens, Lowell, Mass.
Vice-Chairman—D. S. Jacobus, New York.
Secretary—C. W. Obert, 29 West 39th Street, New York.

### National Board of Boiler and Pressure Vessel Inspectors

Chairman—J. F. Scott, Trenton, N. J.

Secretary-Treasurer—C. O. Myers, State House, Columbus, Ohio.

Vice-Chairman—R. L. Hemingway, San Francisco, Cal.
Statistician—W. E. Murray, Seattle, Wash.

### American Boiler Manufacturers' Association

President—A. G. Pratt, Babcock & Wilcox Company, New York.

Vice-President—G. S. Barnum, The Bigelow Company, New Haven, Conn.

Secretary and Treasurer—H. N. Covell, Lidgerwood Manufacturing Company, Brooklyn, N. Y.

Executive Committee—F. C. Burton, Erie City Iron Works, Erie, Pa.; E. C. Fisher, Wickes Boiler Company, Saginaw, Mich.; C. V. Kellogg, Kellogg-McKay Company, Chicago, Ill.; W. S. Cameron, Frost Manufacturing Company, Galesburg, Ill.; W. A. Drake, The Brownell Company, Dayton, Ohio; Alex. R. Goldie, Goldie & McCullock Company, Galt, Ont., Can.; F. G. Cox, Edge Moor Iron Company, Edge Moor, Del.; J. C. McKeown, John O'Brien Boiler Works Company, St. Louis, Mo.

### International Brotherhood of Boiler Makers, Iron Ship Builders and Helpers of America

Louis Weyand, Acting International President, suite 315 Wyandotte building, Kansas City, Kans.

Frank Reinemeyer, International Secretary-Treasurer, suite 315 Wyandotte building, Kansas City, Kans.

James B. Casey, Editor-Manager of Journal, suite 312-314 Wyandotte building, Kansas City, Kans.

William Atkinson, Acting Assistant President, suite 315 Wyandotte building, Kansas City, Kans.

International Vice-Presidents—Joe Reed, 1123 East Madison street, Portland, Ore.; Thomas Nolan, 700 Court street, Portsmouth, Va.; Joseph Flynn, 111 South Park avenue, Little Rock, Ark.; M. A. Maher, 2114 Eighteenth street, Portsmouth, Ohio; E. J. Sheehan, 7826 South Shore Drive, Chicago, Ill.; John J. Dowd, 953 Avenue C, Bayonne, N. J.; R. C. McCutcheon, suite 15, La Salle Block, Winnipeg, Man., Can.; Joseph P. Ryan, 7533 Vernon avenue, Chicago, Ill.; John F. Schmitt, 1489 North Fourth street, Columbus, Ohio.

### Boiler Makers' Supply Men's Association

President—Frank J. O'Brien, Globe Seamless Steel Tubes Company, Milwaukee, Wis.

Vice-President—William B. Wilson, Flannery Bolt Company, Pittsburgh, Pa.

Secretary—George B. Boyce, A. M. Castle & Company, 91 Connecticut street, Seattle, Wash.

Treasurer—Stephen H. Sullivan, Ewald Iron Company, Chicago, Ill.

### Master Boiler Makers' Association

President—Charles P. Patrick, Mgr., Chicago, Wilson Welding Repair Company, Chicago, Ill.

First Vice-President—Thomas Lewis, general B. I., L. V. System, Sayre, Pa.

Second Vice-President—T. P. Madden, general B. I., M. P. R. R., 6947 Clayton avenue, St. Louis, Mo.

Third Vice-President—E. W. Young, general B. I., C. M. & St. P. R. R., 81 Caledonia Pl., Dubuque, Iowa.

Fourth Vice-President—Frank Gray, G. F. B. M., C. & A. R. R., 705 West Mulberry street, Bloomington, Ill.

Fifth Vice-President—Thomas F. Powers, System G. F., Boiler Dept., C. & N. W. R. R., 1129 Clarence avenue, Oak Park, Ill.

Secretary—Harry D. Vought, 26 Cortlandt street, New York City.

Treasurer—W. H. Laughridge, G. F. B. M., Hocking Valley Railroad, 537 Linwood avenue, Columbus, Ohio.

Executive Board—John F. Raps, general B. I., C. R. R., 4041 Ellis avenue, Chicago, Ill., chairman.

## TRADE PUBLICATIONS

AUTOMATIC CUTTING MACHINE.—In a booklet recently issued the General Welding & Equipment Company, Boston, Mass., manufacturers of welding equipment, is described the construction and operation of the "Gewe" automatic cutting machine. This machine is mechanically driven, uses oxygen and hydrogen in the torch, and follows templates made of fiber or similar material for patterns during the cutting operation.

MACHINE TOOLS.—The "Triplex" No. 1 machine tool designed for turning and boring, milling, thread cutting and drilling is described in detail and its application to each of these operations in a pamphlet sent out by the Triplex Machine Tool Corporation, New York. The advantage of this machine is that it combines a number of machine tools in one, cutting down equipment investment and saving floor space. A price list is included in the pamphlet.

STAYBOLT TAPS.—The new "Maxitap" produced by the Greenfield Tap & Die Corporation, Greenfield, Mass., is featured in a new pamphlet recently issued. It is claimed that this tap overcomes many of the difficulties of the usual staybolt tap design by means of its special pilot point, chip breaker, special hook on the lands, long taper and special relief.

SPIRAL PIPE.—The American Spiral Pipe Works, Chicago, Ill., has distributed a production book outlining by technical descriptions and illustrations, the manufacture, installation and service of its products including spiral riveted pressure pipe, lap welded steel pipe, forged steel pipe flanges, corrugated furnaces for land and marine boilers and similar specialties. The company has endeavored to make this book an interesting exposition of the part played in meeting engineering demands for pipe service of all kinds and to indicate the scope of the equipment available for special service requirements.

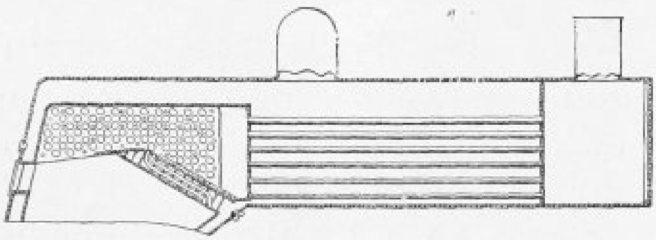
# SELECTED BOILER PATENTS

Compiled by
GEORGE A. HUTCHINSON, Patent Attorney,
Washington Loan and Trust Building,
Washington, D. C.

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

1,397,460. WATER ARCH FOR THE FURNACES OF STEAM BOILERS. ROBERT G. SEAMAN, OF SUMMERHILL, PENNSYLVANIA.

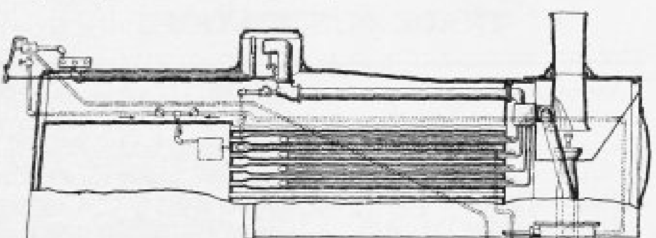
*Claim* 1.—In a boiler furnace having upper and lower portions, an inclined water arch comprising a casing having a top and bottom walls and



longitudinal flues extending through the casing, said flues having intakes opening through the bottom wall near the lower forward end of the firebox, and having outlets through the top wall of the casing, discharging at a point approximately midway of the front and rear walls of the furnace, the upper and lower portions of the furnace chamber being in communication at the rear of the water arch. Three claims.

1,354,238. LOCOMOTIVE. ARTHUR L. BRIDGHAM, OF BOSTON, MASSACHUSETTS, ASSIGNOR OF ONE-HALF TO CHARLES H. SHERBURNE, OF BOSTON, MASSACHUSETTS.

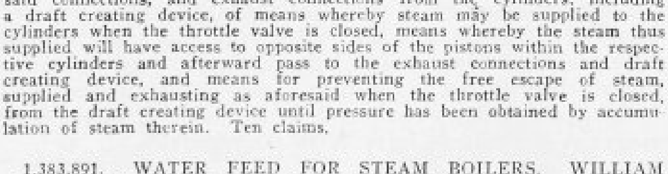
*Claim* 1.—In a steam locomotive, the combination with the boiler, cylinders and pistons, steam connections through which steam from the boiler is



directed to the cylinders for actuating the pistons, a throttle valve in said connections, and exhaust connections from the cylinders, including a draft creating device, of means whereby steam may be supplied to the cylinders when the throttle valve is closed, means whereby the steam thus supplied will have access to opposite sides of the pistons within the respective cylinders and afterward pass to the exhaust connections and draft creating device, and means for preventing the free escape of steam, supplied and exhausting as aforesaid when the throttle valve is closed, from the draft creating device until pressure has been obtained by accumulation of steam therein. Ten claims.

1,383,891. WATER FEED FOR STEAM BOILERS. WILLIAM ALBERT WHITMORE, OF NELSONVILLE, OHIO.

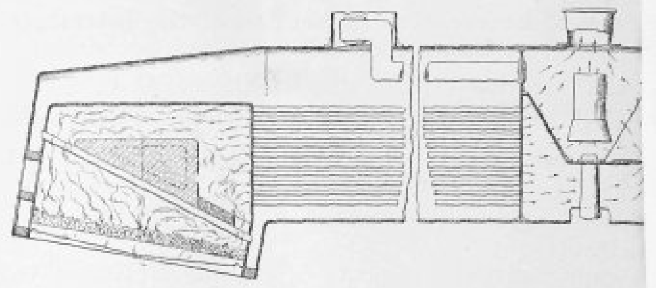
*Claim* 1.—A water feed apparatus for steam boilers, including a steam trap, a receiver adapted to contain water and having an outlet independent



of the steam trap and adapted to be connected with the steam boiler for the direct feed of the water from the receiver to the boiler, a supply connection between the receiver and trap to direct water to the trap from the receiver, and means controlled by the operation of the trap to direct steam to the receiver from the boiler to balance the pressure of the receiver and cause the discharge of water to the boiler from the receiver, together with means independent of the receiver to connect the trap with the boiler and deliver water to the boiler from the trap without passing it through the receiver.

1,395,610. BOILER FURNACE. JOSEPH H. STANNARD, SR., COLUMBIA, SOUTH CAROLINA.

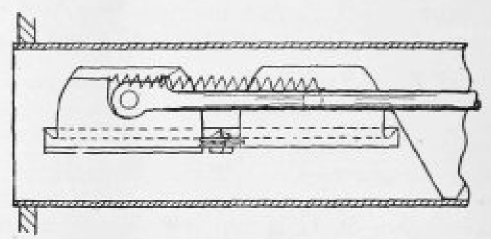
*Claim* 1.—In a horizontal fire tube boiler, including a firebox prov with a grate, a crown sheet and a substantially vertical tube sheet, an extending from side to side of the firebox above the grate with its lo



surface inclined longitudinally and its upper surface separated from crown sheet by a passage of substantially uniform height throughout length of the arch and extending to within a short distance of the tu sheet, said arch being provided with means of preventing direct passage products of combustion from most of the grate area to the tubes openi through the lower section of the tube sheet. Three claims.

1,395,186. APPARATUS FOR TIGHTENING LEAKAGES IN AN ABOUT BOILER TUBES AND THE LIKE. JOHAN MARTI JOHANSEN, OF TRONDHJEM, NORWAY.

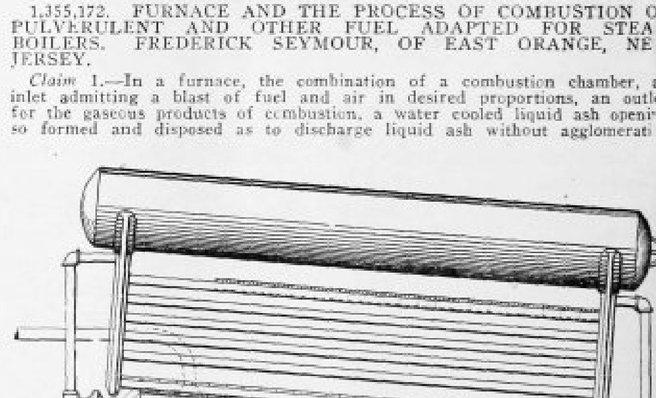
*Claim* 1.—In an apparatus for tightening leakages and the like, a tig ening plug, consisting of two halves, one half of the tightening plug be



pivotally mounted at the front end of a bar, adapted to be introduce through a boiler tube, while the other half of the plug is hinged at i circumference to the first mentioned half of the plug. Two claims.

1,355,172. FURNACE AND THE PROCESS OF COMBUSTION O PULVERULENT AND OTHER FUEL ADAPTED FOR STEA BOILERS. FREDERICK SEYMOUR, OF EAST ORANGE, NE JERSEY.

*Claim* 1.—In a furnace, the combination of a combustion chamber, inlet admitting a blast of fuel and air in desired proportions, an outl for the gaseous products of combustion, a water cooled liquid ash openi so formed and disposed as to discharge liquid ash without agglomerati



except in lumps, a water cooled ash pit covered except as to the liqu ash opening, said combustion chamber being formed to cause the fu and air to move progressively and in the final stages toward said outl but not to pass through said outlet until combustion within the chamb is substantially complete, boundaries of said combustion chamber, t most and preferably all of which comprise refractory materials, the sid preferably vertical, water cooling means associated with refractory materia maintaining the body of refractories at incandescence but at a tempe ture below the fusing temperature thereof and causing and permitting the combustion chamber approximately the maximum combustion tempe ture, all adapted to burn the fuel in maximum quantity, in minimum tim in suspension in air, completely before substantially any particles there contact with heat absorbing means beyond the combustion chamber. Fifte claims.

# THE BOILER MAKER

FEBRUARY, 1922


# Staying Flat End Plates In Lancashire Boilers

### Spacing the Stays — Design of the Gusset Stay — Method of Determining Required Thickness of End Plate

**By Harold E. Pearsall**

IN Lancashire boilers of the "flat ended" type the method adopted for supporting the end plates is by the use of gusset stays. In the designing of suitable stays the designer must aim at obtaining an end plate that is sufficiently supported but at the same time flexible enough to employment of an angle ring for attachment not being practicable as the flue gases passing round the lower portion would soon burn the angle away. Five gusset stays, usually, are arranged above the flues and two or three, according to size and working pressure of the boiler, below the flues.

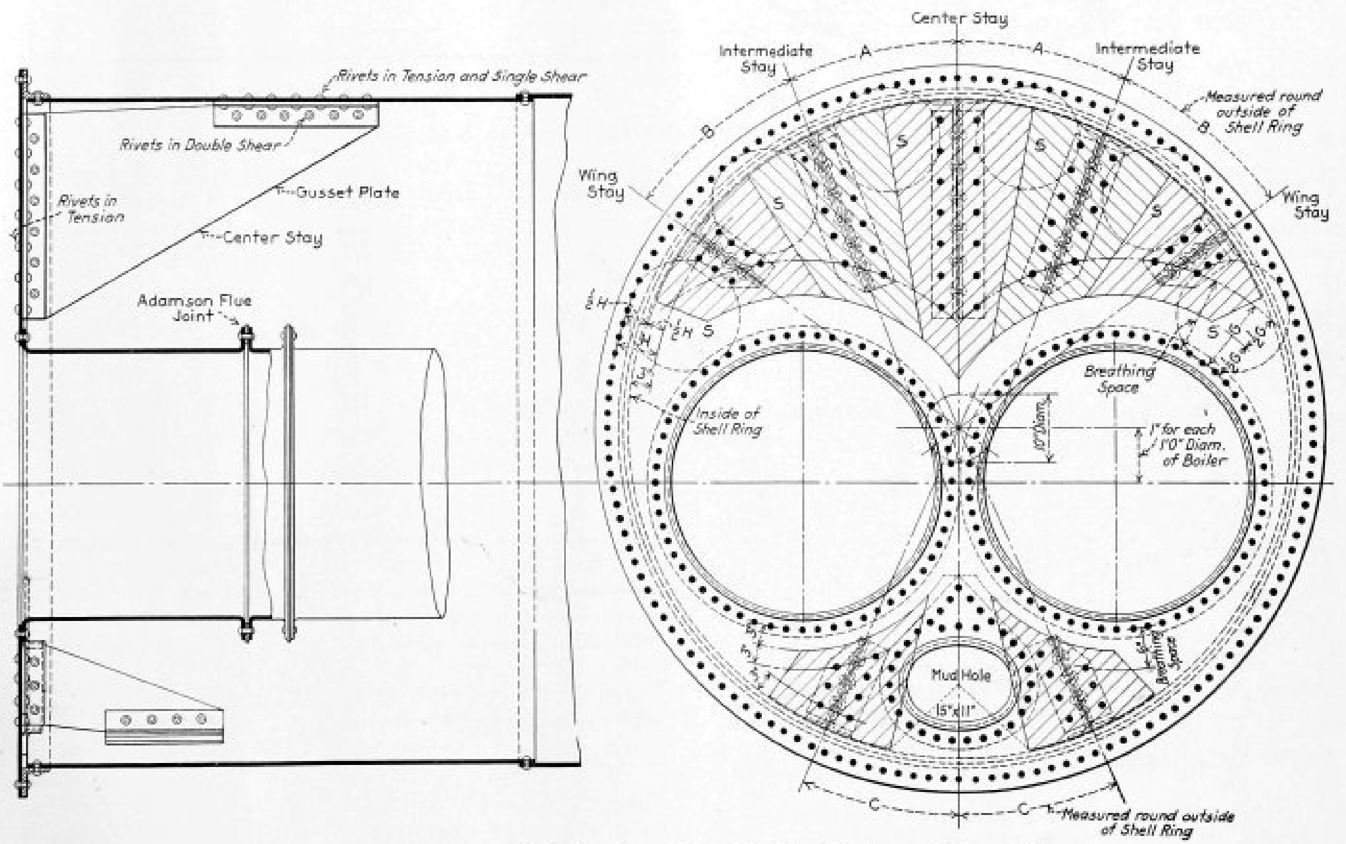



Fig. 1.—Arrangement of Setting Out Front End for Design of Gusset Stays

allow for the expansion and contraction of the boiler flues. Much of the flue expansion is taken up by the use of the Adamson flue joint for connecting the various flue sections, and the introduction of a corrugated section of about a quarter of the length of the boiler, at about the middle of the flues, helps considerably in preventing undue bulging of the end plates.

The front end plate is usually attached to the shell by means of an angle ring riveted to the end plate and shell. Gusset stays, usually five above the flues and two below, are then suitably arranged in the unsupported area.

The back end plate is flanged and riveted to the shell, the

#### Spacing of the Stays

The spacing and design of the gusset stays depend largely upon:

(a) The method adopted in attaching the end plate to the shell.
(b) The method of attaching the flue tubes to the end plate.

The portion of the end plate around the flues is the part affected most by the movement of the flues when expanding and contracting and it is here where the serious risk of grooving arises. Sufficient distance must therefore be allowed between the flues and the stays angles to meet this contingency. This distance is called the "breathing space" and varies with:

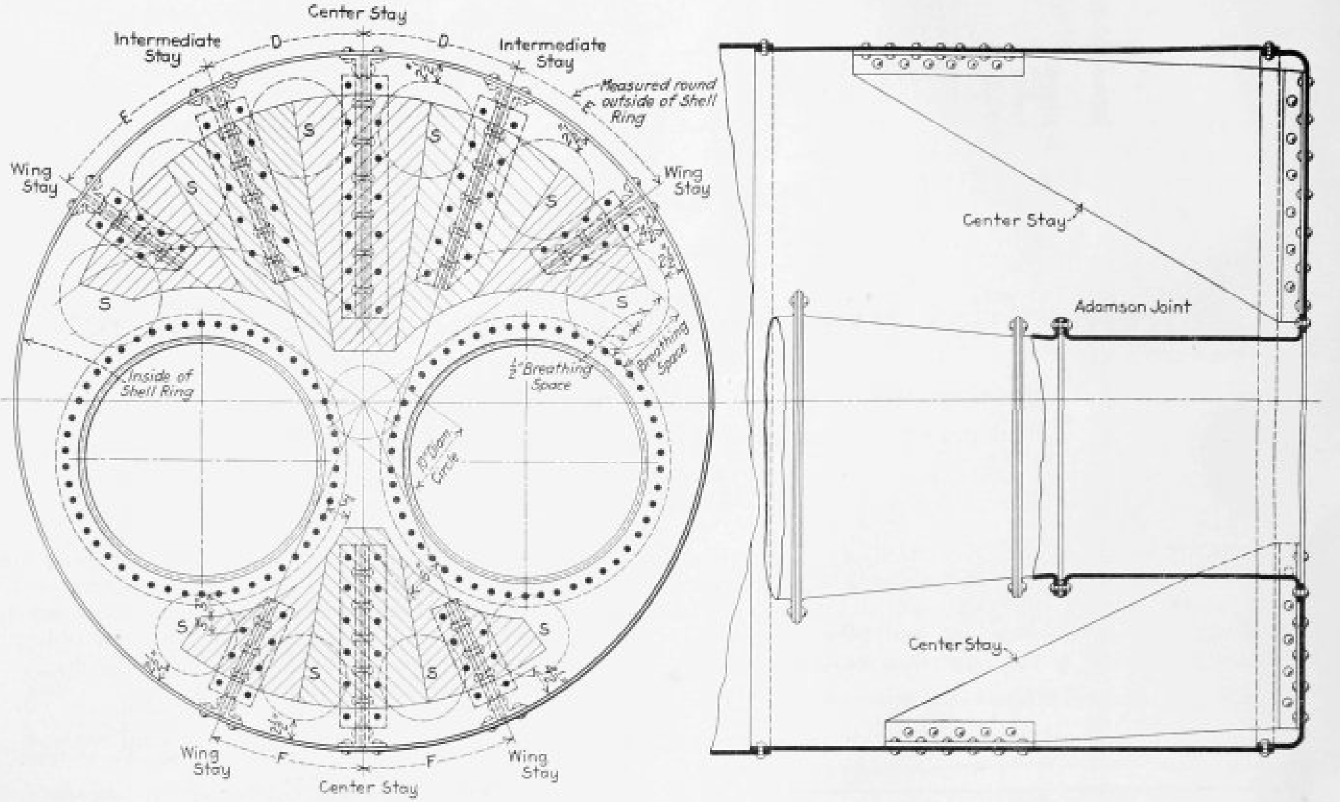



Fig. 2.—Arrangement of Setting Out Back End Plate

(a) Type of flue, whether plain or fitted with corrugated sections.
(b) The method of attaching the flue to the end plate.
(c) The thickness of the end plate.

As grooving hardly ever occurs below the flues, less distance can be allowed between the flues and stays.

Table I gives the breathing spaces required for the conditions given:

TABLE I.—BREATHING SPACES REQUIRED

| Thickness of end plate in inches | Breathing spaces required above flues | | | | Breathing spaces below flues | |
|---|---|---|---|---|---|---|
| | A | B | C | D | A and B | C and D |
| 9/16" | 10 " | 8 " | 11 " | 9 " | 6" | 6" |
| ⅝" | 10½" | 8½" | 11½" | 9½" | 6" | 6" |
| 11/16" | 11 " | 9 " | 12 " | 10 " | 6" | 6" |
| ¾" | 11½" | 9½" | 12½" | 10½" | 6" | 6" |
| 13/16" | 12 " | 10 " | 13 " | 11 " | 6" | 6" |
| ⅞" | 12½" | 10½" | 13½" | 11½" | 6" | 6" |

Column A.—(When flues have flanged attachment to end plate and consist of plain flanged sections throughout as in Fig. 3.)
Column B.—(When flues have flanged attachment to end plate, but flues fitted with corrugated sections at least one-quarter length of boiler, i. e., similar to Fig. 4 but fitted with corrugated section as Fig. 4.)
Column C.—(When flues consist of plain flanged sections throughout but end plate flanged as Fig. 5, to receive flues.)
Column D.—(When flues are fitted with a corrugated section at least one-quarter length of boiler and end plate flanged as Fig. 5, to receive flues.)

Reference to Figs. 3 and 5 will show how the distances should be measured for the varying cases.

## PITCH OF THE GUSSET STAYS

Table II will serve as a guide when fixing the position of the gusset stays. The dimensions A, B, C, and D, E, F, as shown in Figs. 1 and 2, are measured round the outside of the shell plate. Care must always be taken in arranging the stays to allow spaces for feed valve, steam and water gages.

TABLE II.—GUIDE FOR LOCATION OF GUSSET STAYS

| Dia. of boiler | Front end plate | | | | | Back end plate | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No. of stays above flues | A | B | No. of stays below flues | C | No. of stays above flues | D | E | No. of stays below flues | F |
| 9'0" | 5 | 2'1" | 2'2" | 2 | 1'9" | 5 | 2'1" | 2'3" | 3 | 1'9" |
| 8'6" | 5 | 2'0" | 2'1" | 2 | 1'8" | 5 | 2'0" | 2'1½" | 3 | 1'8½" |
| 8'0" | 5 | 1'10½" | 1'11½" | 2 | 1'8" | 5 | 1'10½" | 1'11½" | 3 | 1'8" |
| 7'6" | 5 | 1'9" | 1'10" | 2 | 1'8" | 5 | 1'8½" | 1'10½" | 2 | 1'7½" |
| 7'0" | 4 | 10½" | 1'11½" | 2 | 1'7½" | 4 | 10½" | 1'11½" | 2 | 10½" |
| 6'6" | 4 | 10½" | 1'10½" | 2 | 1'7" | 4 | 10" | 2'0" | 2 | 10½" |

## DESIGN OF THE GUSSET STAY

In order to design a suitable stay it is necessary to determine the area which the gusset stay supports. The cross sectioned areas in Figs. 1 and 2 show clearly the area attributed to each stay. When the end attachment is made by means of an angle ring, as in Fig. 1, the distance to which the stay supports should be taken is midway between the rivets in the angle ring and the top rivets in the gusset angles. When the flue is flanged and riveted to the end plate the distance supported by the stays is taken midway between rivets in the flue flange and lower rivets in the gusset angles.

When the end plate attachment is made by flanging the plate, as in Fig. 2, then the end plate may be regarded as supporting to a distance as given by the following formula:

$$S = \frac{5t}{\sqrt{WP}}$$

in which,

S = distance from outside end plate to maximum line of support in inches.
t = thickness of end plate in sixteenths of an inch.
WP = working pressure in pounds per square inch gage.

In cases where the flue is attached by the flanging of the end plate, as in Fig. 5, the same formula may be used to determine the line to which this flanging supports.

The staying of the portion of the front end below the flues has been evolved as a result of experience, as the load coming

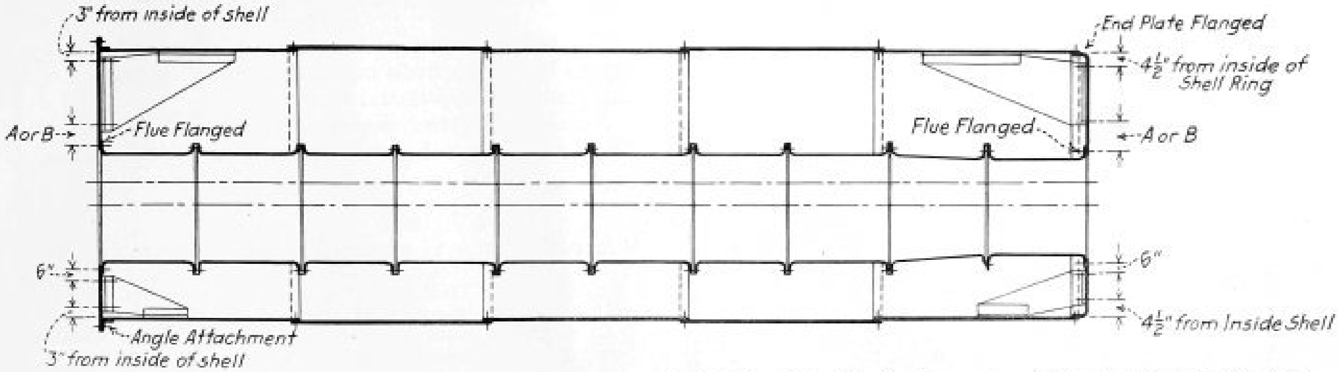



**Fig. 3.—Showing Boiler with Plain Flues Throughout and Having Flue Ends Flanged and Riveted to End Plates**

upon it depends upon the form of compensating ring fixed around the mudhole opening. If, as in Fig. 1, a steel frame of deep section is employed, the edge of the frame lies close to the shell angle and to the flue riveting, this considerably strengthens the portion of the end plate to which it is attached and it becomes to a certain extent self supporting. With such a frame the area supported may be taken as shown cross sectioned in the illustration. If, on the other hand, a plain flat plate, equal in thickness to the end plate, is fitted, then the area to be carried by the stay must be taken as indicated by the shaded area plus the area indicated by the dotted lines in Fig. 1. The stays must be kept as close as possible to the manhole frame. As a general rule the gusset plate angles should touch the edge of the manhole frame.

### Radial and Non-Radial Stays

Reference to Figs. 1 and 2 shows that all the stays except the intermediate stays above the flues are set radially to the center of the boiler. In the intermediate stays, which are not radial but at a tangent to a 10-inch diameter circle in the center of the end, care must be taken in fixing the gusset angles to the shell. These should be given a slight set so as to prevent any cracking of the stay plate. This is illustrated in Fig. 6.

### Double Riveted Angles for Gusset Stays

In high pressure boilers it is often found necessary to use double riveted angles in order to get the required number of

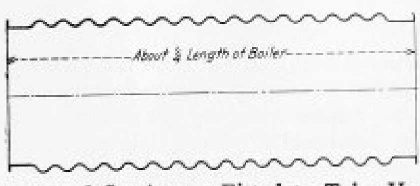



**Fig. 4.—Corrugated Section as Fitted to Take Up Expansion of Flues. The Fitting of These Reduces Breathing Space**

rivets in the angles at a suitable pitch. When such angles are used it will sometimes be found necessary to carry the angles connecting the stay to the shell of one of the intermediate stays on to the second shell ring so that it shall be clear of the longitudinal joint on the first shell ring.

### Allowable Stresses

The following can be used as safe stresses in the material for calculations of the gusset stay strength:

Tensile stress, 9,000 pounds per square inch.
Shear stress, 9,500 pounds per square inch.
Bearing stress, 18,000 pounds per square inch.

Double shear should be taken as 1¾ times single shear.

### Pitch of the Rivets

The rivets connecting the gusset stay angles to the boiler shell must be suitably pitched so that the strength of the drilled plate shall not be less than the strength of the longitudinal seam. This means that, if rivets of the same size as in the longitudinal joint are used, the pitch of the rivets must not be less than the pitch in the joint. The pitch of the rivets in the gusset angles riveted to the end plates is fixed by no definite rule but it is advisable that the minimum pitch should never be less than that given in Table III.

Table III.—Minimum Pitch of Rivets in Gusset Stay Angles

| | | | | | |
|---|---|---|---|---|---|
| Size of Rivet hole | 3/4" | 13/16" | 7/8" | 15/16" | 1" |
| Minimum pitch of rivets in gusset angles | 1-7/8" | 2-1/8" | 2-1/4" | 2-3/8" | 2-1/2" |

### Diameter of Rivets

It is usual to have rivets of the same diameter as in the boiler shell joint which should be in accordance with the well known Unwin formula

$$\text{Diameter of Rivet} = 1.2\sqrt{\text{plate thickness}}$$

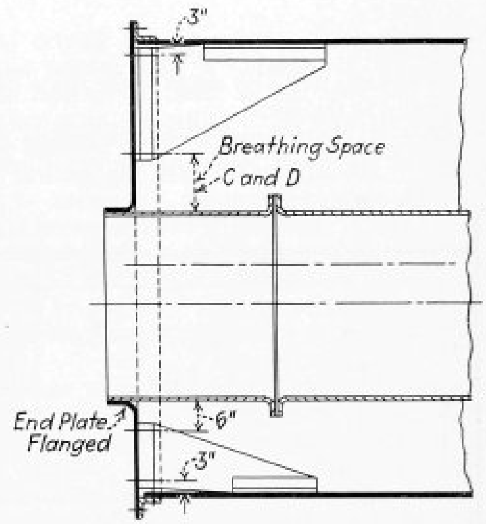



**Fig. 5.—Details of End Plate Flanged Out for Flue Attachment**

The sizes in Table IV are based on this.

Table IV.—Diameter of Rivets

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Plate thickness | 1/2" | 9/16" | 5/8" | 11/16" | 3/4" | 13/16" | 7/8" |
| Dia. of rivet holes required | 13/16" | 7/8" | 7/8" | 1" | 1" | 1-1/16" | 1-1/16" |

### Gusset Stay Angles

The size of the angles of the gusset stay depends largely upon the size of the rivets to be used. The thickness of the angles should be about the same as the plate to which they are riveted.

13/16-inch and 7/8-inch holes require angles 3½-inch by 3½-inch by thickness of plate.

1-inch and 1-1/16-inch holes require angles 4-inch by 4-inch by thickness of plate.

To determine the number of rivets required for attachment of stay to end plate: Having set out the areas supported by each stay shown in Figs. 1 and 2, determine the area supported by each stay by use of a planimeter or other means. Then the load on the stay equals area supported in square inches times working pressure in pounds per square inch.

Let A = Area supported by stay in square inches.
W P = Working pressure of the boiler in pounds per square inch.
a = Area of one rivet in square inches.
N = Number of rivets in both angles.

Then the number of rivets required for connecting the two gusset angles to the end plate, these rivets being in tension

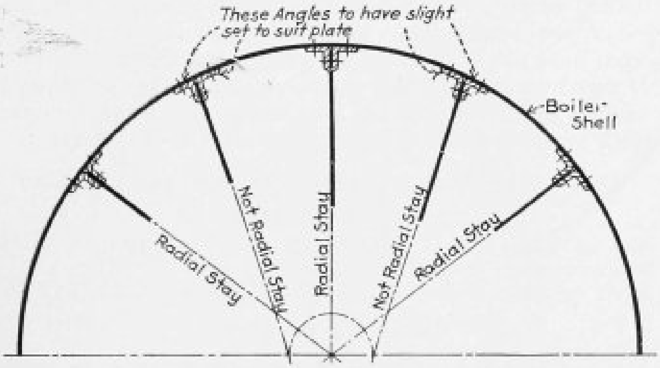



**Fig. 6.—Arrangement of Angles to Shell for Non-Radial Stays**

the stress can be taken as 9,000 pounds per square inch, can be found by the formula

$$N = \frac{A \times WP}{a \times 9000}$$

This same formula will also apply to the rivets connecting the gusset angles to the shell.

The number of rivets required for connecting the shell gusset angles to the gusset plate and the end gusset angles

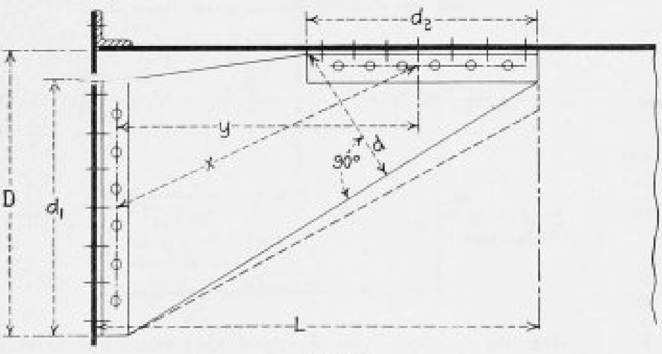



**Fig. 7**

to the gusset plate will be the same and can be found by the following:

$$N = \frac{A \times WP}{a \times 9500 \times 1.75}$$

9500 × 1¾ being the safe stress for double shear.

It is unnecessary to deal with the shear of the rivets in the gusset angles riveted to the shell as the tensile stress is slightly less than the shearing stress. Therefore the number of rivets required to resist tension will be ample to resist shear.

### Bearing Stress

The bearing stress of the rivets is often neglected by designers but where rivets of small diameter are used it is most important that this should be tried.

Number of rivets required for connecting either shell gusset angles or end plate gusset angles to gusset plate = N.

$$N = \frac{A \times WP}{t \times d \times 18000}$$

Where A = Area supported by stay in square inches.
W P = Working pressure in pounds per square inch.
t = Thickness of gusset plate in inches.
d = Diameter of rivets in inches.
18000 = Safe bearing stress of rivets in pounds per square inch.

To find the number of rivets required in the gusset angles riveted to the shell is unnecessary, although this can be found by a similar formula, but in place of *t* the thickness of the shell plate or the thickness of the angle (whichever is the thinner) must be substituted.

### Thickness of the Gusset Plate

The necessary thickness of gusset plate required can be found from the following formula which allows for the stay being a diagonal and not a direct stay.

$$t = \frac{A \times WP \times x}{d \times 9000 \times y}$$

Where t = Thickness of gusset plate in inches.
A = Area supported by stay in square inches.
W P = Working pressure in pounds per square inch.
x = Diagonal distance from center of gusset angles on end plate to center of gusset angles on shell ring.
y = Horizontal distance between center of end plate gusset angles and shell gusset angles.
d = Net depth of plate—and must be taken as the least of the following cases:

[(d)—(Diameter of one rivet hole)]
[($d_1$)—(Number of rivet holes times diameter)]
[($d_2$)—(Number of rivet holes times diameter)]
x, y, d, $d_1$, and $d_2$ are as shown in Fig. 7.

The ratio of L and D, that is the length and depth of the gusset stay (as shown in Fig. 7), should not be less than the ratio of 2 and 1. Where necessary to obtain the required depth of the gusset plate, d must be slightly increased as indicated by the dotted lines in Fig. 7, but if possible this method should be avoided.

### To Determine the Required Thickness of End Plate

The thickness required for a suitable end plate depends upon the largest amount of unstayed area that occurs in the plate and no definite rule for the thickness seems to have been found theoretically. Numerous experiments, however, have been carried out by different authorities for determining a suitable formula and various ones have been established. In order to avoid confusion by reference to different formulas the following which gives results which are an average of some of the most used formulas can be employed.

$$t = \frac{S \times \sqrt{WP}}{K} \quad \text{or} \quad S = \frac{t \times K}{\sqrt{WP}} \quad \text{and} \quad WP = \left(\frac{t \times K}{S}\right)^2$$

Where t = Thickness of the end plate in sixteenths of an inch.
W P = Working pressure of boiler in pounds per square inch.
K = Constant depending upon the position of the unstayed area.
When unstayed area is not in contact with flue gases K = 17
When unstayed area is in contact with flue gases K = 16
S = Diameter of largest circle which can be inscribed in an unstayed area.

The method of drawing the circles in the unstayed area is illustrated in Figs. 1 and 2 by the circles marked S.

Table V.—Working Pressures for Flat Ends of Lancashire Boiler

| Diameter of circle in inches inscribed in unstayed area. | Thickness of Plates in Inches. 9/16" Z. | 9/16" Z.1. | 5/8" Z. | 5/8" Z.1. | 11/16" Z. | 11/16" Z.1. | 3/4" Z. | 3/4" Z.1. | 13/16" Z. | 13/16" Z.1. | 7/8" Z. | 7/8" Z.1. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10" | 234. | 208. | 290. | 256. | | | | | | | | |
| 10½" | 212. | 188. | 262. | 232. | 316. | 280. | | | | | | |
| 11" | 193. | 171. | 238. | 211. | 290. | 256. | | | | | | |
| 11½" | 177. | 157. | 218. | 194. | 265. | 235. | 313. | 278. | | | | |
| 12" | 162. | 144. | 200. | 178. | 243. | 215. | 290. | 256. | | | | |
| 12½" | 150. | 132. | 184. | 164. | 224. | 198. | 267. | 235. | 312. | 276. | | |
| 13" | 138. | 122. | 170. | 151. | 207. | 184. | 246. | 217. | 290. | 256. | | |
| 13½" | 128. | 114. | 158. | 140. | 192. | 170. | 228. | 202. | 267. | 237. | 310. | 275. |
| 14" | 119. | 106. | 147. | 130. | 178. | 159. | 212. | 188. | 250. | 220. | 290. | 256. |
| 14½" | 111. | 99. | 137. | 122. | 167. | 158. | 198. | 175. | 232. | 206. | 270. | 238. |
| 15" | 104. | 92. | 128. | 114. | 156. | 138. | 185. | 164. | 217. | 192. | 252. | 222. |
| 15½" | 97. | 86. | 120. | 106. | 146. | 129. | 173. | 153. | 203. | 180. | 236. | 208. |
| 16" | 91. | 81. | 113. | 100. | 137. | 121. | 163. | 144. | 191. | 169. | 221. | 196. |
| 16½ | 86. | 76. | 106. | 94. | 129. | 114. | 153. | 135. | 180. | 159. | 208. | 184. |
| 17" | 81. | 72. | 100. | 89. | 121. | 107. | 144. | 127. | 169. | 150. | 196. | 173. |
| 17½" | 76. | 68. | 94. | 84. | 114. | 101. | 136. | 120. | 160. | 141. | 185. | 164. |
| 18" | 72. | 64. | 89. | 79. | 108. | 96. | 128. | 114. | 151. | 133. | 175. | 154. |
| 18½" | 68. | 60. | 84. | 75. | 102. | 91. | 121. | 107. | 143. | 126. | 166. | 146. |
| 19" | 65. | 57. | 80. | 71. | 97. | 86. | 115. | 102. | 135. | 120. | 157. | 139. |
| 19½" | 62. | 54. | 76. | 67. | 92. | 82. | 109. | 97. | 127. | 114. | 149. | 132. |
| 20" | 59. | 52. | 72. | 64. | 88. | 78. | 104. | 92. | 122. | 108. | 142. | 125. |

Column Z gives working pressures of end plates when area is *not exposed* to the flue gases.

Column Z. 1., gives working pressures of end plate when area *is exposed* to the flue gases.

Working pressures are in pounds per square inch.

For all circles in the front end and also above the flue crowns in the back end, K may be taken as 17, but for circles below the flue crowns or tops of flues K must be taken as 15.

The circles in the back end plate which is flanged and riveted to the shell need not be drawn touching the outside of the end because the radius of the plate at the flange acts as a stay. This radius is usually about 2½ inches on the outside on the flange. Therefore the circle can be inscribed touching a point 2½ inches from the inside of the shell ring. Reference to Fig. 2 shows clearly the method of inscribing the circles in the back end.

Table V compiled from this formula gives the thickness of plates and working pressures for inscribed circles from 10 to 20 inches diameter, for circles in contact with the gases and for circles not in contact with them.

It is often necessary to know the thickness of a suitable end plate without setting out all the staying arrangement which is rather a long process. Table VI gives the approximate thickness.

Table VI.—Approximate Thicknesses for Flat End Plates of Lancashire Boilers

| Diameter of Boiler. | 9'0" | | | 8'6" | | | 8'0" | | |
|---|---|---|---|---|---|---|---|---|---|
| Working Pressure Pounds. | 100 | 120 | 150 | 100 | 120 | 150 | 100 | 120 | 150 |
| Thickness of Plate. | 5/8" | 11/16" | 3/4" | 5/8" | 11/16" | 3/4" | 5/8" | 11/16" | 11/16" |

| Diameter of Boiler. | 7'6" | | | | 7'0" | | | | 6'6" | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Working Pressure Pounds. | 80 | 100 | 120 | 150 | 80 | 100 | 120 | 150 | 80 | 100 | 120 |
| Thickness of Plate. | 9/16" | 9/16" | 5/8" | 11/16" | 9/16" | 9/16" | 5/8" | 11/16" | 9/16" | 9/16" | 9/16" |

## Six-Roll Superheater Flue Expander

There exists a difference of opinion among engineers as to the advantages and disadvantages of the six-roll flue expander as compared with the three-roll type for the superheater flue work. On small tube work, the three-roll expander is universally used, and when the superheater was fitted to British locomotives the expander for the large flues was designed on similar lines to the small tube expander. The roll box of the expander was made with an adjustable cap to enable the rolls to be adjusted to suit various tube sheet thicknesses. It is necessary that a flue should be expanded about ⅛ inch through the sheet and the cap on the three-roll expander enables the operator to do this.

This cap is fixed, and therefore the length of roll is not controlled by the operator, an important point, since when new flues are inserted in a flue sheet they are first expanded, then beaded over and afterwards re-expanded. When this work is done by the six-roll expander the first expanding lays down only a portion of the flue, as the allowance tor beading, 9/16 inch prevents the rolls from passing further into the flue. After the flue is beaded the re-expanding covers an additional portion of flue, which is not good in practice. This trouble does not exist when the three-roll expander is used, as the cap fits over the beading and rests against the flue sheet. The length of the flue expanded thus remains constant.

The three-roll expanders are fitted with a nut on the end of the mandrel, which is used for removing the expander after the flue has been sufficiently expanded. This nut is screwed against the box portion and the mandrel is thereby forced out. The pressure necessary to make a good joint is obtained by driving the tapered mandrel in with a copper hammer and turning with a ratchet. In the six-roll expanders the rolls are inclined, so that they will tighten up during the action of expanding. The flues are expanded by turning the mandrel to the right, and the expanders are released by turning the mandrel to the left. This is an advantage, as hammering the mandrel drives the rollers on to the flue at points of contact, and tends to make grooves in the tube surface. It is necessary that the inclination on the rolls be made so that they will not tighten the expander too suddenly, and at the same time be sufficient to release the expander without the operator having to resort to the use of a hammer.

An advantage which the six-roll expander has over the three-roll expander is that, having several points of contact, the tendency to straighten out the flue between the rolls is negligible. Consider a three-roll tube expander inserted in a tube 4 15/16 inches in diameter which is in position in a flue hole 5 inches in diameter. The spindle, on being driven in, lays the flue down in three places, the metal of the flue between these points, about 5¼ inches apart, being lifted further through the flue sheet and somewhat straightened. A similar flue expanded with the six-roll expander would be opened evenly and gradually, as no driving of the mandrel is required with this expander.

After a boiler has been working for a time the flue sheet holes become misshapen, due to upward expansion of the firebox, downward thrust of the steam pressure on the firebox crown, and stress put into the flue sheet by expanding the flues. The flues in the misshapen holes give considerable trouble from leaking, and have to be re-expanded from time to time in the locomotive terminals. It is not economical to

(*Continued on page* 58)

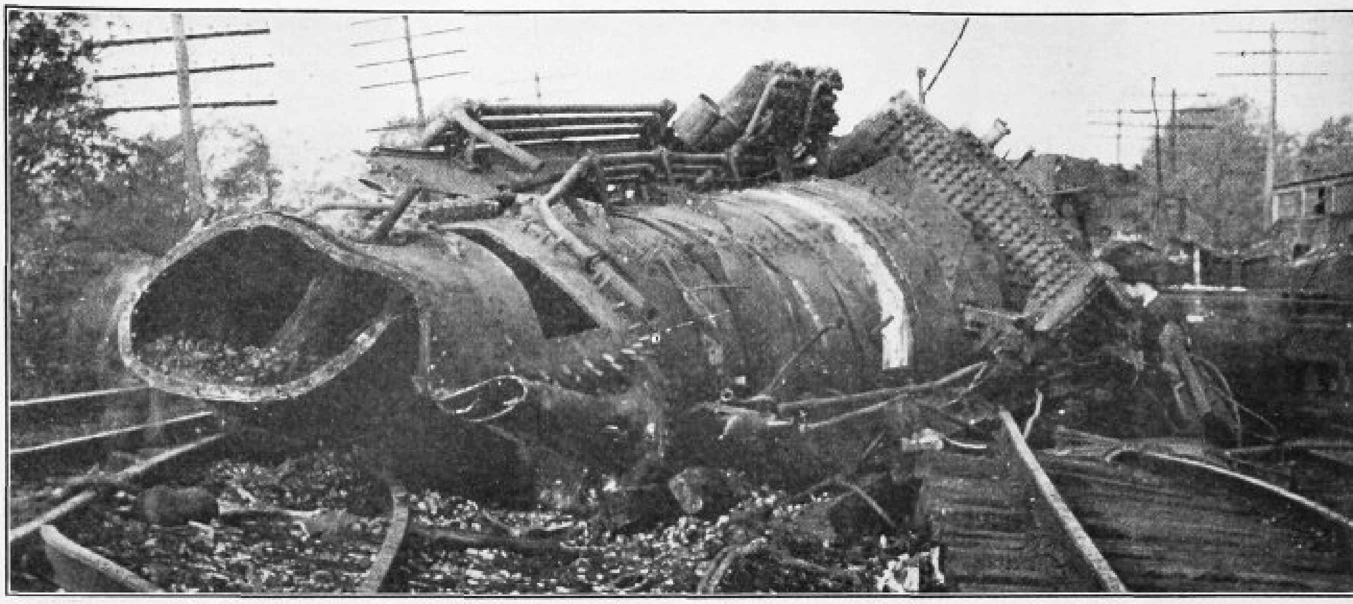


Fig. 1.—Result of a Boiler Explosion Caused by the Failure of the Crown Sheet

# Locomotive Accidents Decrease in Past Year

## Boiler Accidents 60 Percent Less Than in First Year of Boiler Inspection Law

By A. G. Pack*

IN the annual report of the Bureau of Locomotive Inspection to the Interstate Commerce Commission, covering the fiscal year ending June 30, 1921, a marked decrease of accidents over these occurring in the previous year is noted.

The summary of all accidents and casualties investigated develops the fact that failures covering the entire locomotive and tender were 12.8 percent less in number than in the preceding year; 3 percent fewer people were killed and 12.6 percent fewer were injured.

TABLE 1.

NUMBER OF ACCIDENTS, NUMBER KILLED, AND NUMBER INJURED AS A RESULT OF FAILURE OF PARTS AND APPURTENANCES OF THE ENTIRE LOCOMOTIVE AND TENDER, BY YEARS.

| | 1921 | 1920 | 1919 | 1918 | 1917 |
|---|---|---|---|---|---|
| Number of accidents | 735 | 843 | 565 | 641 | 616 |
| Decrease from previous year (percent) | 12.8 | [1] 49.2 | 11.8 | [1] 4.1 | ... |
| Number killed | 64 | 66 | 57 | 46 | 62 |
| Decrease from previous year (percent) | 3 | [1] 15.8 | [1] 23.9 | 25.8 | ... |
| Number injured | 800 | 916 | 647 | 756 | 721 |
| Decrease from previous year (percent) | 12.6 | [1] 41.6 | 14.4 | [1] 4.8 | ... |

[1] Increase.

TABLE 2.

NUMBER OF ACCIDENTS, NUMBER KILLED, AND NUMBER INJURED AS A RESULT OF THE FAILURE OF SOME PART OR APPURTENANCE OF THE BOILER ONLY.

| | 1921 | 1920 | 1915 | 1912 |
|---|---|---|---|---|
| Number of accidents | 342 | 439 | 424 | 856 |
| Number killed | 51 | 48 | 13 | 91 |
| Number injured | 379 | 503 | 467 | 1,005 |

During the first six months of the fiscal year 1921 accidents and casualties occurred at an alarming rate and exceeded those of any like period during the five preceding years. However, during the last six months a marked reduction is recorded. The number of accidents and casualties during the year was considerably in excess of those occurring during the year 1919, and as referred to in my last annual report, a large number of accidents resulting in serious injury were caused by the failure of what are frequently termed unimportant parts. For instance, during the year 85 accidents were caused by the failure of some part of the grate-shaking apparatus, 82 by squirt hose, and 65 by some part of the reversing gear, all of which could have been avoided by reasonable care.

*Chief Inspector, Bureau of Locomotive Inspection.

### Reduction in Boiler Accidents

Comparing 1912, the first year of the boiler inspection law, covering parts and appurtenances of the boiler only, with the year 1915, the fourth year of the law, there is shown to be a reduction of 50 percent in the number of accidents, 85.7 percent in the number killed and 53.5 percent in the number injured.

Comparing 1912, the first year of the boiler inspection law, with the year 1921, covering parts and appurtenances of the boiler only, there is shown to be a reduction of 60 percent in the number of accidents, 44 percent in the number killed and 62 percent in the number injured.

Comparing 1915, the fourth year of the existence of the law, with the year 1921, there is shown a decrease of 19 percent in the number of accidents, an increase of 292 percent in the number killed, and a decrease of 17 percent in the number injured, due to the failure of some part or appurtenance of the boiler only. Barrel explosions have been entirely eliminated, and while the so-called crown sheet failures have materially decreased, the great increase in fatalities indicates that the severity of these failures has increased tremendously.

During the year there were a number of accidents investigated in which firebox seams formed by the autogenous welding process were involved, where, through the failure of these seams, it is believed the result of the accident was much more serious than would otherwise have been. Autogenous welding can be used on many parts of the locomotive and tender and on parts of the stayed surfaces of the boiler with safety and economy, but inasmuch as our accident investigations show that approximately 80 percent of the autogenously welded seams fail, where they are involved in the accidents, we believe that such methods should be avoided in firebox crown sheet seams where overheating and failure are liable to occur, or on any part of the boiler where the strain to which the structure is subjected is not carried by other construction which fully meets with the requirements of the law and rules, at least until some means has been developed through which the quality and tenacity of the weld may be established in advance of its failure. This should apply on all parts of the locomotive and tender where, through failure, an accident and an injury might result.

Table 3 shows that boiler explosions have been the most prolific source of serious and fatal injuries.

### Water Level Indicating Devices

In my last annual report was included a report covering tests made to determine the action of water in the boiler on the water-indicating appliances with respect to their correct registration. These tests established that gage cocks screwed directly in the boiler do not correctly indicate the general water level while steam is rapidly escaping from the boiler, and in order to secure a proper appliance it was recommended that a water column to which three gage cocks and one water glass were attached be applied.

As far as we have been able to determine, practically all new locomotives constructed since that report was rendered have had water columns applied. On old locomotives the application has not progressed rapidly, probably due to the difficulty in obtaining necessary appropriations. The necessity for such appliances, however, is practically unquestioned, and some roads are proceeding with the application in a very satisfactory way. It is hoped that in the near future this important appliance will be applied on all locomotives, so that enginemen may have accurate knowledge of the general water level in the boiler under all conditions of service.

Transcribed reports showing defects found on all locomotives ordered out of service and those found approaching violations of the law and rules were furnished the chief operating officers of the carriers monthly, so that they might be fully informed of the condition of their locomotives as disclosed by our inspectors.

During the year 209 applications were filed for extension of time for the removal of flues, as provided in rule 10. Investigation showed that in 25 of these cases the condition of the locomotives was such that no extension could properly be granted; 22 were in such condition that the full extension requested could not be granted, but an extension for a shorter period within the limits of safety was allowed; 25 extensions were granted after defects disclosed by our investigation had been repaired; 38 applications were withdrawn for various reasons; and the remaining 99 were granted for the full period requested.

As provided in rule 54, there were filed 2,791 specification cards and 9,785 alteration reports. These have been carefully checked to determine whether the boilers represented were so constructed as to safely withstand the pressure to which they were being subjected and that the stresses given in the specifications and alteration reports had been correctly calculated.

The law provides that whenever any district inspector shall in the performance of his duty find any locomotive or apparatus pertaining thereto not conforming to the requirements of the law or the rules and regulations established and approved he shall notify the carrier in writing that the locomotive is not in serviceable condition, and thereafter shall not be used until in serviceable condition: *Provided*, That a carrier, when notified by an inspector in writing that the locomotive is not in serviceable condition because of defects set out and described in said notice, may appeal to the chief inspector to have the locomotive reexamined. The carrier, being dissatisfied with the decision of the chief inspector, may appeal to the Interstate Commerce Commission.

Under this provision of the law not a single formal appeal has been taken from the decision of any inspector during the fiscal year. This demonstrates that wisdom and good judgment have been exercised by our inspectors in the performance of their duties.

### Recommendations for Betterment of Service

In my last annual report certain recommendations were made for the betterment of the service in accordance with section 7 of the act as amended. During the year experience has further demonstrated the wisdom of these recommendations; therefore they are respectfully renewed and the reasons therefor given.

First. That the act of February 17, 1911, be amended so as to provide for additional inspectors to be appointed by the commission as the needs of the service develop.

The act of February 17, 1911, provides that 50 inspectors be appointed, whose duties shall be to make such personal inspections from time to time of locomotive boilers under their care as might be necessary to fully carry out the provisions of the act, so the locomotive might be employed in moving traffic without unnecessary peril to life or limb. At the time this law was enacted there were approximately 63,000 locomotives coming under its jurisdiction.

This act has since been amended, extending the authority of the chief inspector and his two assistants, together with all of the inspectors, to cover the entire locomotive and tender and all of their appurtenances. The number of locomotives has increased to more than 70,000. With the extended duties of the inspectors and the increase in the number of locomotives, it is impossible for the number of inspectors now provided to adequately accomplish the purpose for which the law was established.

New duties and responsibilities have been imposed upon the commission by the transportation act of 1920, and the act to regulate commerce has been extended, and no doubt in the future, as in the immediate past, this bureau will be called on from time to time to make investigations necessary to carry out the requirements.

To be in position to effectively carry out the duties imposed, it is necessary to have an efficient corps of competent and well-trained inspectors who can be called upon when occasion requires. In order to obtain and retain in the service such inspectors, their salaries should be increased to be commensurate with the duties performed and the responsibilities imposed. The absence of inspectors from their accustomed duties or the lack of a sufficient number is reflected by the increased number of accidents and casualties and the deficiency of motive power. It is therefore respectfully recommended that the act of February 17, 1911, be amended so as to provide for additional inspectors to be appointed by the commission as the needs of the service develop and that adequate salaries may be paid that will obtain and retain in the service a full corps of well-trained, efficient inspectors, and that the amounts directly appropriated to carry out the provisions of the act of February 17, 1911, as amended, be increased to meet the requirements.

Second. That all locomotives not using oil for fuel have a mechanically operated fire door so constructed that it may be operated by pressure of the foot on a pedal or other suitable device located on the floor of the cab or tender at a proper distance from the fire door, so that it may be conveniently operated by the person firing the locomotive.

This recommendation is based on the results of many investigations of boiler failures of such character as to permit the steam and water contained in the boiler at the time of the accident to be discharged into the firebox, many times

TABLE 3.

ACCIDENTS AND CASUALTIES RESULTING FROM FAILURES OF LOCOMOTIVES AND TENDERS AND THEIR APPURTENANCES.

| Part or appurtenance which caused accident | Year ended June 30 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1921 | | | 1920 | | | 1919 | | | 1918 | | |
| | Accidents | Killed | Injured | Accidents | Killed | Injured | Accidents | Killed | Injured | Accidents | Killed | Injured |
| Air reservoirs | 1 | ... | 1 | 2 | 1 | 2 | 2 | ... | 2 | 5 | ... | 7 |
| Aprons | 16 | ... | 16 | 8 | ... | 8 | 5 | ... | 5 | 5 | ... | 5 |
| Arch tubes | 5 | ... | 5 | 9 | 1 | 15 | 7 | 2 | 9 | 9 | ... | 16 |
| Ash-pan blowers | 5 | ... | 5 | 6 | 1 | 5 | 11 | 1 | 10 | 7 | ... | 7 |
| Axles | 5 | ... | 6 | 5 | ... | 5 | 2 | ... | 2 | 4 | ... | 4 |
| Blow-off cocks | 14 | ... | 14 | 15 | ... | 15 | 4 | ... | 4 | 17 | 1 | 18 |
| Boiler checks | 7 | 1 | 7 | 5 | ... | 6 | 4 | ... | 4 | 13 | ... | 14 |
| Boiler explosions | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| A. Shell explosions | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| B. Crown sheet; low water; no contributory causes found | 20 | 19 | 26 | 24 | 22 | 35 | 31 | 26 | 46 | 34 | 15 | 61 |
| C. Crown sheet; low water; contributory causes or defects found | 33 | 24 | 52 | 35 | 19 | 46 | 34 | 13 | 63 | 51 | 17 | 82 |
| D. Firebox; defective staybolts, crown stays, or sheets | 1 | 2 | ... | 2 | ... | 2 | 2 | ... | 3 | 5 | ... | 6 |
| E. Firebox; water foaming | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Brakes and brake rigging | 6 | ... | 6 | 3 | ... | 3 | 8 | 3 | 10 | 2 | ... | 2 |
| Couplers | 11 | 1 | 13 | 8 | ... | 8 | 12 | ... | 14 | 6 | 2 | 4 |
| Crank pins, collars, etc | 6 | 3 | 8 | 4 | ... | 4 | 5 | ... | 6 | 7 | ... | 9 |
| Crossheads and guides | 4 | 1 | 4 | 5 | 2 | 3 | 5 | ... | 5 | 1 | ... | 1 |
| Cylinder cocks and rigging | 4 | ... | 4 | ... | ... | ... | 2 | ... | 2 | 2 | ... | 2 |
| Cylinder heads and steam chests | 6 | ... | 6 | 9 | ... | 9 | 5 | ... | 7 | 4 | ... | 4 |
| Dome caps | ... | ... | ... | ... | ... | ... | ... | ... | ... | 1 | ... | 1 |
| Draft appliances | 8 | ... | 9 | 1 | ... | 1 | 2 | ... | 4 | 5 | ... | 5 |
| Draw gear | 8 | 1 | 8 | 11 | 2 | 9 | 7 | 1 | 6 | 11 | 2 | 9 |
| Fire doors, levers, etc | 8 | ... | 8 | 11 | ... | 11 | 7 | ... | 7 | 6 | ... | 6 |
| Flues | 32 | 1 | 35 | 45 | ... | 52 | 33 | 1 | 39 | 40 | ... | 47 |
| Flue pockets | 1 | 1 | ... | ... | ... | ... | 2 | ... | 2 | 2 | ... | 2 |
| Footboards | 8 | 3 | 5 | 23 | ... | 23 | 7 | ... | 7 | 7 | ... | 7 |
| Gage cocks | ... | ... | ... | 2 | ... | 2 | ... | ... | ... | 1 | ... | 1 |
| Grease cups | 7 | ... | 7 | 10 | ... | 10 | 3 | ... | 3 | 1 | ... | 2 |
| Grate shakers | 85 | ... | 85 | 108 | ... | 109 | 37 | 1 | 36 | 39 | ... | 39 |
| Handholds | 19 | ... | 20 | 15 | 1 | 14 | 16 | 1 | 15 | 15 | 1 | 14 |
| Headlights and brackets | 8 | 2 | 6 | 9 | 1 | 9 | 4 | ... | 5 | 9 | ... | 10 |
| Injectors and connections (not including injector steam pipes) | 15 | 2 | 13 | 23 | ... | 27 | 21 | ... | 22 | 23 | ... | 24 |
| Injector steam pipes | 15 | ... | 17 | 23 | 1 | 29 | 14 | ... | 20 | 16 | ... | 18 |
| Lubricators and connections | 12 | ... | 12 | 14 | ... | 15 | 11 | ... | 13 | 12 | ... | 12 |
| Lubricator glasses | 3 | ... | 3 | 17 | ... | 17 | 9 | ... | 9 | 12 | ... | 12 |
| Patch bolts | ... | ... | ... | ... | ... | ... | ... | ... | ... | 2 | ... | 3 |
| Pistons and piston rods | 3 | ... | 3 | 3 | 1 | 3 | 2 | ... | 2 | 2 | ... | 2 |
| Plugs, arch tube and washout | 15 | ... | 18 | 28 | ... | 40 | 30 | 1 | 34 | 14 | 2 | 19 |
| Plugs in fire box sheets | 2 | ... | 2 | 1 | ... | 2 | 2 | 1 | 1 | 3 | ... | 3 |
| Reversing-gear | 65 | ... | 65 | 59 | ... | 59 | 31 | ... | 31 | 40 | ... | 40 |
| Rivets | 4 | ... | 5 | ... | ... | ... | 2 | ... | 2 | 3 | ... | 3 |
| Rods, main and side | 18 | ... | 21 | 16 | 2 | 20 | 14 | ... | 15 | 18 | ... | 22 |
| Safety valves | ... | ... | ... | ... | ... | ... | 1 | ... | 1 | ... | ... | ... |
| Sanders | ... | ... | ... | 1 | ... | 1 | ... | ... | ... | 2 | ... | 2 |
| Side bearings | ... | ... | ... | ... | ... | ... | 1 | ... | 1 | ... | ... | ... |
| Springs and spring rigging | 3 | ... | 3 | 9 | 2 | 18 | 5 | 2 | 4 | 7 | ... | 7 |
| Squirt hose | 82 | ... | 82 | 82 | ... | 82 | 54 | ... | 54 | 47 | ... | 50 |
| Staybolts | ... | ... | ... | 2 | 2 | 1 | 2 | ... | 2 | 6 | ... | 8 |
| Steam piping and blowers | 9 | ... | 9 | 18 | 1 | 19 | 8 | ... | 11 | 10 | ... | 11 |
| Steam valves | 11 | ... | 12 | 17 | ... | 17 | 9 | ... | 10 | 7 | ... | 17 |
| Studs | 7 | ... | 7 | 9 | ... | 11 | 7 | ... | 9 | 12 | ... | 13 |
| Superheater tubes | 1 | ... | 2 | 4 | ... | 6 | 1 | ... | 1 | 3 | ... | 4 |
| Throttle glands | ... | ... | ... | 3 | ... | 4 | ... | ... | ... | 3 | ... | 3 |
| Throttle leaking | 3 | ... | 3 | 1 | 1 | ... | 1 | ... | 1 | 2 | ... | 2 |
| Throttle rigging | 1 | ... | 1 | 6 | ... | 6 | 4 | 1 | 7 | 5 | ... | 5 |
| Trucks, leading, trailing, or tender | 6 | ... | 8 | 1 | 3 | 1 | 2 | 1 | 2 | 1 | ... | 1 |
| Valve gear, eccentrics, and rods | 10 | ... | 10 | 6 | ... | 6 | 9 | ... | 9 | 12 | ... | 12 |
| Water bars | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Water glasses | 25 | ... | 25 | 32 | ... | 32 | 26 | ... | 26 | 20 | ... | 20 |
| Water-glass fittings | 2 | ... | 2 | 4 | ... | 4 | 4 | ... | 4 | 11 | 1 | 10 |
| Wheels | 4 | 1 | 4 | 2 | 1 | 4 | 3 | ... | 5 | 7 | 5 | 5 |
| Miscellaneous | 91 | 2 | 117 | 87 | 2 | 86 | 35 | 2 | 35 | 32 | ... | 43 |
| Total | 735 | 64 | 800 | 843 | 66 | 916 | 565 | 57 | 647 | 641 | 46 | 756 |

being directed toward the fire door at the rear of the firebox.

The old swing-type door, which is largely used at present, is almost invariably blown open in case of such accidents and permits the discharging steam and boiling water, with the contents of the firebox to be blown into the cab of the locomotive, seriously and most frequently scalding and burning the persons therein. Such accidents frequently occur while coal is being put into the firebox, and with the fire door necessarily open, under such circumstances it is impossible for it to be closed.

The automatic fire door would remain closed if closed when the accidents occur. If open, it would automatically close the moment the operator's foot was removed from the operating device, thus preventing the direct discharge of the scalding water and fire into the cab of the locomotive with such serious results.

The automatic fire door is not a new and untried device, as there are thousands of them in service, and they are required by law in some states. The automatic fire door is also of great value in prevention of serious cracks and leaks in firebox sheets by limiting the time the fire doors are open when placing coal on the fire, thus reducing the amount of cold air admitted, which causes loss of temperature and consequent expansion and contraction and the setting up of great strains.

Their use is also very valuable in the conservation of fuel, which is at the present time a most important item.

Third. That all locomotives be provided with a bell so arranged and maintained that it may be operated from the engineer's cab by hand and by power.

Fourth. That cabs of all locomotives not equipped with front door or windows of such size as to permit of easy exit have a suitable stirrup or other step and a horizontal handhold on each side approximately the full length of the cab, which will enable the enginemen to go from the cab to the running board in front of it.

Fifth. That all locomotives where there is a difference between the readings of the gage cocks and water glass of 2 or more inches under any condition of service be equipped with a suitable water column, to which shall be attached three gage cocks and one water glass, with not less than 6 inches, preferably 8 inches, clear reading, and one water glass with not less than 6 inches, preferably 8 inches, clear reading on the left side or back head of the boiler.

Water glasses should be so located, constructed, and maintained that they will register the approximate general water level in the boiler under all conditions of service and show within 1 inch a corresponding level, and so maintained that the engineer and fireman may have under all conditions of service a clear view of the water in the glass from their respective and proper positions in the cab.

Gage cocks should be located within easy reach of the engineer from his proper position in the cab, while operating the locomotive, extension handles to be applied if necessary to accomplish this. All gage cocks to be supplied with suitable nipples that will directly discharge into a properly constructed and located drain or dripper that will convey the discharged water to near the cab deck or floor, nipples to be not less than one-half inch nor more than 1 inch above the dripper or drain and kept in correct alignment.

Gage cocks and water glasses are now universally used for gaging the water level in the boiler, and since the two appliances located on the same boiler do not show a corresponding level under operating conditions it is clear that one or the other is incorrect and therefore misleading.

Investigations have clearly established that gage cocks when screwed directly into the boiler do not correctly register the proper water level over the crown sheet. It is very important that at least two appliances attached separately be employed for this purpose so as to form a double check and so as to have one appliance in case of failure of the other while on the road and away from points where repairs can be made.

Should any other appliance than the water column or water glass be invented which will safely and correctly indicate the water level in the boiler, due consideration can be given. The requirements herein recommended should be complied with the first time the locomotive is shopped for classified repairs, as established by the United States Railroad Administration.

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# 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, C. W. Obert, 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.

Below are given the interpretations of the Committee in Cases Nos. 370 to 374, inclusive, as formulated and approved by the Council.

CASE NO. 370—*Inquiry:* Is it permissible, under the rules in the Boiler Code, to construct a boiler drum, 36 inches internal diameter, built with the shell in one sheet, $^{13}/_{16}$ inch thick, with one longitudinal seam having butt straps ½ inch thick on each side? Information is also requested as to the maximum allowable working pressure as determined by the efficiency of the longitudinal seam and the tube-hole ligament.

*Reply:* It is the opinion of the Committee that a boiler drum constructed as described does not conform to the requirements of paragraph 19 of the Code. The committee is not in a position to determine the maximum allowable working pressure for constructions not permitted by the Code and would recommend that the question be taken up with the state authorities or insurance companies interested.

CASE NO. 371—*Inquiry:* Is it permissible to construct vertical fire-tube boilers of either the through tube or submerged tube types with the tubes welded in both the upper and lower tube sheets?

*Reply:* It is the opinion of the Committee that paragraph 250 was not intended to forbid rolling and welding at both ends of the tubes of a fire tube boiler, when desired.

CASE NO. 372—*Inquiry:* An opinion is requested as to the actual distance above tubes at which the fusible plug should be inserted in economic-type boilers under the requirements of paragraph 430*r*. Is 1 inch above the upper row of tubes sufficient?

*Reply:* It is the opinion of the Committee that, as this type of boiler is quite similar in construction to an horizontal return tubular boiler, an elevation of the fusible plug 2 inches above the upper row of tubes will be necessary to meet the requirements of paragraph 430*r*.

CASE NO. 373—*Inquiry:* Will the rules of the Boiler Code for calculation of the Adamson type of furnace apply to the design of the conical furnace shown in Fig. 1, using the mean diameter of the cone as the nominal diameter of the furnace

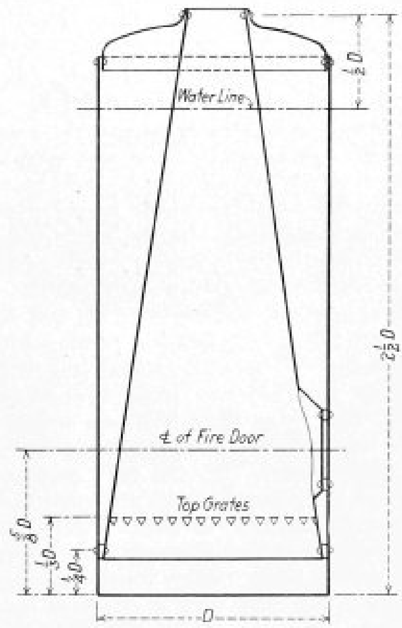



**Fig. 1 (Case 373).—Design of Vertical Boiler with Continuous Unstayed Conical Furnace**

and is it permissible in such construction to form the two vertical seams therein by autogenous welding?

*Reply:* It is the opinion of the Committee that paragraph 231 covers the construction described. Autogenous welding is not permissible in this type of boiler, except in those portions of the furnace which are to be stayed.

CASE NO. 374—*Inquiry:* Does the requirement of paragraph 256 of the Code, relative to the term: "machine driven," refer solely to hydraulic or other forms of pressure riveters, or will pneumatic riveters conform to this requirement?

*Reply:* It was the intent of the Committee that the term: "machine driven" should apply only to those types of riveting machines which are able to drive the rivets with sufficient pressure to fill the rivet holes and allow them to cool and shrink under pressure.

# Locomotive Boiler Construction on the North Eastern

## British Shop Practice Demonstrated in the Building of 0-8-0 Mineral Type Locomotives

THE methods used in building locomotives in British shops are typified in the construction of a number of mineral locomotives of the North Eastern Railway which have been giving good performance records since their completion some months ago. These engines, designed by Sir Vincent Raven, chief mechanical engineer of the road, are of the T.3 type having an 0-8-0 wheel arrangement and were built in the company's shops at Darlington, England. At present they are being used in the coal traffic in the Newcastle district where the ruling grade is 0.5 percent and they are required to haul about 1,543 tons.

Steam is supplied by the boilers to three simple cylinders at a pressure of 180 pounds, giving a rated tractive effort to each engine of 36,960 pounds. The weight of the engines in working order is given as 160,380 pounds and of the engine and tender as 259,200 pounds.

These locomotives are equipped with Schmidt type superheaters, brick arches, reverse gear, forced feed lubrication to

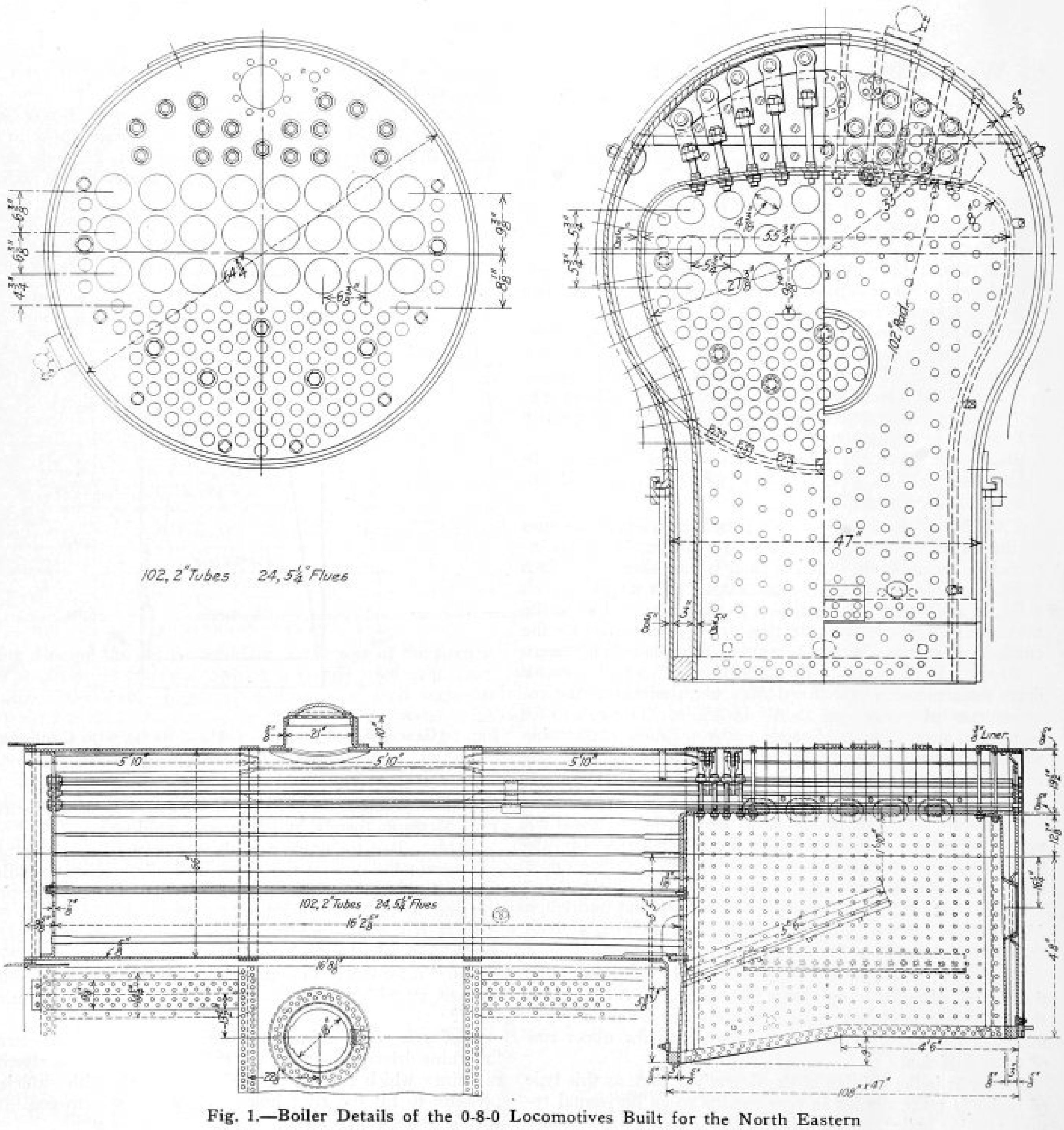



Fig. 1.—Boiler Details of the 0-8-0 Locomotives Built for the North Eastern

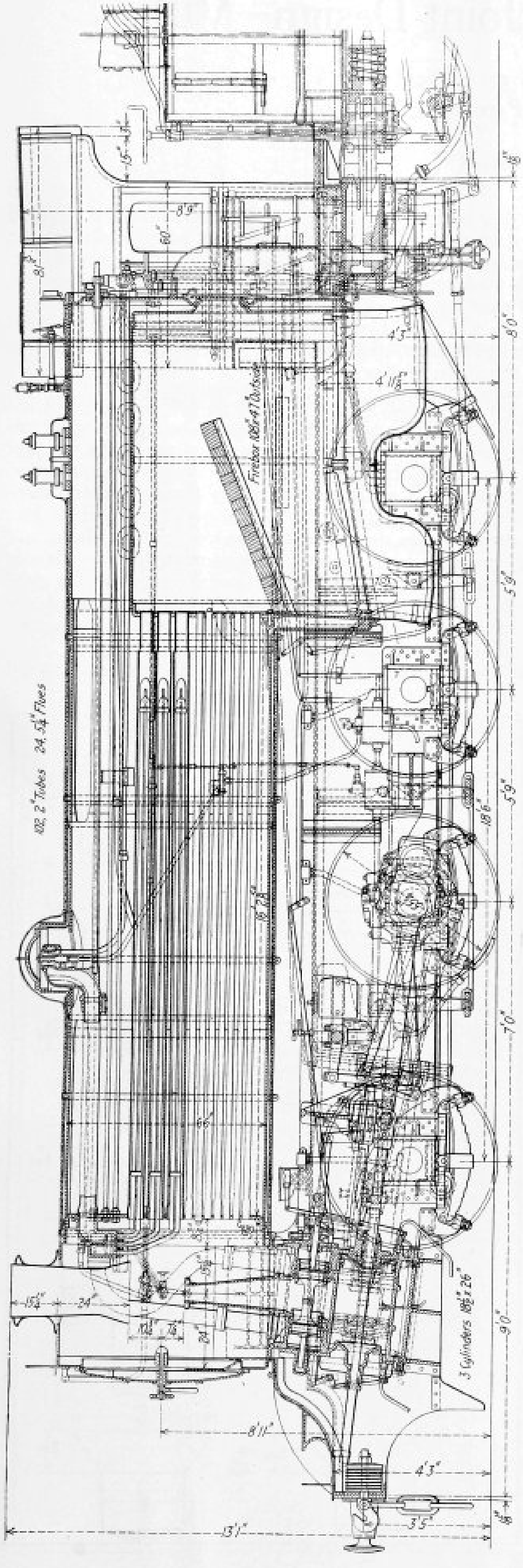



Fig. 2.—General Arrangement of the North Eastern Locomotives

the cylinders, the Lockyer double beat throttle valves and exhaust steam injectors.

### Details of Boiler

Great care was taken in carrying out the construction of the boilers on these locomotives which are made up of three parallel rings of 66 inches outside diameter. The barrel plates are ⅝ inch thick, the front tube sheet ⅞ inch thick, the wrapper sheet ⅝ inch thick and a back head of ⅝ inch. The firebox is made of copper, the roof and side sheets being made in one piece and being ⅝ inch thick. The tube sheet is 1 3/16 inches thick, being narrowed down to ⅝ inch at the throat. This boiler has 102, 2-inch tubes and 24, 5¼-inch superheater flues and 7 stay tubes. The distance between the tube sheets is 16 feet 2⅝ inches. Through these stay tubes pass stay rods of 1 inch diameter which are held by cap nuts at the tube sheets. These are shown in the boiler drawing.

Contrary to a very general practice used in England and also on the North Eastern whereby an angle ring is used on the front end of the boiler to which is riveted the barrel and the front tube sheet, as indicated on the left hand end of the boiler barrel shown in Fig. 2, the front tube sheet of the boiler is flanged and riveted directly to the boiler barrel. The back head is flanged on its periphery to provide for riveting it to the firebox wrapper sheet from the outside. Likewise a similar joint is made with the copper back sheet of the firebox and the back head at the door. This is not common practice in England, a door ring being the customary form of construction.

It will be noted from the boiler drawing that the barrel courses are butt riveted on the circumferential seam. This practice is common throughout the English railways. After the barrel sheets have been trimmed and rolled, they are held by straps of scrap iron bolted into "tack" holes which are drilled in the sheets before they are rolled. All three courses being treated in the same manner, the process of assembling is as follows: The middle or dome course is placed end up on the floor. The circumferential welt plate, being bored to a diameter ⅛ inch less than the outside diameter of the boiler barrel, is heated to a cherry red and placed over the upper end of the dome course and held in position by tack bolts. The third barrel ring is then fitted into place by means of an overhead crane and is also held in place by tack bolts. The welt is thus shrunk on to the barrel sheets. (It should be mentioned, in passing, that the only holes drilled in these sheets and the welt strips are those necessary for holding them together with tack bolts. These holes are of a smaller diameter than the rivets and are redrilled as explained later.) With the second and third courses thus united the same process is carried through in applying the circumferential welt to the first and second courses.

After both rings have been put in place and securely fastened and the longitudinal welt strips "tacked" in place, the boiler is taken to a boiler barrel drilling machine. All rivet holes both for the longitudinal and circumferential seams are then drilled in this machine. This is done to obtain a true radial rivet hole and one that will exactly match in the welt strips and plate thus making any drifting unnecessary. After all the rivet holes have been drilled, the longitudinal welt strips are removed and the surfaces of the boiler and welt strip thoroughly cleaned. Every hole is then slightly countersunk with a pneumatic rotary machine. The butt straps are again replaced and the boiler is ready for riveting in a bull riveter.

The rivet and staybolt holes in the firebox wrapper sheets and copper roof and side sheets are drilled on the flat to slightly less than the ultimate diameter, four or five sheets being drilled at a time with, of course, the top sheet being

(*Continued on page* 58)

# Principles of Riveted Joint Design—VIII

## Determining the Strength of Helical Joints and Angularity for 100 Percent Efficiency

**By William C. Strott***

THE pitch and arrangement of rivets attaching reinforcing rings to circular or semi-circular openings in cylindrical shells is a matter that requires special consideration. A study of the accompanying illustrations Figs. 52 and 53 will show that these connections are to be treated identically as riveted joints.

### Helical Joints

In the first chapter of this treatise, wherein the stresses in cylindrical vessels when subjected to internal pressure, were analyzed, we learned that the hoop-stress in the shell is exactly twice as great as the transverse stress. In other words, we found that the girth seams of any cylindrical vessel require but one half the efficiency necessary in longitudinal seams, for a given working pressure.

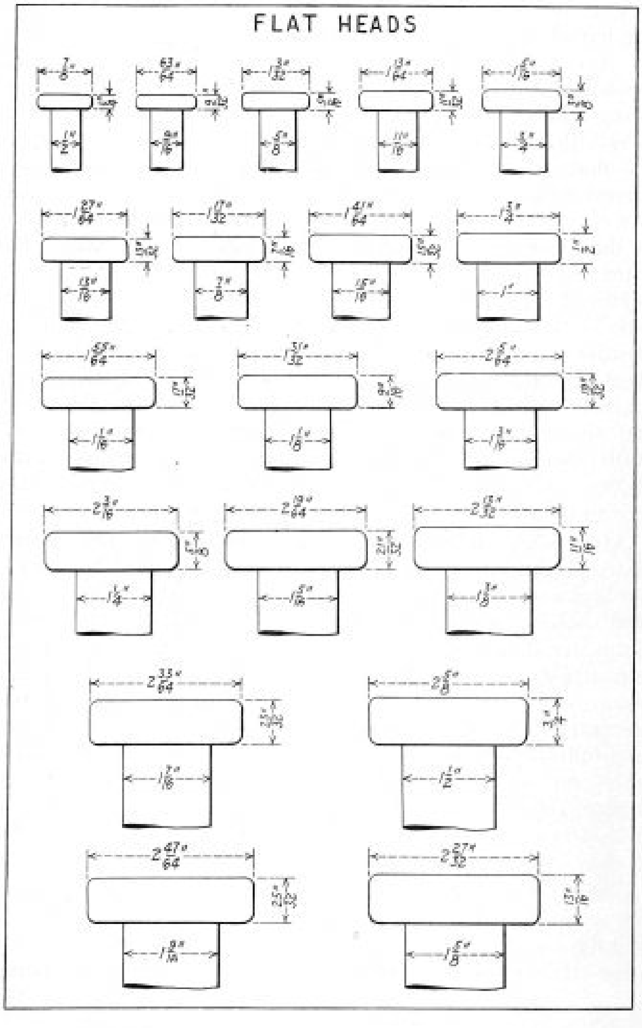
From this it follows, that if a longitudinal seam were inclined at an angle with the longitudinal axis of the shell, it would more nearly approach the position of a girth seam, whence it would become inherently stronger than when in the true horizontal position. This theory has given rise to the development of helical riveted joints on cylindrical shells, especially when the diameter is very small in comparison with the length as in the case of pipes. For large diameters and short lengths, as in steam boilers and other pressure vessels, helical joints have not come into favor due to the necessary loss in plate, which may very readily be understood from an inspection of Fig. 54.

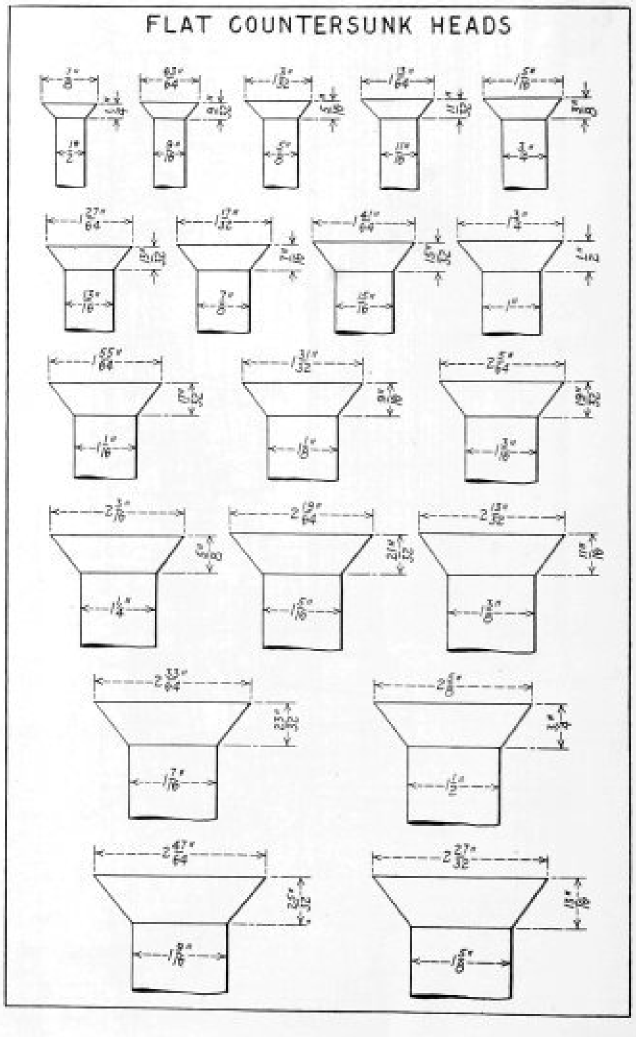
### Determination of Stresses in Helical Joints

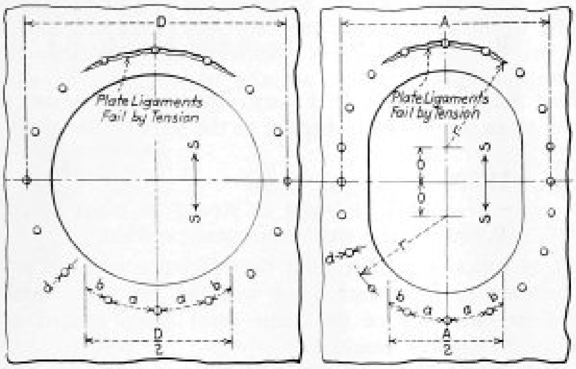
Calculations to determine stresses in helical seams necessarily involve the use of trigonometry and unless the designer has a working knowledge of this branch of mathematics, together with an understanding of the composition and resolution of forces, little if anything can be expected of him in attempting to design helical riveted joints. The actual design of such joints involves nothing more than has already been covered in the design of horizontal joints, but the main problem is to determine the required angularity of the inclined joint to give it a higher efficiency than when used in the horizontal position.

In the diagram, Fig. 55, we have two forces, viz., $P_1$ and

*Engineering department of The Koppers Company, Pittsburgh, Pa.; formerly designer, Blaw-Knox Company, Pittsburgh, Pa., and Union Iron Works, Erie, Pa.





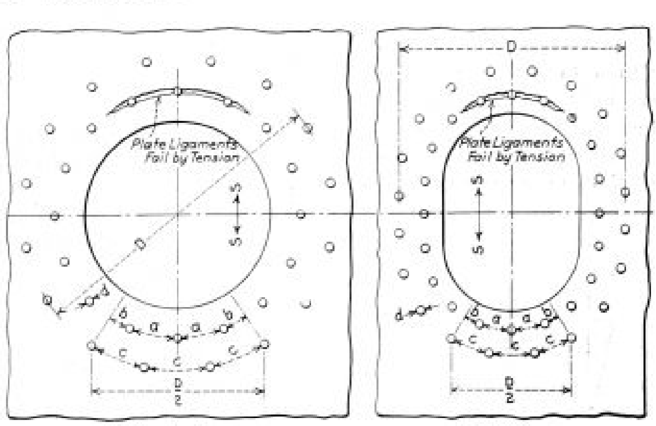
(a) Circular Seam (b) Oval Seam

Fig. 52.—Single Riveted Seam Reinforcements

$P_2$, acting at right angles to each other, where $P_2$ is the unit stress in the shell plate due to the hoop tension and $P_1$ is the unit transverse stress due to the end thrust of the heads of the cylindrical vessel.

It should be quite plain that $P_2$ is twice as great as $P_1$ and that $\alpha$ is the angle which the helical seam makes with the longitudinal axis of the shell. In the above diagram, it may be seen that R is the resultant stress created by the combined action of two component forces, viz., *a* and *b* which act at right angles to each other. As shown, force *a* acts lengthwise through the diagonal joint. The resultant force R represents the maximum stress in the seam and the magnitude of this stress is the final value sought.

By means of a trigonometrical analysis, a detailed dis-



(a) Circular Seam (b) Oval Seam

Fig. 53.—Double Riveted Seam Reinforcements

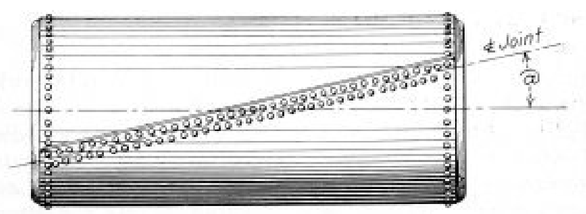
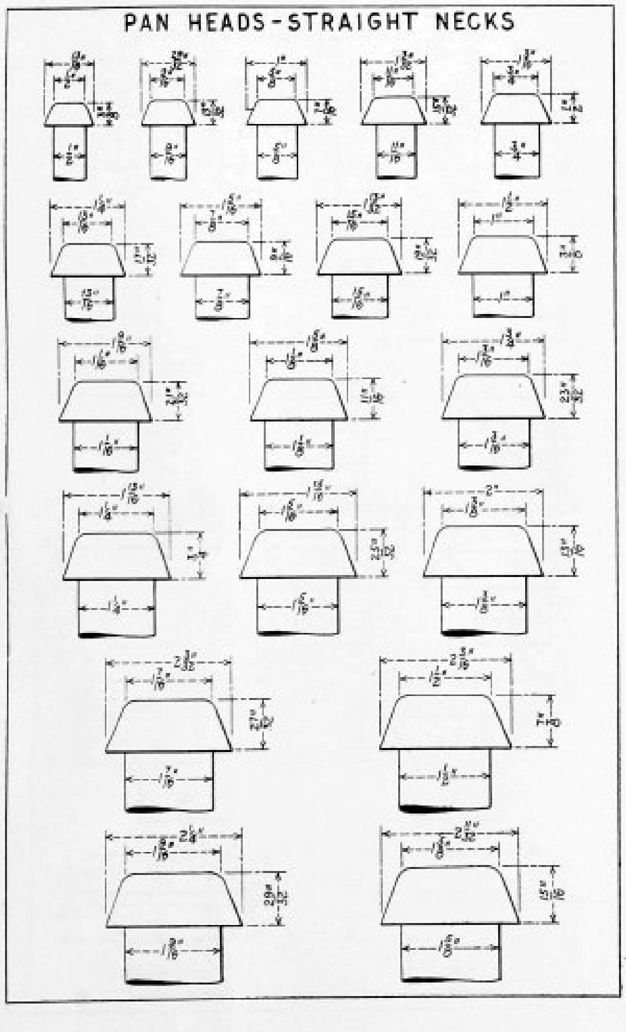
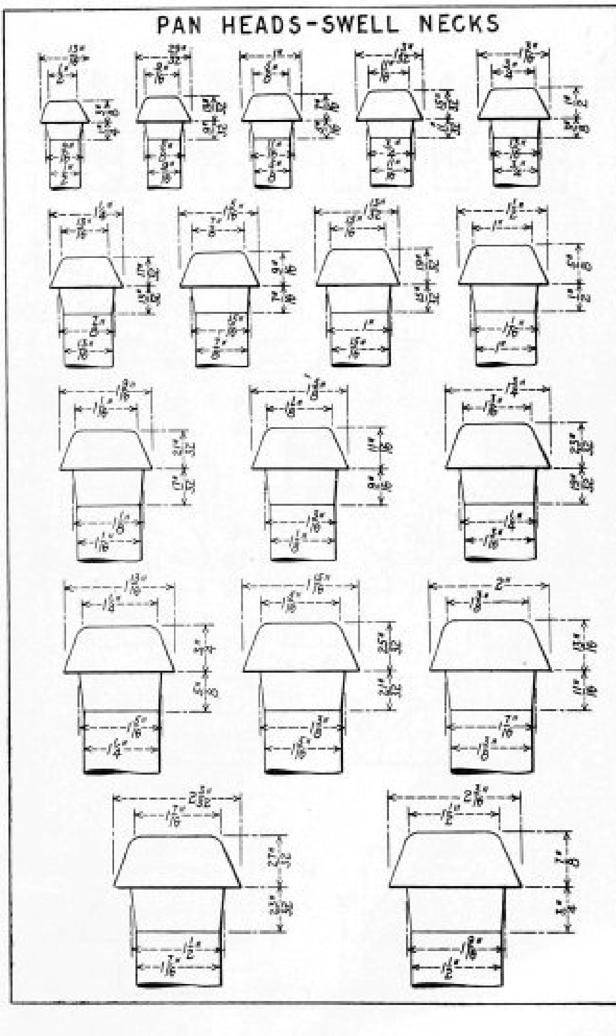



Fig. 54.—Application of Helical Riveted Longitudinal Seam

cussion of which would, however, be superfluous here, it can be proved that:



$$R = \frac{P_2}{2}\sqrt{4 - (3 \sin^2 \alpha)},$$

in which the notations have the same significance as those given on the stress diagram, Fig. 55. A practical solution of the above formula will now be given.

$P_2$ may in all cases be taken at 11,000 pounds per square inch, it being assumed that the hoop tension in the shell is

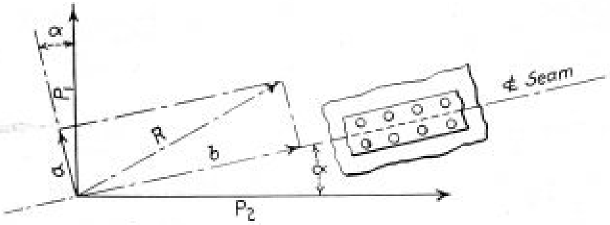



**Fig. 55.—Stress Diagram for Helical Joints**

sufficient to stress the material up to its highest safe working value, with a factor of safety of 5.

Let us assume that the angularity ∝ of a certain diagonal seam is 30 degrees. Then from a table of natural trigonometric functions of angles we find that the sin of 30 degrees is 0.5. We may now substitute figures for letters in the formula.

$$R = \frac{11{,}000}{2} = \sqrt{4 - (3 \times 0.5 \times 0.5)}$$

Whence;

$$R = 5{,}500\sqrt{3.25}, \text{ or } 9{,}900 \text{ pounds per square inch.}$$

This finally means that any longitudinal seam when placed at an angle of 30 degrees to the axis of the shell will be:

$\frac{11{,}000}{9{,}900}$ or 1.11 times as strong as when placed in the true horizontal position.

Let us suppose further, that the efficiency of such a joint (determined in the usual way) were 85 per cent; then the equivalent efficiency of the same joint when placed at an angle of 30 degrees would be:

$$100 \times 1.11 \times 0.85 = 94.35 \text{ per cent.}$$

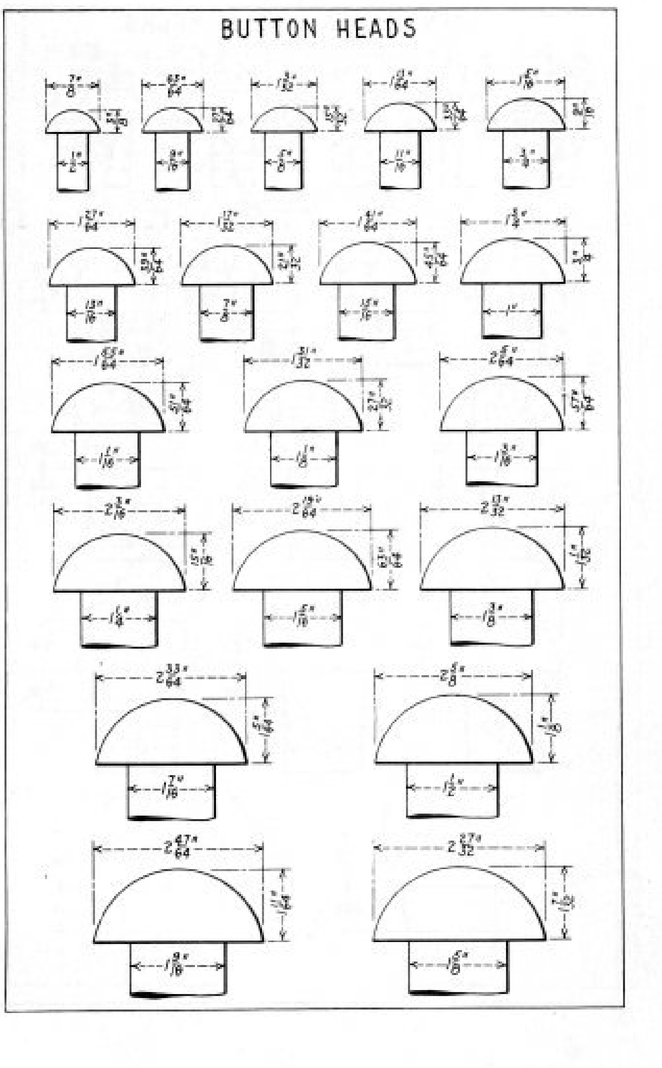
In this case, if the actual efficiency required were only 85 per cent, then a lighter and consequently a more economical joint could be employed; whence one having an efficiency of:

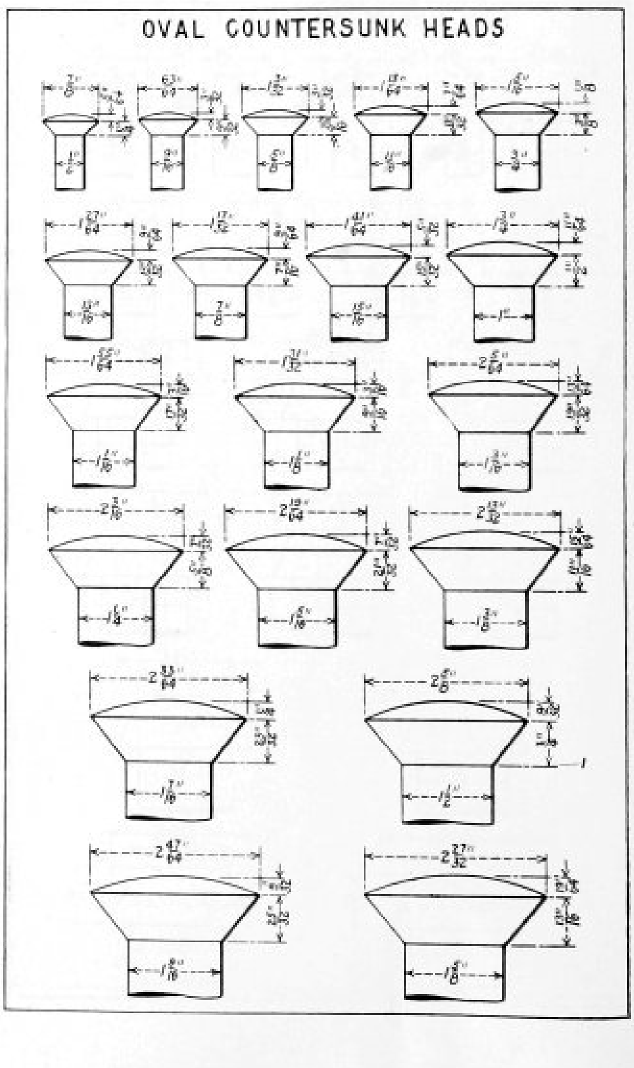
$\frac{85}{1.11}$ or 76.2 per cent would be satisfactory.

The other alternative would be to retain the higher joint efficiency and reduce the thickness of the shell plate instead.

An examination of the formula above will disclose the fact that as angle ∝ increases, the resulting value of R will be decreased. The minimum value of R is evidently reached when angle ∝ becomes 90 degrees, whence the stress in the joint will be $\frac{P_2}{2}$, which also is the stress existing in the girth seams.

In order to facilitate the solution of problems involving



this formula, the following tables have been prepared. Table 5 is employed when it is desired to know how much the strength, or rather the efficiency of an existing straight seam is increased by placing it in the diagonal position.

TABLE 5

| Angularity of Diagonal Seam, degrees | Sin of Angle α | Equivalent Efficiency Factor |
|---|---|---|
| 10 | .17365 | 1.010 |
| 15 | .25882 | 1.031 |
| 20 | .34202 | 1.047 |
| 25 | .42262 | 1.070 |
| 30 | .50000 | 1.110 |
| 35 | .57358 | 1.155 |
| 40 | .64275 | 1.205 |
| 45 | .70711 | 1.265 |
| 50 | .76604 | 1.337 |
| 55 | .81915 | 1.417 |
| 60 | .86603 | 1.510 |
| 65 | .90631 | 1.615 |
| 70 | .93969 | 1.720 |

Table 6 gives the number of degrees of inclination required to make any existing straight seam as strong as the solid plate, in other words, to give it an equivalent efficiency of 100 per cent. The practical example given in connection with each table will render their use absolutely clear.

### TO FIND THE EQUIVALENT EFFICIENCY OF ANY DIAGONAL JOINT WHEN THE ANGULARITY OF THE JOINT IS KNOWN

Example: Given a straight seam having an efficiency of 75 per cent; what will be its equivalent efficiency when placed at an angle of 40 degrees with the axis of the shell?

Solution: In Table 5 it is found that any joint when placed at 40 degrees with the axis of the shell will have an equivalent efficiency of 1.2 times that of the straight seam. The equivalent efficiency is therefore:

$$1.2 \times 75 \text{ or } 90 \text{ per cent.}$$

TABLE 6

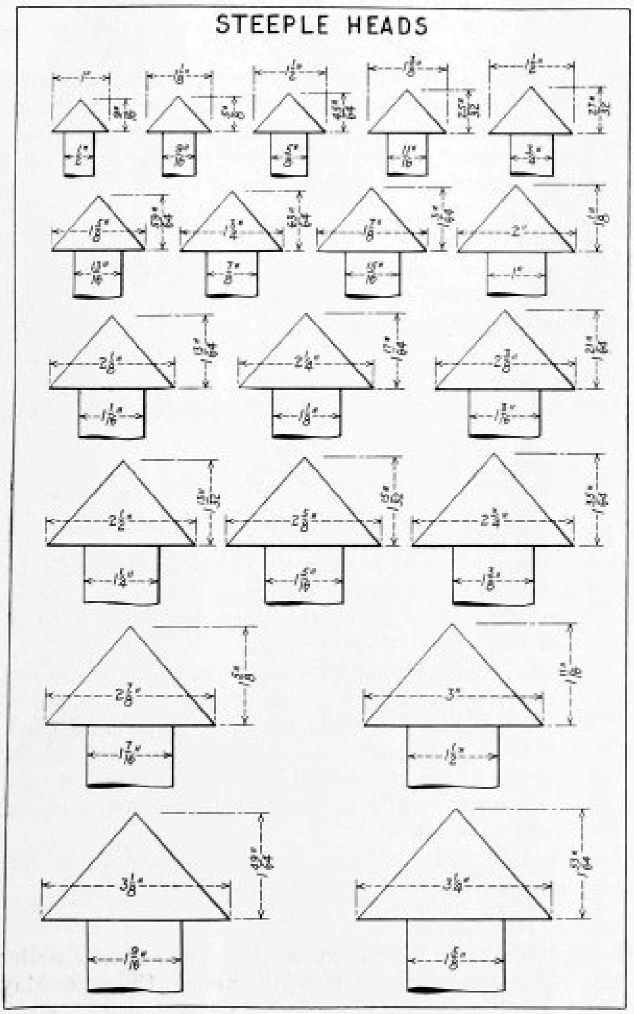
| Efficiency of Straight Seam Per Cent | Required Angularity of Diagonal Seam to Give an Equivalent Efficiency of 100 Per Cent Degrees |
|---|---|
| 50 | 90 |
| 55 | 74.5 |
| 60 | 67.3 |
| 65 | 61.3 |
| 70 | 55.6 |
| 75 | 50 |
| 80 | 44 |
| 85 | 37.6 |
| 90 | 30.5 |
| 95 | 21 |

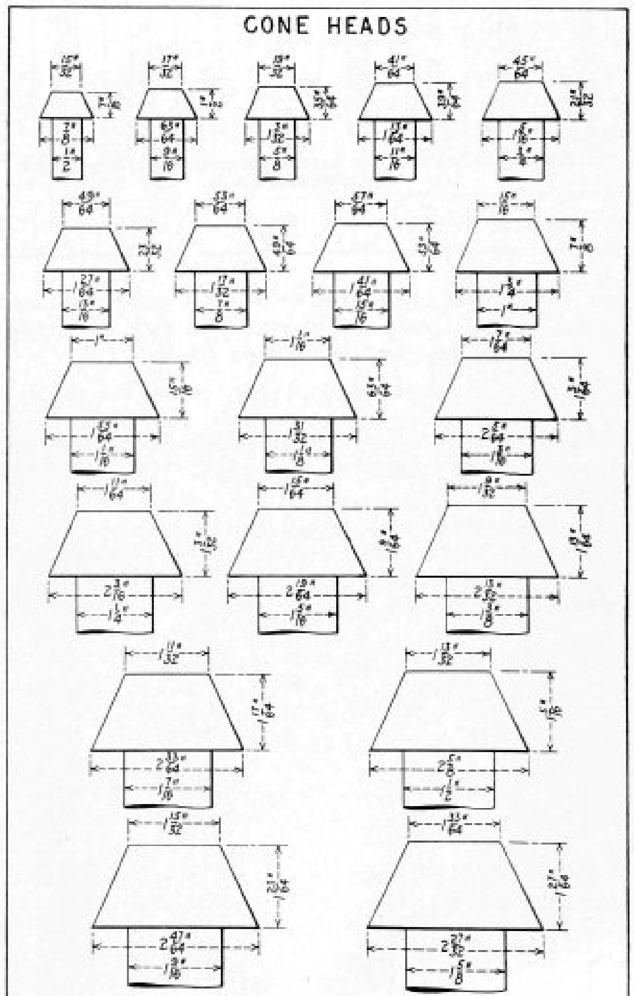
### TO FIND THE ANGULARITY OF A DIAGONAL JOINT TO GIVE AN EQUIVALENT EFFICIENCY OF 100 PER CENT.

Example: The efficiency of a straight seam is 75 per cent; what angle must this joint make with the axis of the shell so as to give the joint an equivalent efficiency of 100 per cent?

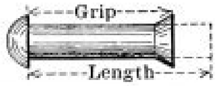
Solution: In Table 6 we find that any longitudinal joint having an efficiency of 75 per cent will become as strong as the solid plate when placed at an angle of 50 degrees with the longitudinal axis of the shell.

Although the above tables do not cover all conditions that



LENGTH OF RIVETS REQUIRED FOR VARIOUS GRIPS, INCLUDING AMOUNT NECESSARY TO FORM ONE HEAD


| Grip of Rivet in Inches. | Diameter of Rivet in Inches. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | ¼″ | ⅜″ | ½″ | ⅝″ | ¾″ | ⅞″ | 1″ | 1⅛″ |
| ½ | 1 | 1¼ | 1½ | 1¾ | 1⅞ | 2 | 2⅛ | 2¼ |
| ⅝ | 1⅛ | 1⅜ | 1⅝ | 1⅞ | 2 | 2⅛ | 2¼ | 2⅜ |
| ¾ | 1¼ | 1½ | 1¾ | 2 | 2⅛ | 2¼ | 2⅜ | 2½ |
| ⅞ | 1⅜ | 1⅝ | 1⅞ | 2⅛ | 2¼ | 2⅜ | 2½ | 2⅝ |
| 1 | 1½ | 1¾ | 2 | 2¼ | 2⅜ | 2½ | 2⅝ | 2¾ |
| 1⅛ | 1⅝ | 1⅞ | 2⅛ | 2⅜ | 2½ | 2⅝ | 2¾ | 2⅞ |
| 1¼ | 1¾ | 2 | 2¼ | 2½ | 2⅝ | 2¾ | 2⅞ | 3 |
| 1⅜ | 1⅞ | 2⅛ | 2⅜ | 2⅝ | 2⅞ | 3 | 3 | 3⅛ |
| 1½ | 2 | 2¼ | 2½ | 2¾ | 3 | 3⅛ | 3⅛ | 3¼ |
| 1⅝ | 2⅛ | 2⅜ | 2⅝ | 2⅞ | 3⅛ | 3¼ | 3¼ | 3½ |
| 1¾ | 2¼ | 2½ | 2¾ | 3 | 3¼ | 3⅜ | 3½ | 3⅝ |
| 1⅞ | 2⅜ | 2⅝ | 2⅞ | 3¼ | 3⅜ | 3½ | 3⅝ | 3¾ |
| 2 | 2½ | 2¾ | 3⅛ | 3⅜ | 3½ | 3⅝ | 3¾ | 3⅞ |
| 2⅛ | 2⅝ | 2⅞ | 3¼ | 3½ | 3⅝ | 3¾ | 3⅞ | 4 |
| 2¼ | 2¾ | 3 | 3⅜ | 3⅝ | 3¾ | 3⅞ | 4 | 4⅛ |
| 2⅜ | 2⅞ | 3⅛ | 3½ | 3¾ | 3⅞ | 4 | 4⅛ | 4¼ |
| 2½ | 3 | 3¼ | 3⅝ | 3⅞ | 4 | 4⅛ | 4¼ | 4⅜ |
| 2⅝ | 3⅛ | 3½ | 3¾ | 4 | 4⅛ | 4¼ | 4⅜ | 4½ |
| 2¾ | 3¼ | 3⅝ | 3⅞ | 4⅛ | 4¼ | 4⅜ | 4½ | 4⅝ |
| 2⅞ | 3⅜ | 3¾ | 4 | 4¼ | 4⅜ | 4½ | 4⅝ | 4¾ |
| 3 | 3½ | 3⅞ | 4⅛ | 4⅜ | 4½ | 4⅝ | 4¾ | 4⅞ |
| 3⅛ | 3⅝ | 4 | 4¼ | 4½ | 4¾ | 4¾ | 5 | 5 |
| 3¼ | 3¾ | 4⅛ | 4⅜ | 4⅝ | 4⅞ | 5 | 5⅛ | 5¼ |
| 3⅜ | 3⅞ | 4¼ | 4½ | 4⅞ | 5 | 5⅛ | 5¼ | 5⅜ |
| 3½ | 4 | 4⅜ | 4⅝ | 5 | 5⅛ | 5¼ | 5⅜ | 5½ |
| 3⅝ | 4⅛ | 4½ | 4¾ | 5⅛ | 5¼ | .5⅜ | 5½ | 5⅝ |
| 3¾ | 4¼ | 4⅝ | 4⅞ | 5¼ | 5⅜ | 5½ | 5⅝ | 5¾ |
| 3⅞ | 4⅜ | 4¾ | 5 | 5⅜ | 5½ | 5⅝ | 5¾ | 5⅞ |
| 4 | 4½ | 4 ⅞ | 5⅛ | 5½ | 5⅝ | 5¾ | 5⅞ | 6 |
| 4⅛ | 4⅝ | 5 | 5¼ | 5⅝ | 5¾ | 5⅞ | 6 | 6⅛ |
| 4¼ | 4¾ | 5⅛ | 5½ | 5¾ | 5⅞ | 6 | 6 ⅛ | 6¼ |
| 4⅜ | 4⅞ | 5¼ | 5⅝ | 5⅞ | 6 | 6⅛ | 6¼ | 6⅜ |
| 4½ | 5 | 5⅜ | 5¾ | 6 | 6⅛ | 6¼ | 6⅜ | 6½ |
| 4⅝ | 5⅛ | 5½ | 5⅞ | 6⅛ | 6¼ | 6⅜ | 6½ | 6⅝ |
| 4¾ | 5¼ | 5⅝ | 6 | 6¼ | 6½ | 6⅝ | 6¾ | 6¾ |
| 4⅞ | 5⅜ | 5¾ | 6⅛ | 6½ | 6⅝ | 6¾ | 6⅞ | 6⅞ |
| 5 | 5½ | 5⅞ | 6¼ | 6⅝ | 6¾ | 6⅞ | 7 | 7 |
| 5⅛ | 5⅝ | 6 | 6⅜ | 6¾ | 6⅞ | 7 | 7⅛ | 7⅛ |
| 5¼ | 5¾ | 6⅛ | 6½ | 6⅞ | 7 | 7⅛ | 7¼ | 7¼ |
| 5⅜ | 5⅞ | 6¼ | 6⅝ | 7 | 7⅛ | 7¼ | 7⅜ | 7⅜ |
| 5½ | 6 | 6⅜ | 6¾ | 7⅛ | 7¼ | 7⅜ | 7½ | 7½ |
| 5⅝ | 6⅛ | 6½ | 6⅞ | 7¼ | 7⅜ | 7½ | 7⅝ | 7⅝ |
| 5¾ | 6¼ | 6¾ | 7 | 7⅜ | 7⅝ | 7⅝ | 7¾ | 7¾ |
| 5⅞ | 6⅜ | 6⅞ | 7⅛ | 7½ | 7¾ | 7¾ | 7⅞ | 7⅞ |
| 6 | 6½ | 7 | 7¼ | 7⅝ | 7⅞ | 7⅞ | 8 | 8⅛ |
| **Amount in Inches to be subtracted from above lengths for Countersunk Heads.** | | | | | | | | |
| | ⅛ | ¼ | ½ | ½ | ⅝ | ¾ | ⅞ | ⅞ |

may be met with in practice, they are presented here merely for reference purposes and also to serve as a check for the designer when applying the formula for R.

### USEFUL DATA

The following table of rivet diameters and cross-sectional areas will prove useful in calculating rivet shearing and bearing values.

TABLE 7

| Diameter of rivet, inches | Diameter of rivet hole, inches | Cross-sectional area of rivet square inches | Cross sectional area of rivets after driving square inches |
|---|---|---|---|
| ½ | 17/32 | .1963 | .2217 |
| 9/16 | 19/32 | .2485 | .2769 |
| ⅝ | 11/16 | .3068 | .3712 |
| 11/16 | ¾ | .3712 | .4418 |
| ¾ | 13/16 | .4418 | .5185 |
| 13/16 | ⅞ | .5185 | .6013 |
| ⅞ | 15/16 | .6013 | .6903 |
| 15/16 | 1 | .6903 | .7854 |
| 1 | 1 1/16 | .7854 | .8866 |
| 1 1/16 | 1 ⅛ | .8866 | .9940 |
| 1 ⅛ | 1 3/16 | .9940 | 1.1075 |
| 1 3/16 | 1 ¼ | 1.1075 | 1.2272 |
| 1 ¼ | 1 5/16 | 1.2272 | 1.3530 |
| 1 5/16 | 1 ⅜ | 1.3530 | 1.4849 |
| 1 ⅜ | 1 7/16 | 1.4849 | 1.6230 |
| 1 7/16 | 1 ½ | 1.6230 | 1.7671 |
| 1 ½ | 1 9/16 | 1.7671 | 1.9175 |
| 1 9/16 | 1 ⅝ | 1.9175 | 2.0739 |
| 1 ⅝ | 1 11/16 | 2.0739 | 2.2365 |

### LENGTH OF RIVETS

For best workmanship, it is absolutely essential that rivets be of exactly the proper length. The length should be such that there will be sufficient metal to exactly fill the rivet hole and to form a perfect head. If too long a shank is left protruding, then the excess metal will be forced out from under the riveting dies, resulting in an appearance as though there were a washer under the head. Rivets so driven require an excessive amount of calking to render them tight against leakage. On the other hand, if the rivet heads formed are too small, the full strength of the rivet cannot be attained.

The accompanying details of rivets will prove exceptionally convenient when detailing riveted joints. The proportions are in accordance with those advocated by the American Society of Mechanical Engineers' Code and are published herewith by courtesy of the Champion Rivet Company of Cleveland, Ohio, by whom the details were prepared.

(*To be continued*)

## Boiler Code Sub-Committee on Code for Care of Steam Boilers in Service

WHEN the A. S. M. E. Boiler Code Committee was appointed in 1911, it was given the following title: Committee to Formulate Standard Specifications for the Construction of Steam Boilers and Other Pressure Vessels and for Their Care in Service. Since its inception, however, the great volume of the committee's work has been devoted to the formulation of rules for the construction of steam boilers of different classes and little opportunity has been given to consider the important problem of their operation.

Realizing this lack in the committee's function, attention has recently been given to the need for operating rules and there was appointed by the Council at the meeting of January 7, at the request of the Boiler Code Committee, the following sub-committee for this purpose:

F. M. GIBSON, *Chairman*, Boston, Mass.
H. F. SCOTT, Framingham, Mass.
J. R. GILL, Meadville, Pa.
W. H. LARKIN, JR., Passaic, N. J.
J. WOLFF, Cleveland, O.
W. G. DIMAN, Manchester, N. H.
J. S. SCHUMAKER, Lincoln, N. H.
E. G. BAILEY, Cleveland, O.
J. W. HAYS, Michigan City, Ind.
S. F. JETER, Hartford, Conn.
NICHOLAS STAHL, Providence, R. I.

This sub-committee consists of active operating engineers who have had long and varied experiences and are eminently fitted for the preparation of rules for the care of boilers in service. The code which they may formulate should be welcomed by all boiler owners, insurance companies and in fact anyone directly or indirectly interested in the field of steam boilers or other pressure vessels.

The Boiler Code Committee desires cooperation in this new department of its activities and requests everyone interested to assist in this important work for the general good. Mr. F. M. Gibson, to whom the committee is indebted for the active effort in inaugurating this work and who has been appointed chairman, will greatly appreciate the assistance of all those who may contribute.

He should be addressed care of the American Sugar Refining Company, 49 Granite street, South Boston, Mass.

DON'T FORGET the annual convention of the Master Boiler Makers' Association at the Hotel Sherman, Chicago, May 23 to 26.

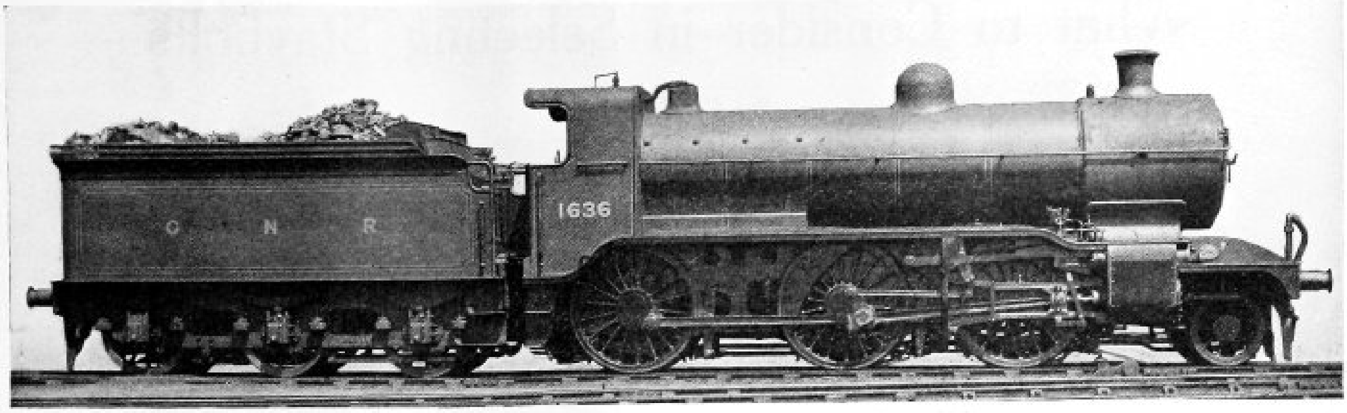



Fig. 1.—Type of Great Northern Railway 2-6-0 Express Locomotive Equipped with Exhaust Steam Injector

# Boiler Feeding With Exhaust Steam Injectors

AT THE present time, over 5,000 locomotives in England and Continental Europe are equipped with exhaust steam injectors of the Metcalfe patent type as standard fittings. These injectors, developed by Davies and Metcalfe, Ltd., at Romiley, England, have been designed to utilize the heat wasted in exhaust steam by heating the boiler feed water and delivering it to the boiler.

Exhaustive tests of the apparatus have developed the fact that the fuel economy on a locomotive can be increased 10 to 15 percent and the water economy 12 to 15 percent by its use.

The exhaust steam injector is equally suitable for application to simple or compound locomotives, working with either saturated or superheated steam at any steam pressure, especially on locomotives which are worked to their maximum capacity or are deficient in steam production. The device is simple in operation and is practically identical in action and working with the ordinary type of injector.

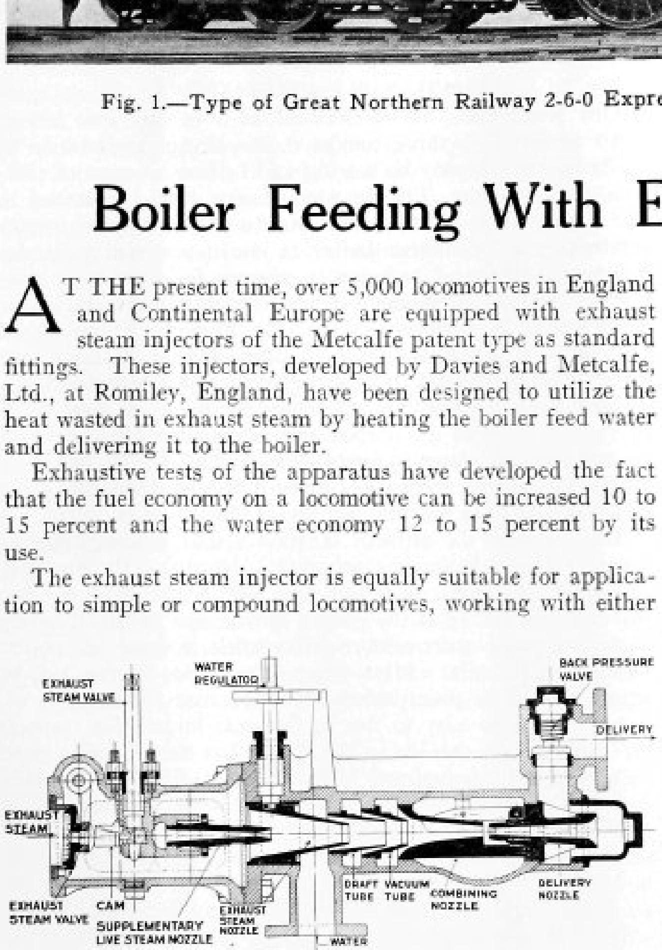



Fig. 2.—Details of Type "F" Exhaust Steam Injector

### Capacity of Injectors

Tests made with a vacuum gage fitted to the smokebox show that no appreciable change in the smokebox vacuum can be noted when the exhaust injector is put into action, so that no alteration is necessary to the blast pipe arrangement, the pipe connection between the blast pipe and the injector being alone required.

The original injector, working with steam at atmospheric pressure, was capable of feeding against pressures up to 70 pounds per square inch; and at its introduction considerable attention was given to the discovery that such high-delivery pressures could be obtained when using low pressure steam. Many improvements have been made since the exhaust injector was first invented and the latest type "F" Metcalfe exhaust injector is capable of feeding with exhaust steam alone against pressures up to 150 pounds per square inch and with the aid of a small jet of supplementary live steam against the highest boiler pressures, the feed water being delivered into the boiler at temperatures varying from 200 degrees to 220 degrees F., dependent upon the exhaust steam pressure. The amount of supplementary live steam used to give the increase of pressure above 150 pounds is small, not exceeding 2½ percent of the evaporation of the boiler.

### Type "F" Exhaust Injector

In the new type "F" exhaust injector, a greatly increased duty is obtained from the exhaust steam by a special arrangement of nozzles. This injector, working with exhaust steam alone, is capable of delivering against the pressure shown in following table:

| Exhaust Steam Pressure Pounds per square inch | Delivery Pressure Pounds per square inch |
|---|---|
| 1 | 150 |
| 3 | 165 |
| 5 | 180 |
| 10 | 210 |

In the multiple jet system employed in the type "F" injector, the exhaust steam entering the injector passes into the main central exhaust steam nozzle, at the mouth of which it meets the feed water, Fig. 2. Condensation immediately takes place—a very high degree of vacuum being formed—and the combined jet flows forward at a high velocity through the draft tube into the vacuum tube. Through this tube a second supply of exhaust steam is admitted, which flowing in at a very high velocity impinges on and is condensed by the combined jet, imparting to it a further supply of energy, so increasing its velocity. The combined jet now enters the combining nozzle, where complete condensation takes place, forming a jet of water at high temperature moving with high velocity. After passing through the combining nozzle, the jet enters the delivery nozzle, where its velocity is reduced, the kinetic energy being changed into pressure energy, and leaving the injector passes through the delivery pipe into the boiler.

The injector consists of two casings bolted together. The first casing contains the exhaust steam valve, the supplementary live steam nozzle and steam inlet and the auxiliary live steam inlet; the second casing contains the injector nozzles, the water regulator, the overflow and back pressure valves and the water and delivery connections.

# What to Consider in Selecting Staybolts*

**By C. A. Seley†**

*The subject of staybolts for steam boilers is not by any means a new one and so the following article is in the nature of a review of recent developments in staybolt design and production. Staybolts are necessary in many types of boilers for staying flat surfaces; in the Scotch marine for staying the combustion chambers; in water-tube boilers having box headers and most important of all in the fireboxes of locomotive boilers. Differences in the material and design of staybolts for various classes of service must be considered and suggestions are given below that will aid in properly determining the types to be used.*

NOT all boilers are afflicted with staybolts, if such a term may be borrowed from authorities of the United States Navy, whose officers do not favor designs of boilers that require staybolts, but prefer watertube types with tubes, headers and drums arranged to avoid the need of staybolts. Many boilers, however, do need staybolts and these will be discussed.

In the Scotch marine type boiler, staybolts are required for staying the flat surfaces of the furnace combustion chambers. Box headers of watertube type boilers are used extensively in land and sea service which require staybolts, but by far the largest number is used in the locomotive type boiler, due to the great number of flat surfaces to be stayed.

In our day there have been attempts to utilize sectional firebox construction which would avoid the use of staybolts, but apparently these have not been successful. Some years ago there was an attempt to utilize the corrugated type of furnace, common in marine practice, in locomotive boilers, but the disadvantages of limited firebox and grate areas were not as well understood in those days as in later years or the idea would never have been considered.

### Materials for Staybolts

The quite general practice of using copper fireboxes and copper or bronze staybolts abroad has not been favored in this country where steel for sheets and iron for bolts is the general practice in locomotive boilers. On account of price and their wonderful properties, modern alloy steels, having extremes of strength and ductility, great vibratory performance in laboratory testing machines, certainly deserve consideration for staybolt work.

Under the United States marine boiler inspection rules, steel is permissible and is used to a considerable extent. One reason is that the service stresses in ordinary marine boilers are by no means as severe as in a locomotive. At the same time the old marine engineer will tell you that if he can replace steel staybolts with iron ones, the trouble ceases. Steel for staybolts for locomotives has never gone beyond the experimental stage in this country, to our knowledge, for very good and sufficient reasons. These reasons are mainly the manner of breakage. Due to the homogeneity of the material the fracture is not progressive. One bolt breaking is likely to set off others in the vicinity, thus breaking in bunches and creating a very unsafe condition, not as readily under control as is the case with iron staybolts, in which fractures are progressive.

The successful material judging from the general practice of builders and users of locomotives in this country is properly manufactured iron very adequately covered by specifications approved by the mechanical section of the American Railway Association, formerly the American Railway Master Mechanics' Association.

*Paper read at a meeting of the Pittsburgh Railway Club, November 18.

†President of the American Flexible Bolt Company, Pittsburgh, Pa.

### Maintenance of Staybolts

One lesson that the mechanical man in any line has to learn is that if a thing breaks it should not necessarily be made bigger. It may be too big and fail on account of stiffness and rigidity. This is a conclusion well illustrated in the maintenance of staybolts. Due to the severity of service conditions, a locomotive boiler at one moment may be developing a thousand horsepower or over, followed by a sudden cessation of demand, causing a maximum variation of temperature in various parts of the firebox. Dumping of fires and rapid and uneven cooling down; washing and water changing; rapid firing up; extreme external temperature conditions, all contribute to relatively unequal movements of various parts of the firebox and combustion chamber with reference to the outer wrapper sheet and shell. It has been well stated that a locomotive firebox, except when cold, is a constant vibrating machine acting on the staybolts.

Here then is the element of service that deserves special consideration. It is easy enough to determine the spacing, pressure per square inch and the total static load on any staybolt and arrive at the proper dimensions to fulfill safety and statutory requirements. That work is done before the locomotive is built. After going into service it may not be many months or years before there is cause for staybolt renewal. It is so easy to run in the next larger size staybolt tap to renew the threads in the sheets that the staybolts grow rather rapidly sometimes and the short life and unsatisfactory service of over-grown staybolts have, on many roads now led to placing a limit, after which staybolt holes and sizes must be reduced by welding down, bushing or use of new sheets. This was and is particularly desirable with the so-called rigid staybolt, ordinarily threaded full length, which, when over-grown is a vicious lever to buckle, work, crack and retire the firebox sheets, causing a renewal at high cost and loss of serviceability. Before the firebox surrenders it may break a lot of staybolts and the bigger they are the quicker they break, adding to expense and loss of engine service.

### Breakage of Rigid Bolts

It is well known and understood that 99 percent plus of the breakage of ordinary rigid staybolts occurs at the end close to the inner surface of outside sheet. In order to detect these breaks readily the outer ends are drilled with tell-tale holes, at least 1¼ inches deep, to comply with Interstate Commerce Commission boiler rules. This depth extends generally ¾ inch or well beyond the usual point of failure and usually announces a fractured or broken bolt by leakage in case it is not previously detected by hammer test.

In order not to have to tear down brick work in oil burners or arches every thirty days or in the case of staybolts located in places inaccessible for convenient inspection and hammer test, the Interstate Commerce Commission rules permit the use of staybolts with tell-tale holes throughout their length. This is a measure for convenience and safety but does not contribute to an increase of life or reduction of breakage as compared with a rigid bolt with short tell-tale hole, nor should it relieve the necessity for monthly inspection in the case of hollow bolts so located as to be available for hammer test.

### Methods of Reducing Failures

The location of breakage of rigid bolts has directed attention towards the means of reducing failures by other expedients. Turning off the threads between the sheets has been practiced to some extent, the idea being that the reduction of body size gained thereby would reduce the rigidity. However, as the outer or better portion of the iron is removed in the threading and turning and, as the body could not be made much if any smaller than the diameter at the roots of the threads, at least in the initial installation, the expense of the material thus wasted and of the time to remove it raises a question as to the expediency and real value of the operation.

It would seem a better plan to directly forge the body of the staybolts between the threaded ends to a minimum diameter consistent with stress requirements and, as larger threaded ends are required by reason of renewals and repairs of fireboxes, maintain such minimum body diameter in the interest of economy of material and reduction of the leverage effect on the firebox sheets. Such forging can be done and still maintain the original structure of the various designs of staybolt iron, thoroughly protecting the continuity of its lines in junctions of the body with such end shapes as are required for the various types of staybolts, whether for the water spaces or crown.

The files of the patent office disclose many devices calculated to overcome the breakage which seems inherent in fully threaded rigid bolts, but few of them have attained practical and commercial success. Most of these include utilizing the link, ball and socket, diaphragm and other modifications of outer end connection to attain their object with more or less success. The main thing disclosed is the fact that staybolts materially larger than stress requirements are mechanically wrong and contribute, not only to their own early failure, but to very expensive repair and renewal of fireboxes.

### Crown Stays

It has been customary for many years to employ the so-called button head stay for some rows each side of the center of the crown sheet of locomotive boilers. This design bolt has a button or collar bearing against the underside of the sheet in addition to a taper threaded body screwed into the sheet. The object of the design is to safeguard the crown or high part of the firebox in case of low water, as against the likelihood of straight threaded, hammered-over bolts pulling through in the event of being overheated.

The button head design presents some difficulties in production and application. Some cases have been known of the button heads pulling off and an etching disclosed that the material had failed in such a way as not to give the full value of the forging. The relatively large body of the button head gets over-heated as it cannot readily transmit its heat to the water, so much so, that in oil-burning locomotives the intense firebox temperature forbids their use. Due to this a taper head radial has been developed which is simple and serves the purpose and incidentally does away with a serious disadvantage of the button head type in application.

It is obviously difficult to accomplish two fits at the same time, that is, to have the threads fit tight in the sheet, simultaneously with a proper fit of the face of the button head against the sheet. It therefore becomes a calking job to get them tight, often repeated after the engine is in service, as the overheating of the mass of the head expands it and breaks the calking joint, making a high cost of maintenance of the button head type. By omitting the button portion, increasing the taper of the threads to 1½ inches or 2 inches in 12 inches and heading over, these troubles are largely done away with.

A committee of the Master Boiler Makers' Association has made a very excellent report in the 1921 proceedings, recommending this type of crown stay, giving the result of test and very convincing reasons for its adoption and use. They conclude the report by suggesting that the five rows of radials, next to the back flue sheet be applied without the taper, so that in case of low water these few bolts may let go and relieve the pressure while the rest of the crown sheet with the taper radials would hold.

### Advantage of Taper Head Radial Stays

The taper head radial can be screwed into a good fit; the sharper taper and heading over afford a safe holding up of the sheet; the heading over does not make a mass of metal that can be over-heated and expanded and in every way the taper head radial seems to be a decided improvement as has been found on many roads. If, as is the case on oil burners, they are a necessity, their advantages on coal burners are obvious in features of manufacturing, application and maintenance. On account of these advantages it is believed that it will become more general practice to increase the number of rows of these taper head radials, leaving a few rows at the sides and upper corners of the fireboxes for plain radial straight threaded bolts, similar to the side stays except as to length.

As staybolts are made of a relatively expensive material, all reductions of weight possible aside from necessary weight to fulfill stress requirements, should have earnest consideration. One of the incidental advantages of the taper radial is a saving by omission of the button.

For some reason, locomotive radial stays have been generally heavier than seems necessary, considering the fact that their spacing is generally about the same as that of water space stays. The Interstate Commerce Commission rules group all stays for fireboxes and combustion chambers with a common maximum stress requirement, viz.: 7,500 pounds per square inch of net cross-sectional area. The same figure is used in the rules as compiled by the Boiler Code Committee of the American Society of Mechanical Engineers and adopted as standard for stationary boilers in general practice, these rules being also adopted by several states and municipalities for boiler inspection and insurance rules.

When in place very few of the threads of a staybolt are in use, the sum of the thicknesses of the sheets stayed generally not exceeding 1 inch. On account of the tell-tale hole that end must not be much shorter than 1½ inches. It would seem, therefore, that very long threaded ends are wasteful of material and that those useless threads in the water and steam spaces only tend to catch and retain the precipitated sediment and do not facilitate cleaning.

### Economizing Staybolt Material

By careful selection of lengths of staybolts in building and repairing, much waste of staybolt material can be saved. True, there is great variation of lengths required by reason of the taper of water spaces, the slope of crown sheets and wrappers, requiring time and care in making up the bill of lengths and number required, but it does not take many inches to make a pound, and unnecessarily long threaded ends may lead to leaning on that fact and trimming off and casting more than necessary.

For convenience in ordering and care of warehouse stock, it has become quite a practice to carry staybolts in inch lengths, and if care is used in ordering the amount of waste beside the square when ends are clipped or burned off before heading over need not exceed an average of about ¾ inch per bolt, some more and some less. A survey of the scrap often discloses the direction in which economies can be made and waste guarded against.

For maximum staybolt material saving it is believed that 13/16 inch for body diameters between the threaded ends of all staybolts 1 inch diameter and over will fulfill Interstate Commerce Commission boiler rules, forging variations, spacings and pressure as found in the average and usual locomotive practice. Three-quarter-inch diameter will allow 207 pounds steam pressure with 4-inch by 4-inch spacing, but 13/16 inch will allow 245 pounds steam pressure or conversely for 200 pounds pressure will carry 19.44 square inches area of plate, in either case not taking into account the area of one body in the rectangle produced by the spacing of the staybolts.

### Types of Staybolt Threads

As applied to staybolts the "V" thread cuts deeper and affords a less cross-section at the root than other types and reduces the allowable steam pressure for any given size. The acute bottom angle offers a succession of breaking points at each thread and facilitates breakage as compared with flat or round bottomed threads.

The principal builders use Whitworth threads unless otherwise specified and many of the roads have abandoned the sharp "V" in favor of Whitworth or U. S. Standard threads in their maintenance work. Theoretically the round bottomed Whitworth is the better of the two but practically there is very little difference. Formerly also there was a tendency to insist on tight fits in staybolt application, which has been modified somewhat. Inasmuch as a straight thread will not make a steam tight fit and as heavy wrenching is very liable to tear the soft iron bolt threads it has been found that best results are obtained by an easy fit which will not disturb the threads. In driving up a perfect thread on the bolt into perfect threads in the sheets the best results can be obtained.

Furthermore, tap expense in the shop is bound to be very high if the tolerances in tap wear and bolt sizes are very close. As the tightness must be obtained by driving up, a reasonable tolerance can be allowed that will work to tap and bolt economies together with proper application and service.

The question of pitch and staybolt threads is one that unduly worries some people as they visualize theoretical perfection in staybolt taps, holes and bolts. Taps may be machined in pitch but do not necessarily stay so after the ordeal of the tempering furnace. The holes in two sheets, anywhere from 4 inches to 40 inches apart, may or may not be in pitch after being threaded with the aforesaid tap. The other work on the boiler, crane lifting, shop temperature changes and the like all tend to mar the accuracy deemed so desirable.

It is rather difficult to obtain full production of staybolts, all in pitch with the facilities provided in many railroad shops, but the bolts go in all the same and make a good job and the practical boilermaker of wide experience has learned that absolute pitch of staybolts is not an essential factor because he cannot guarantee his taps or tapping.

### Applying Stays to Combustion Chambers

The most difficult application is probably that of combustion chamber stays, tying two semi-circular surfaces together. No staybolt has been found that will answer perfectly to the requirement of 100 percent service in this location. Combustion chambers are found only as a rule in large boilers or at a great distance from the back head and the accumulated travel and vibration are very difficult to accommodate, tying such rigid sheets as are here used.

# Examinations for Locomotive Inspectors Announced

THE United States Civil Service Commission announces an open competitive examination for inspector of locomotives on March 8 and 9, 1922, at all of the principal cities in the United States. Vacancies in the Interstate Commerce Commission at salaries of $3,000 a year, and in positions requiring similar qualifications, at this or higher or lower salaries, will be filled from this examination, unless it is found in the interest of the service to fill any vacancy by reinstatement, transfer, or promotion.

Appointees will be allowed necessary expenses when absent from headquarters in the discharge of their official duties.

All citizens of the United States who meet the requirements, both men and women, may enter this examination; appointing officers, however, have the legal right to specify the sex desired in requesting certification of eligibles. For this position in the Interstate Commerce Commission men are desired.

### Preliminary Requirements

It must be shown in connection with each application (*a*) that the applicant is a person of good moral character and habits, active, intelligent, and discreet; of good speech and manner, qualified to address and confer with railroad officials as occasion may require; and (*b*) that the applicant has had not less than three years' railroad experience in the capacity of master mechanic, road foreman of engines, roundhouse foreman, shop foreman, locomotive engineer, locomotive boiler maker, locomotive boiler inspector, or locomotive machinist; or not less than five years as locomotive inspector or locomotive fireman; and has been, within two years next preceding the date of his application, in active service in any such capacity, or employed in connection with the inspection of locomotive equipment under the Government of the United States or of any state or territory thereof.

The experience herein required must be in addition to the time served in apprenticeship or spent attending a technical school.

No person interested either directly or indirectly in any patented article required to be used on any locomotive coming under the jurisdiction of the law, or who is intemperate in his habits, shall be eligible for appointment.

### Subjects and Weights

Competitors will be rated on the following subjects, which will have the relative weights indicated:

| *Subjects.* | *Weights.* |
|---|---|
| 1. Spelling (twenty words of average difficulty in common use) | 10 |
| 2. Arithmetic (fundamental operations, common and decimal fractions, and simple percentage) | 10 |
| 3. Practical questions relating to the construction, testing, inspection, repair and operation of locomotive boilers and their appurtenances | 20 |
| 4. Practical questions relating to the construction, testing, inspection, repair, and operation of locomotives and tenders and their appurtenances | 20 |
| 5. Report writing (a report of not less than 200 words on a given case relating to the inspection of locomotives and tenders) | 20 |
| 6. Training and experience in railroad work and general fitness | 20 |
| Total | 100 |

The rating received by the applicant in Subject 6 will be based upon evidence furnished in connection with his application and upon corroborative investigation. Different grades of experience will be rated according to their importance.

(*Continued on page* 57)

# The Boiler Maker

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There are two ways in which our readers can help us make the coming issues of THE BOILER MAKER of greater service to them in their work—first, by telling us what particular information will help them most and, second, by sending us facts and data from their own store of information and experience which will help other men in the shops. Neither of these requires much time or effort but both will be amply repaid.

As to the first, it is not a difficult matter for any reader of THE BOILER MAKER to send us a brief letter telling what class of work he is doing or in which he is especially interested, so that we may be sure to include in the coming issues the latest ideas and developments in that particular class of work. The boiler making field offers a wide range of subjects to be covered each month and it frequently happens that, in our endeavor to do justice to all, we unwittingly slight some subject which, to a certain class of our readers, is of special importance at a particular time. If so, we would like to know about it. Also, if any of our readers are confronted by special problems or jobs with which they are unfamiliar, a letter to the editor will bring a quick response as to ways and means or sources of information as to up-to-date methods of doing the work. The time and trouble required in making your wants known to us will be amply repaid by the prompt service which we are in a position to give. We therefore urge all of our readers to remember that by the simple means of correspondence with the editors a direct way is open for help in solving their individual problems through publication of the information which they desire in the magazine.

The second way in which our readers can help make THE BOILER MAKER of greater service, namely, the sending of facts, data and other information for publication, is something about which unfortunately there seems to be a misunderstanding. To many, contributing to a magazine seems a difficult task, and something which requires either a lot of hard work or unusual ability as a writer. In the case of THE BOILER MAKER, this feeling should be dispelled at once; for we do not expect our contributors to send us long carefully prepared essays when all we need is facts and figures. All of us can talk shop in the shop, and there is no reason why, with pencil and paper, the same facts cannot be put down in black and white and transmitted to our office where it is the task of the editorial department to put them in readable form for publication in the magazine. In other words, the help that our readers can give us in this way is not a difficult thing but something which anyone can do if he will take the time to do it. Moreover, once the information is in our hands and space found for it in the magazine, a check will be sent to the sender of the information paying him for it at regular space rates, so that he will not only have the satisfaction of seeing his ideas and information in print, and of helping his fellow workers by passing along a useful bit of advice or information, but he will also have earned a little extra money for the time which he has taken to do it.

Other misconceptions about contributing material for publication which should be dispelled are the length of articles or letters and the matter of illustrations. Articles may be of any length, from a few lines to several pages. Many times a few words or figures jotted down on a sheet of paper in the form of a memorandum, giving such information as the size of rivets or method of handling a tool for a certain piece of work, will give more information to a boiler maker than a long argument or description. It is not the number of words that count so much as the ideas or facts which they contain. If illustrations are required, we can use almost any kind of a drawing or sketch regardless of whether it is a rough freehand pencil sketch or a finished drawing in ink or a blue print. All illustrations are redrawn in our office of suitable size and arrangement for reproduction to suit the size of our columns. Therefore, no one need hesitate about sending us information for publication just because he doubts his ability as a writer or draftsman.

If these facts are thoroughly understood, we hope that many more of our readers will be only too glad to cooperate with us by sending in letters telling in their own way details of new and interesting shop methods and appliances, as well as news of the work and men in the shops.

# Engineering Specialties for Boiler Making

## New Tools, Machinery, Appliances and Supplies for the Boiler Shop and Improved Fittings for Boilers

### Safety Cleaning Machine for Small Parts

A new machine intended to replace the wasteful "bucket and brush" method of cleaning small parts has been developed by the Black and Decker Manufacturing Company, Baltimore, Md. This machine consists of a cast iron pedestal with a bowl at the top, 13 inches in diameter and about 12 inches deep. About 5 inches from the bottom of the bowl a fine mesh brass screen is supported. A plunger pump is cast integral with the bowl at one side. The bowl is provided with a safety cover, arranged so that it cannot be left open. This cover is controlled by a handle which operates the plunger pump when the cover is lifted.

Cleaner in Operation

A gallon of gasoline, kerosene or a similar liquid cleanser is poured into the bowl of the machine and the operation of the plunger pump forces a stream of this fluid from one side into the center of the bowl. It passes through the screen and returns to the pump so that the liquid is used over and over again. It is merely necessary to hold the part to be cleaned under the stream of cleaning liquid which washes dirt, chips and foreign matter from the part to be cleaned and deposits it on the screen below.

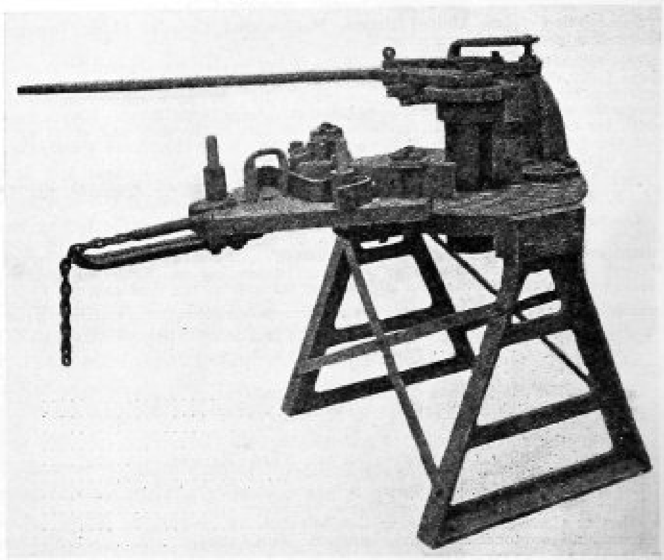
This machine is particularly useful for cleaning ball bearings, roller bearings, gears, drills, milling cutters, tools, etc.

### Bending, Forming and Shearing Machine

A hand-operated metal bending, forming and shearing machine of the type shown in the accompanying illustration is being produced by the Bussel Machine Company, El Paso, Texas. Three sizes are furnished, the one illustrated being the No. 3 machine equipped with a compound ratchet lever and with the forming and shearing plate in position.

Among the advantages claimed for the machine are that it requires no extra dies to bend any size stock within its capacity to any angle and that stock will not shift, but will bend on the exact mark. The machine will work right or left without adjustment and one man can operate it. The table, it is pointed out, is an important feature, as all kinds of jobs can be done on it, such as bending heavy angle circles or heavy bars. The bending posts have four bending edges and make less than one-fourth turn in producing a 90 degree angle. Stock larger than the bending posts will take edgewise can be bent on the outside of the post. A 90 degree angle can be bent without the use of a square.

The No. 3 machine has two bending posts, one for light, the other for heavier jobs. The small post will bend ¼ by

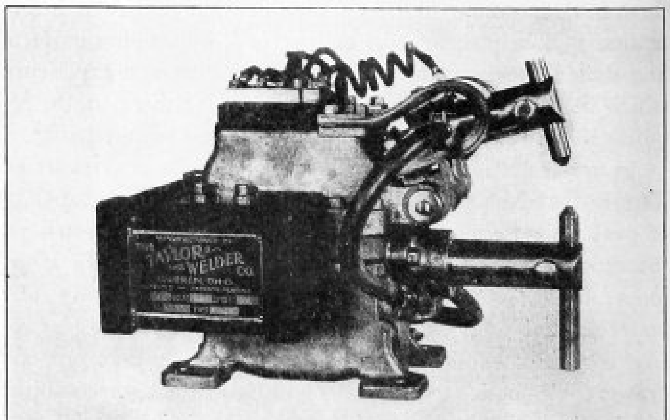


This Type Machine Is Equipped with Compound Ratchet Lever and with Forming and Shearing Plate

6 inch cold; ⅝ by 6 inch with sharp corner, hot; and ⅞ inch, round or square, cold. The large post will bend ⅜ by 6 inch, cold; 1 by 6 inch with sharp corner, hot; 1¼ by 6 inch, with round corner, hot; and 2 inch and under pipe. The weight of the machine illustrated is 840 pounds.

### Bench Type Spot Welder

A new spot welding machine of the bench type, having a capacity of two pieces of No. 30 to No. 16 gage sheet metal, has recently been put on the market by the Taylor Welder



Bench Spot Welder with Water Cooled Welding Horns

Company of Warren, Ohio. The machine has a cast copper frame which acts as a secondary and adds to its efficiency. Two horns of cold drawn copper 1¼ inch in diameter protrude from the machine, the upper horn being capable of movement through a distance of one inch. The lower horn is made adjustable by drilling three sets of holes in the base of the frame and setting the horn to suit the work, a long electrode being furnished to meet this condition.

With the lower horn in its highest position the distance between the two horns is three inches. This distance can be increased to five inches when the lower horn is in its lowest position. The transformer has a capacity of 3 kilowatts and a 4-step regulator is used for adjusting the current. Cooling is effected by the circulation of water through both the upper and lower horns. The floor space occupied by the machine is 10 inches by 17 inches and the extreme height from the bench is 12 inches. An automatic single pole switch closes the circuit and the upper horn and contact point is brought against the work by the operation of a foot pedal, not shown in the illustration. The approximate weight of the machine is 150 pounds.

## Safety Locomotive Ash Pan Blow-Out Valve

Four distinctive features and important advantages are claimed for the new locomotive ash pan blow-out valve illustrated; namely, safety, elimination of packing troubles, small space occupied and automatic closure. Patents are now pending on the device which has been developed by Arthur Brigham, an employee of the New York,

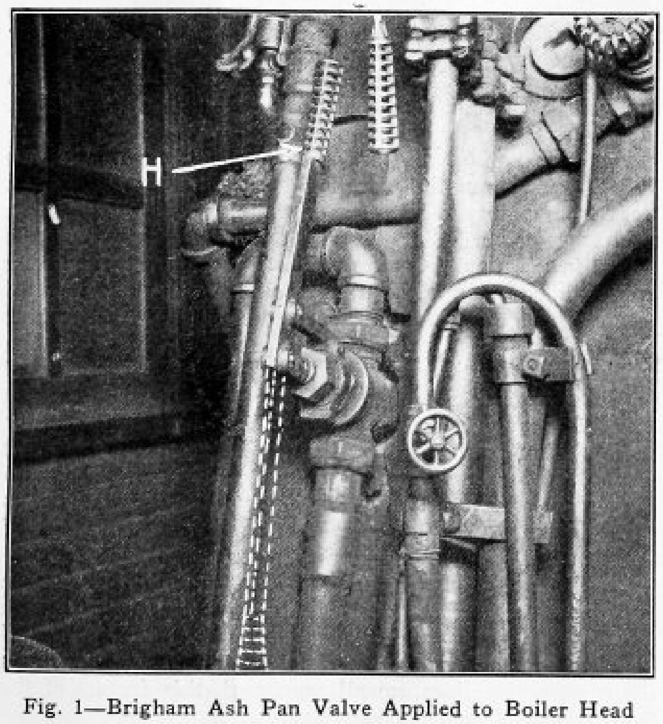



Fig. 1—Brigham Ash Pan Valve Applied to Boiler Head

New Haven & Hartford at the Dover street roundhouse, Boston, Mass. Several of the valves have been made and applied and they are recommended with considerable enthusiasm by the men responsible for their maintenance and operation.

Referring to Fig. 1 the valve will be seen applied to the back head of a locomotive boiler with handle *H* in the upper position. A direct, steady pull on the handle will admit steam to the body of the valve and direct it to the upper pipe, and connecting pipes to the front ash pan. When the ash pan has been cleared of ashes, handle *H* is released and automatically goes back to the closed position, shutting off the supply of steam. This is an important feature since, should anything happen to the fireman or hostler while operating the valve, it will close automatically. When it is desired to blow out the rear ash pan, handle *H* and its fulcrum lever are revolved parallel with the boiler head to the lower position, shown in dotted lines. A direct pull on the valve handle when in the lower position will admit steam from the boiler to the valve and the lower pipe and then through the connecting pipes and fittings to the rear ash pan. As in the previous case the valve is closed automatically by releasing the handle.

The safety feature of the valve can be more plainly seen by referring to Fig. 2 in which the valve is shown disconnected from the boiler head. It is apparent from the illustration that the valve screws into the boiler head at thread *A*, check valve *B* which controls the flow of steam being inside

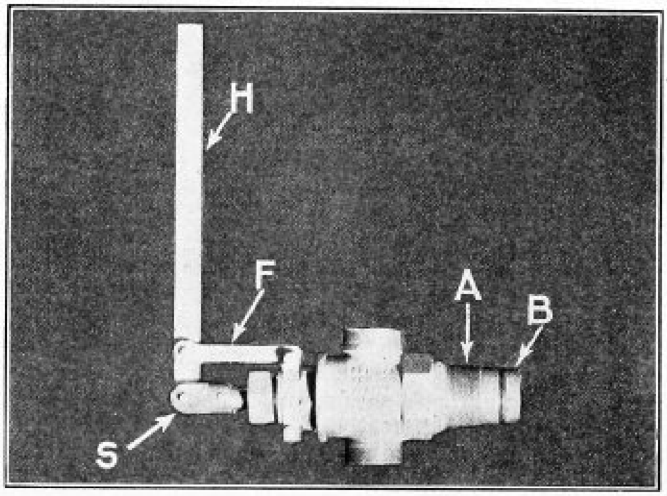



Fig. 2—View Showing Location of Check Valve

the boiler sheet. The blow-out valve is grooved internally just to the left of thread *A* so that should the valve receive an accidental heavy blow it will break at this groove, leaving thread *A* and check valve *B* intact. Referring to Fig. 2 the operation of the valve and handle will also be more readily apparent. The movement of handle *H* to the left opens check valve *B*. A one-ported hollow internal sleeve is provided in the valve and directs the flow of steam into the upper or lower pipes, depending upon the position of handle *H*. Reference to Fig. 1 shows the small amount of room required for the valve and it is stated that owing to the absence of steam from the blow-out valve when not in use no packing is needed.

## BUSINESS NOTES

The Rathbun-Jones Engineering Company, Toledo, O., has appointed the Ingersoll-Rand Company, New York, general sales agent for Rathbun gas engines.

The Philadelphia office of the Hauck Mfg. Company, Brooklyn, N. Y., has been moved to 1726 Sansom street. Herbert Vogelsang will be in charge of the office.

The Novelty Steam Boiler Works Company, Baltimore, Md., is building another factory building two stories high of brick and steel, 110 feet by 155 feet, on South Howard street.

Through a decree of the circuit court in St. Louis, Mo., the Heine Boiler Company has passed under the control of C. R. D. Meier, president of the company. Mr. Meier is a son of the late Col. E. D. Meier, founder of the concern.

# Questions and Answers for Boiler Makers

## Information for Those Who Design, Construct, Erect, Inspect and Repair Boilers—Practical Boiler Shop Problems

**Conducted by C. B. Lindstrom**

*This department is open to subscribers of* THE BOILER MAKER *for the purpose of helping those who desire assistance on practical boiler shop problems. All questions should be definitely stated and clearly written in ink, or typewritten, on one side of the paper, and sketches furnished if necessary. 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 permission to do so.*

### Pressure on Stayed Flat Plate

Q.—Would you please let me know as to the proper weight and design of a staybolt testing or tapping hammer? The diagram, Fig. 1, shows an example in staybolting. There are 64 square inches contained inside of these nine staybolts; the working pressure is 180 pounds per square inch. I would like to know if the center staybolt were broken, would the sheet inside of these other eight bolts be subjected to 180 x 64 equals 11,520 pounds total pressure. It has been proved that when a stay breaks that the sheet would bulge or bag out, which did not occur before the bolt was broken.—C. B.

A.—Any type of boiler maker's hand hammer weighing one or two pounds is suitable for testing stays. The hammer test is not always a sure means of finding broken stays. The sound of a solid stay is clear and distinct, while that of a broken stay is usually a dull sound. However, if the stay is only slightly cracked and the bolt sections are firmly

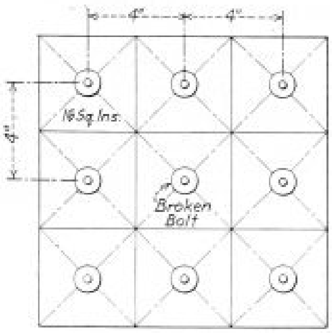



**Fig. 1.—With One Bolt Broken, to Determine Stress on Remaining Bolts**

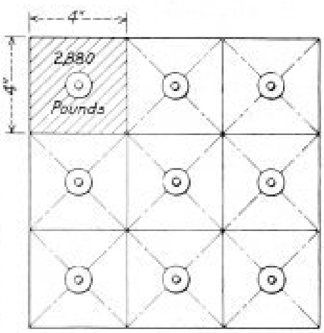



**Fig. 2.—Eight Stays Would Be Required to Carry a Pressure of 3,365 Pounds**

butted against each other, the sound from tapping will be very nearly that of a solid stay and the hammer will rebound quickly from the blow.

The load carried by the staybolts as illustrated in Fig. 1 is greater than the load you determined in your calculations. To make this clear refer to the sketch, Fig. 2, the shaded portion within the pitch 4 inches by 4 inches less the cross sectional area of the stay is the net area each stay supports. The load on each stay is figured by multiplying the pitch together and the product so found by the working pressure; thus, $4 \times 4 = 16$; $16 \times 180 = 2,880$ pounds, total pressure.

There are 9 sections carrying this pressure, and $2,880 \times 9 = 26,920$, as against a total pressure of 11,520 pounds figured in your example. If the center stay breaks, 8 stays must carry the load of 26,920 pounds, and each stay would carry $26,920 \div 8 = 3,365$ pounds. The plate in such a case would bulge tending to form a spherical section or some of the stays might break, increasing the possibility of a boiler explosion.

### Transition Hood Development

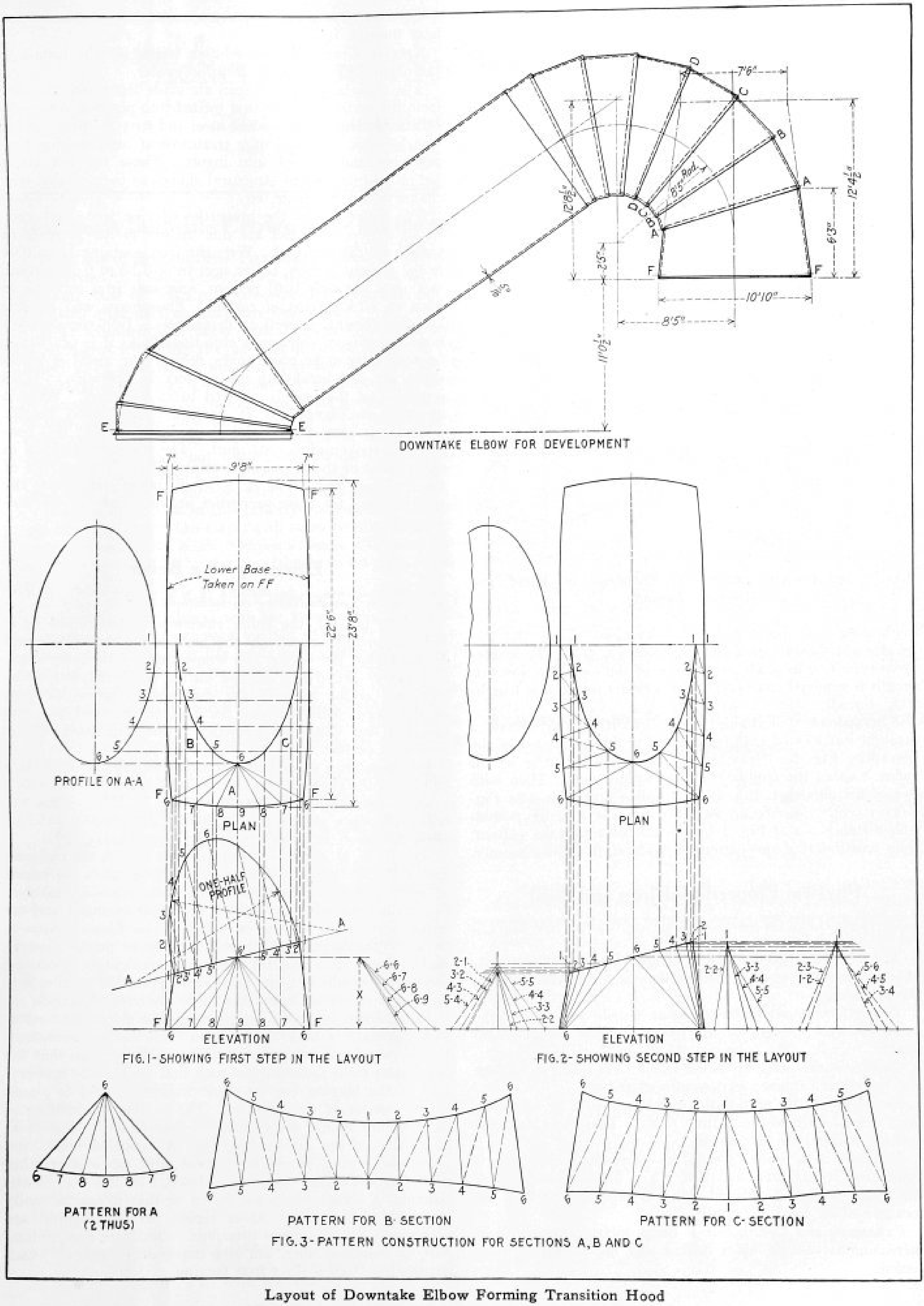
Q.—I am writing you to ask if you will please indicate a method of developing the accompanying elbow problem, the most difficult part of which seems to be the hood, with an angle of the elbow on top of it?—J. S.

A.—The layout of this problem is shown to the best advantage by illustrating the three principal steps, as in Figs. 1, 2 and 3. Owing to the irregular shape of this pipe connection, the triangulation system is applied. The lower base taken on F-F plan view, Fig. 1, has a curved outline along the respective sides. These can be laid off by indicating the width and length of a rectangular form drawn to the dimensions given. Then with a pliable strip of wood, or iron strip, the curved outlines can be described. The elevation is then drawn showing the true position of the miter plane A-A.

The shape of the section on this plane is an ellipse as indicated in the profile view A-A. As the plane is inclined to the horizontal, it will appear foreshortened in the plan. Therefore, to obtain its foreshortened view, a true development of the ellipse is made as shown to the left of the plan and also a one-half section at right angles to the miter A-A of the elevation. Divide its outline into equal divisions, as shown from 1 to 6. By projecting vertical lines from points 1'-2'-3', etc., from the elevation to intersect the horizontal lines from points 1-2-3, etc., of the elliptical profile view, establishes points 1-2-3, etc., on the foreshortened view of the ellipse in the plan. For convenience in handling the fitting up of this transition piece, it should be made in several sections. In this case four parts are chosen as A for the ends and B and C for the sides.

The layout of the end sections will be made from Fig. 1 in this manner. Space off the curve 6-6 in the plan into equal parts as 6-7, 7-8 and 8-9. The lines from 7-8 and 9 radiate from point 6. The true lengths of these lines are determined by developing the right angle triangle, shown to the right of the elevation. The height for these triangles is equal to the vertical distance taken between points 6-9 of the elevation. The bases for these triangles equal respectively the lengths of the radials 6-7, 6-8 and 6-9 of the plan and the hypotenuses are the required true lengths in Fig. 3. The pattern is constructed by assembling the true radial lengths and using the arc lengths of the curve plan view. As the construction lines are all numbered, this feature of the work should be understood.

The construction of Fig. 2, as in regard to the outline of the plan and elevation, is the same as in Fig. 1. The purpose of this, Fig. 2, is to indicate the triangulation requirements for the sections B and C. As will be noted, the elliptical outline is divided into equal divisions as before and that the curved outlines for the longer sides of the base are also spaced into equal parts. The points are then located in their relative positions in the plan view by projection. The lengths of the triangulation lines are then developed to their true size as indicated to the left and right of the elevation. As all lines are numbered, this work needs no further explanation. Fig. 3 shows the complete development of the patterns for B and C. Allow for laps.

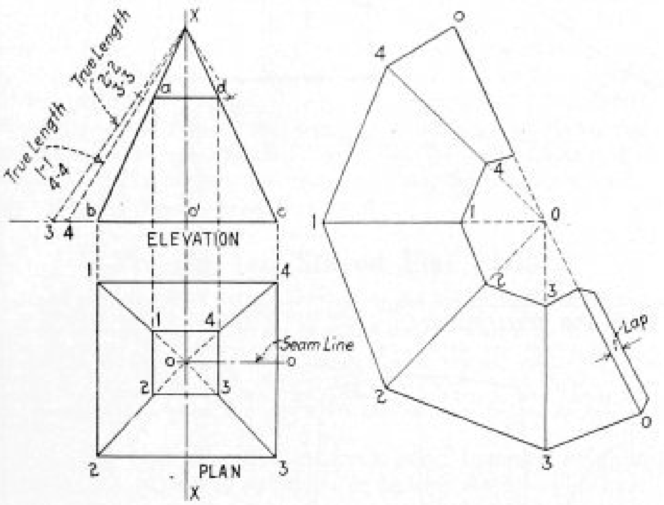



**Layout of Downtake Elbow Forming Transition Hood**

## Layout of a Square Hood

Q.—I would like an explanation of the method for developing a hood, tapering from a square base to a smaller square section at the top. Also show how the seam should be made so as not to come along the bend of the hood.—F. N.

A.—From the arrangement of the two openings of the hood, Fig. 1, it will be seen that the upper or smaller base is not exactly in the center of the large base. The bend lines of the hood come on lines *1-1*, *2-2*, *3-3* and *4-4* and intersect in the center, *o*. The true lengths of *o-1*, *o-2* are found by setting off these lengths of the plan, on the base line of the elevation, from the point *o'*. Diagonal lines are then drawn




**Figs. 1 and 2.—Arrangement of Openings in Hood and Pattern Layout**

connecting with point *x* in the elevation. Thus the true lengths are shown at *1-1* and *4-4* and *2-2*, *3-3*. The lengths from *o* to *1*, *o* to *4*, etc., equal *x-d* of the elevation and this length is resolved from point *x* as a center to the true lengths *1-1*, *4-4*, etc.

The pattern is developed as shown in Fig. 2. Draw a straight line as *o-3*, making it equal to the length *x-3* of the elevation, Fig. 1. Draw an arc and from point *3* set off point *2* using the length *3-2* of the plan view. Then with *x-4* of the elevation, Fig. 1, as a radius and with *o* in Fig. 2 as a center describe an arc. From point *2* in the pattern and distance *2-1* of Fig. 1 set off the point *1* in the pattern. The remainder of the pattern is laid off in a like manner.

## Physical Properties of Iron and Steel

Q.—Will you please give a brief description of the physical properties of metals used in boiler construction, such as steel, wrought iron, cast steel and cast iron?—S. D.

A.—The qualities of these materials that make them suitable for pressure vessels, such as boilers and tanks comprise the following:

*Tensity*, commonly referred to as *tensile strength* of the metal, is that strength of the metal to resist being pulled apart.

*Quality* is the property which enables the metal to be bent and drawn to a thinner section without fracture.

*Fusibility* is the property a metal possesses of becoming fluid when heated to the melting point. This is an essential feature in metals to be welded.

*Elasticity* is the power a metal has of resuming its original form after it has been stretched. The ultimate strength of the metal within its elastic limit to resist rupture is the measure of its tensile strength.

*Expansion and Contraction* is the property a metal has of increasing its length when heated and decreasing it when cooled.

*Conductivity* is the property a metal has of transmitting heat through it.

*Specific Gravity* is the relative weight of the metals as compared with an equal volume of water.

The materials iron and steel are made from iron ore taken from the earth, which is first melted into pig iron commonly called cast iron. To produce steel and wrought iron, the pig iron is subjected to furnace treatment at high melting temperatures and formed into ingots. These red hot ingots are rolled into various structural shapes as bars, angles, tees, channels and flat plate, etc.

The difference in the properties of cast iron, cast steel, wrought iron and steel are due mainly to the presence of carbon in the material. Wrought iron contains from 0.01 to 0.2 percent carbon, boiler steel from 0.12 to 0.30 percent, cast steel not over 0.30 percent, and cast iron contains as high as 4.75 percent of carbon. Phosphorus and sulphur are also present, as well as manganese. Iron containing a large quantity of sulphur is objectionable as it is practically impossible to make good welds, because the metal is brittle while hot and breaks up during forging operations. This condition of the iron is referred to as *hot short*. When a quantity of phosphorus is present brittle metal results. This arises after the metal is heated and cooled; this condition is spoken of as *cold short*. The slightest variation in the amount of the chemical elements alters the properties of the steel and iron. The A. S. M. E. boiler code covers the specifications for these properties and strengths of the materials.

## Efficiency of a Boiler

Q.—On what basis is the efficiency of a boiler determined? Is it on the amount of heat absorbed by the boiler?—S. B.

A.—In general, the boiler efficiency is determined by a test, measuring respectively the heat in the steam delivered by the boiler, the weight and temperature of the feed water, and the weight of fuel burned during the boiler test. The efficiency is the ratio of the difference between the heat of the steam delivered and the heat in the feed water to the heat that would be developed if the combustion of the fuel were perfect.

For example, a steam boiler absorbs 130,686,500 B. T. U.'s of heat in the evaporation of water into steam, the test shows a total heat supply of 210,300,600 B. T. U.'s. Then the boiler efficiency equals $130{,}686{,}500 \div 210{,}300{,}600 = 62.14$ percent.

The B. T. U. expression is called the British thermal unit and it is the amount of heat required to raise one pound of water 1 degree Fahrenheit. The boiler efficiency involves two factors, namely, the furnace as a heat producer and the boiler surfaces as a heat absorber. The furnace may be so well constructed and proportioned as to produce nearly perfect combustion and yet a low boiler efficiency results on account of insufficient and poor arrangement of heating surfaces and radiation losses due to poorly-covered boilers.

Every detail in boiler design should be given strict attention to obtain a high efficiency in both factors mentioned. Boiler coverings should be made heavy enough so that the heat losses from radiation are such that the outside temperature of the lagging can be borne when the hand is placed on the outside of the covering. The outside temperature of the covering should not be over 40 degrees to 50 degrees F. above that of the surrounding air. All exposed boiler surfaces and piping should be covered with asbestos or other good nonconducting material. Material of this sort is obtainable in sheets which are wired so that it can be easily installed and replaced when repairs to the lagging are necessary. Plastic cement coverings, mixed with lime, animal hair or vegetable fiber, are also employed outside of which is usually placed a sheet iron lagging.

# Letters from Practical Boiler Makers

**This Department Is Open to All Readers of the Magazine —All Letters Published Are Paid for at Regular Rates**

## Is Brass a Suitable Crown Stay Material?

Have any of the readers of THE BOILER MAKER ever heard it suggested that solid brass crown stays be used in the firebox and roofs of Belpaire type locomotive boilers, in lieu of the usual mild steel, or Yorkshire iron stays?

It is admitted that brass with a lower tensile strength, as compared with mild steel or iron, does not appear at first glance to be suitable for this use in crown stays and that to take stays of ordinary 1 inch diameter, perhaps the diameter of the stays, if of brass, would need to be greater than steel or iron, or else the pitch would need to be altered and more stays used. Again the hexagonal head as adopted here would be awkward; but could not this be obviated and cheaply enough made by using an hexagonal bar, leaving the head, and machining the stay itself into the round?

It seems to me that in this country (Australia), where we use steel and iron crown stays, with brass ferrules filled with cement, that the bad water troubles we meet with here would be better provided for by the use of brass crown stays without ferrules and cement.

I would point out here that a great deal of trouble is experienced on our railways with the crown stays; the quality and action of the water used tending to quickly corrode and eat away the stay, their life being very short indeed; this in spite of the fact that water purifying plants are very extensively used in our worst districts. Apart from the brass stay I suggest, do you consider, or know of any other metal, or method, that would better the existing mild steel or Yorkshire iron stays used. (The iron seems to do rather better here than the steel.)

New South Wales, Australia. GEORGE E. JORDAN.

## Derivation of the Word Caulking

It is always interesting to discover the origin of the most ordinary things, everything had a beginning however remote, the more usual and everyday the object or article the more unusual is likely to be its origin.

Technical terms are among the most puzzling things to explain and in most instances their origin is wrapped in mystery. There are some exceptions, however, and in perusing "The Romance of Words," by Ernest Weekley, M.A., a most fascinating volume and the only attempt to deal in a similar manner with unusual terms in the English language, the origin of the term most familiar to the boilermaker was discovered.

"We now *caulk* a ship by forcing oakum into the seams. Hence the verb to *caulk* is explained as coming from Mid. Eng. *caulken,* to tread, Old Fr. *cauquer, caucher,* Lat. *calcare,* from *calx,* heel. This makes the process somewhat acrobatic, although this is not, philologically, a very serious objection. But we *caulk* the ship or the seams, not the oakum. Primitive *caulking* consisted in plastering a wicker coracle with clay. The earliest caulker on record is Noah, who pitched his ark within and without with pitch. In the Vulgate (Genesis, 6.14), the *pitch* is called *bitumen* and the verb is *linere,* 'to daub, besmear, etc.' Next in chronological order comes the mother of Moses who 'took for him an ark of bulrushes, and daubed it with slime and with pitch' (Exodus, 2, 3), *bitumine ac pice* in the Vulgate. Bitumen, or mineral pitch, was regularly applied to this purpose, even by Elizabethan seamen. Failing this, anything sticky and unctuous was used, e. g., clay or lime. *Lime* now means usually calcium oxide, but its original sense is anything viscous; c.f. Ger. *Leim,* glue, and our bird-*lime.* Our *caulk* is in medieval Latin *calcare,* and this represents a rare Latin verb *calicare,* to plaster with lime, from *calx,* lime. The oldest example of the verb to *caulk* is about 1500. In Mid. English we find to *lime* used instead, e. g., in reference to the ark, 'set and *limed* agen the flood' (c. 1250), and '*lyme* it with cleye and pitche within and without' (Caxton, 1483). Almost every language which has a nautical vocabulary uses for our *caulk* a verb related to Fr. *calfater.* This is of Spanish or Portuguese origin. The Portuguese word is *calafeter,* from *cal,* lime, and *afeitar,* to put in order, trim, etc."

So that when the boilermaker borrowed the word caulk (or calk) he passed into the possession of a term of great antiquity, but in so borrowing he applied it to a more important process which really deserved a new term all to itself. Like his previous users, the boilermaker adopted the current term rather than coin a new one. The continuity is that called by whatever name the object was the same—to ensure freedom from leak.

London, England. A. L. HAAS.

## Examination for Locomotive Inspector Announced

(*Continued from page* 50)

Competitors who fail to receive an eligible rating on each of subjects 3, 4, 5, and 6 will not be given ratings on the other subjects.

AGE AND PHYSICAL ABILITY

Applicants must have reached their thirtieth but not their fiftieth birthday on the date of the examination; must be physically qualified for performing the duties required in this position, and may be required to take a physical examination when reporting for duty. The above age limits do not apply to persons entitled to preference because of military or naval service.

APPLICATIONS

Applicants should at once apply for form 1892, stating the title of the examination desired, to the Civil Service Commission, Washington, D. C.; the Secretary of the United States Civil Service Board, Customhouse, Boston, Mass., New York, N. Y., New Orleans, La., Honolulu, Hawaii; Post Office, Philadelphia, Pa., Atlanta, Ga., Cincinnati, Ohio, Chicago, Ill., St. Paul, Minn., Seattle, Wash., San Francisco, Calif., Denver, Colo.; Old Customhouse, St. Louis, Mo.; Administration Building, Balboa Heights, Canal Zone; or to the Chairman of the Porto Rican Civil Service Commission, San Juan, P. R.

Applications should be properly executed and must be filed with the Civil Service Commission, Washington, D. C., in time to arrange for the examination of the applicant.

## Six-Roll Superheater Flue Expander

(*Continued from page* 35)

remove these flues and round up the holes by means of rose-bitting, as frequently the flues are of good thickness. It is possible to make such flues steam tight with a three-roll expander, but this cannot be done with the six-roll expander. When operating in an oval-shaped hole the mandrel of the three-roll expander takes an eccentric path, which allows it to press on the rolls as they pass over the portion of flue which is out of shape, thus allowing the flue to be made tight.

The six-roll expander will not do this, as having more points of contact the rolls are permitted to ride loosely over the misshapen portions of the flue. An experiment was made in this direction on a leaking flue, which was 1/8 inch out of round. The flue was covered with chalk internally and well expanded with the six-roll expanders. This failed to stop the leakage, and on removing the expander it was found that the chalk was cleaned from the sides of the flue, but remained on the top and bottom. On expanding the same flue with a three-roll expander the leakage was stopped and it was found that the chalk was well cleaned off all round the flue.

If expanding could be continued with the six-roll expander the flue hole would be rolled round, but this is not to be desired, as adjacent flues would be affected. Also the inclination on the rolls would prevent this being done, as the expander would get so tight as to become immovable before the shape of the hole had been appreciably altered.

To sum up, the six-roll expander in its present form requires modifying and fitting with an adjustable cap which would make it most suitable for new work and for expanding flues in sheets which have had their flue holes rosebitted round. The three-hole tube expander is most suitable however for the tube repairs which have to be made in locomotive terminals.—*The Railway Engineer.*

## Locomotive Boiler Construction on the North Eastern

(*Continued from page* 41)

the only one "laid out." The sheets are then rolled to shape and after they are assembled, the rivet and staybolt holes are reamed out to the proper size.

All of the copper sheets are flanged by hand with the exception of the door-hole in the back firebox sheet which is done in a press. All the steel flange work is done in the hydraulic presses. After the back firebox sheet and the back head have been flanged and trimmed, they are carefully fitted together at the door hole, distance pieces being placed between them to represent the water space. These plates are clamped together and the rivet holes through the two sheets drilled. The copper back firebox sheet is then taken to a machine and the door-hole machined out. Copper staybolts are used for the firebox. These are cut off to give a 7/16-inch stay head in the copper sheet and 3/8-inch head in the steel outside sheet. A long stroke pneumatic hammer with a pneumatic holder-on is used in riveting the staybolts. The foundation ring, which in this case is 3 inches by 4 inches, is machined on the outside and on the inside corners. In cases where steel fireboxes are used it is machined on both inside and outside.

While a large number of English roads use the ferrules between the tubes and the tube sheet, it is not the practice on the North Eastern. The tubes extend through the copper tube sheet 3/8 inch, for beading and about 1/2 inch through the front tube sheet. The tubes are rolled by a three roller expander driven by pneumatic portable machine and are beaded on the firebox end only, with the exception of the stay tubes which are beaded on both ends. The ends of the superheater flues extending through the firebox tube sheet are machined on the outside and care is taken to prevent any scale or foreign matter from working in between the sheet and the flue. These flues are then expanded by a special five roller expander and beaded as in the case of the small tubes.

The North Eastern has a particularly well equipped boiler shop which is of sufficient capacity to more than take care of the needs of the road.

These engines are the latest to be constructed by the North Eastern and bear a great similarity to a 4-6-0 design, which is also new, for fast freight traffic. These engines use the same cylinder castings, and the same boiler. The dimensions of the 0-8-0 type are given below.

| | |
|---|---|
| Type | 0-8-0 |
| Gage | 4 feet 8½ inches |
| Service | Heavy freight |
| Fuel | Soft coal |
| Tractive effort | 36,960 pounds |
| Weight in working order | 160,380 pounds |
| Weight on drivers | 160,380 pounds |
| Weight on engine and tender in working order | 259,200 pounds |
| Wheel base, driving | 18 feet 6 inches |
| Wheel base, total | 18 feet 6 inches |
| **CYLINDERS** | |
| Kind | Simple |
| Number | 3 |
| Diameter and stroke | 18½ inches by 26 inches |
| **VALVES** | |
| Kind | Piston |
| Number | 3 |
| Diameter | 8¾ inches |
| **WHEELS** | |
| Diameter of tires | 55¼ inches |
| **BOILER** | |
| Style | Straight |
| Working pressure | 180 pounds per square inch |
| Outside diameter | 66 inches |
| Firebox, length and width | 9 feet by 3 feet 11 inches |
| Tubes, number and outside diameter | 102—2-inch |
| Flues, number and diameter | 24—5¼-inch |
| Stay tubes, number and diameter | 7—2-inch |
| Tubes and Flues, length | 16 feet 2⅝ inches |
| Heating surface, tubes | 1,407 square feet |
| Heating surface, firebox | 166 square feet |
| Heating surface, total | 1,573 square feet |
| Superheater surface | 530 feet |
| Equivalent heating surface | 2,368 square feet |
| Grate area | 27 square feet |
| **TENDER** | |
| Tank | Six wheel |
| Weight | 98,800 pounds |
| Water capacity | 4,125 gallons |
| Coal capacity | 5½ tons |

## PERSONAL

T. H. HAYS has been appointed manager of the Indianapolis, Ind., office of the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

H. D. JAMES, manager of the control engineering department of the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., has been elected president of the Engineers' Society of Western Pennsylvania. Other officers, who were also elected at the annual meeting of the society, are Frederick Crabtree, vice-president, and J. C. Hobbs and C. D. Terry, directors. Mr. James had served as director of the society for three years and has been president for the past two years. He is a graduate of the University of Pennsylvania and is a member of the American Institute of Electrical Engineers.

## ASSOCIATIONS

### Bureau of Locomotive Inspection of the Interstate Commerce Commission

Chief Inspector—A. G. Pack, Washington, D. C.
Assistant Chief Inspector—J. M. Hall, Washington, D. C.

### Steamboat Inspection Service of the Department of Commerce

Supervising Inspector General—George Uhler, Washington, D. C.
Deputy 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—John A. Stevens, Lowell, Mass.
Vice-Chairman—D. S. Jacobus, New York.
Secretary—C. W. Obert, 29 West 39th Street, New York.

### National Board of Boiler and Pressure Vessel Inspectors

Chairman—J. F. Scott, Trenton, N. J.
Secretary-Treasurer—C. O. Myers, State House, Columbus, Ohio.
Vice-Chairman—R. L. Hemingway, San Francisco, Cal.
Statistician—W. E. Murray, Seattle, Wash.

### American Boiler Manufacturers' Association

President—A. G. Pratt, Babcock & Wilcox Company, New York.
Vice-President—G. S. Barnum, The Bigelow Company, New Haven, Conn.
Secretary and Treasurer—H. N. Covell, Lidgerwood Manufacturing Company, Brooklyn, N. Y.
Executive Committee—F. C. Burton, Erie City Iron Works, Erie, Pa.; E. C. Fisher, Wickes Boiler Company, Saginaw, Mich.; C. V. Kellogg, Kellogg-McKay Company, Chicago, Ill.; W. S. Cameron, Frost Manufacturing Company, Galesburg, Ill.; W. A. Drake, The Brownell Company, Dayton, Ohio; Alex. R. Goldie, Goldie & McCullock Company, Galt, Ont., Can.; F. G. Cox, Edge Moor Iron Company, Edge Moor, Del.; J. C. McKeown, John O'Brien Boiler Works Company, St. Louis, Mo.

### International Brotherhood of Boiler Makers, Iron Ship Builders and Helpers of America

Louis Weyand, Acting International President, suite 315 Wyandotte building, Kansas City, Kans.
Frank Reinemeyer, International Secretary-Treasurer, suite 315 Wyandotte building, Kansas City, Kans.
James B. Casey, Editor-Manager of Journal, suite 312-314 Wyandotte building, Kansas City, Kans.
William Atkinson, Acting Assistant President, suite 315 Wyandotte building, Kansas City, Kans.
International Vice-Presidents—Joe Reed, 1123 East Madison street, Portland, Ore.; Thomas Nolan, 700 Court street, Portsmouth, Va.; Joseph Flynn, 111 South Park avenue, Little Rock, Ark.; M. A. Maher, 2114 Eighteenth street, Portsmouth, Ohio; E. J. Sheehan, 7826 South Shore Drive, Chicago, Ill.; John J. Dowd, 953 Avenue C, Bayonne, N. J.; R. C. McCutcheon, suite 15, La Salle Block, Winnipeg, Man., Can.; Joseph P. Ryan, 7533 Vernon avenue, Chicago, Ill.; John F. Schmitt, 1489 North Fourth street, Columbus, Ohio.

### Boiler Makers' Supply Men's Association

President—Frank J. O'Brien, Globe Seamless Steel Tubes Company, Milwaukee, Wis.
Vice-President—William B. Wilson, Flannery Bolt Company, Pittsburgh, Pa.
Secretary—George B. Boyce, A. M. Castle & Company, 91 Connecticut street, Seattle, Wash.
Treasurer—Stephen F. Sullivan, Ewald Iron Company, Chicago, Ill.

### Master Boiler Makers' Association

President—Charles P. Patrick, Mgr., Chicago, Wilson Welding Repair Company, Chicago, Ill.
First Vice-President—Thomas Lewis, general B. I., L. V. System, Sayre, Pa.
Second Vice-President—T. P. Madden, general B. I., M. P. R. R., 6947 Clayton avenue, St. Louis, Mo.
Third Vice-President—E. W. Young, general B. I., C. M. & St. P. R. R., 81 Caledonia Pl., Dubuque, Iowa.
Fourth Vice-President—Frank Gray, G. F. B. M., C. & A. R. R., 705 West Mulberry street, Bloomington, Ill.
Fifth Vice-President—Thomas F. Powers, System G. F., Boiler Dept., C. & N. W. R. R., 1129 Clarence avenue, Oak Park, Ill.
Secretary—Harry D. Vought, 26 Cortlandt street, New York City.
Treasurer—W. H. Laughridge, G. F. B. M., Hocking Valley Railroad, 537 Linwood avenue, Columbus, Ohio.
Executive Board—John F. Raps, general B. I., C. R. R., 4041 Ellis avenue, Chicago, Ill., chairman.

## TRADE PUBLICATIONS

Iron Workers Tools.—The Scully Steel and Iron Company, Chicago, is sending out a somewhat elaborate pamphlet showing iron workers' tools for hand and pneumatic work. The tools are made especially for boiler makers and iron workers and include hammers, sledges, chisels, punches, rivet snaps, side sets, calking tools, drift pins, rippers, beading tools and the like. This pamphlet will be sent to any one upon request.

Sprague Electric Dynamometers.—The Sprague Electric Works, New York, has published a well illustrated circular describing the construction, control and application of the research type of the Sprague electric dynamometer which is a highly accurate and easily operable apparatus for the measure of torque or power.

New Quigley Pulverized Fuel Bulletin.—A new bulletin on the Quigley Fuel Systems, comprising methods of preparing, transporting and burning of pulverized fuels has just been published by the Hardinge Company, 120 Broadway, New York. This bulletin is known as No. 12 and treats the subject of pulverized fuels in a manner never before attempted. One of its distinguishing features is the fact that emphasis is laid upon the methods employed to properly prepare and burn the powdered coal, rather than occupying most of the space discussing the pulverizer. Aside from complete plant layouts, what the manufacturers term as a "Unit Milling Plant" is described. This layout is radically different from anything ever before developed. The System comprises a method of pulverizing and transporting the coal to one or more furnaces in the same locality, at the same time securing positive regulation and continuous operation over extended periods. The cost of this unit is but a fraction of that of the larger Systems where the coal must be transported several hundred feet to a number of furnaces. The range of capacity for the complete pulverized fuel plants is extreme.

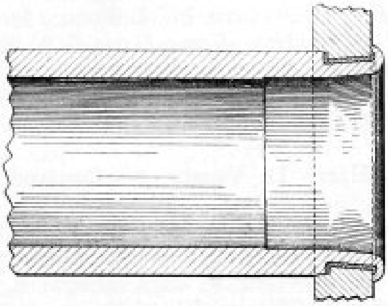
# SELECTED BOILER PATENTS

Compiled by
GEORGE A. HUTCHINSON, Patent Attorney,
Washington Loan and Trust Building,
Washington, D. C.

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

1,340,118. BOILER TUBE AND END PLATE CONNECTION. CHARLES S. COLEMAN, OF LOS ANGELES, CALIFORNIA, ASSIGNOR TO THE COLEMAN BOILER APPLIANCE COMPANY, OF LOS ANGELES, CALIFORNIA, A CORPORATION OF DELAWARE.

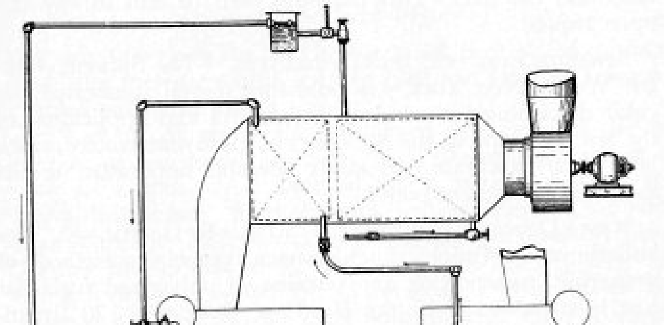
*Claim* 1.—The combination with a tube sheet having an opening of differential diameters to form an annular shoulder between the ends of the opening, the side walls of the opening on opposite sides of the shoulder being beveled outwardly forming oppositely inclined walls, of a soft metal gasket comprising a cylinder having a flange on one end adapted to seat, on



the shoulder, said gasket formed to conform to the outer inclined wall of the opening and beaded over the margin of the latter, and a tube point having a reduced portion at its outer end, the same terminating in a shoulder adapted to seat on the flange of the gasket and having a beveled wall conforming to the inner beveled wall of the opening, the outer end of said tube being turned outward against the gasket and beaded over the outer end of the latter. 5 Claims.

1,393,445. STEAM BOILER ECONOMIZER SYSTEM. DAVID S. JACOBUS, OF JERSEY CITY, NEW JERSEY, ASSIGNOR TO THE BABCOCK & WILCOX COMPANY, OF BAYONNE, NEW JERSEY. A CORPORATION OF NEW JERSEY.

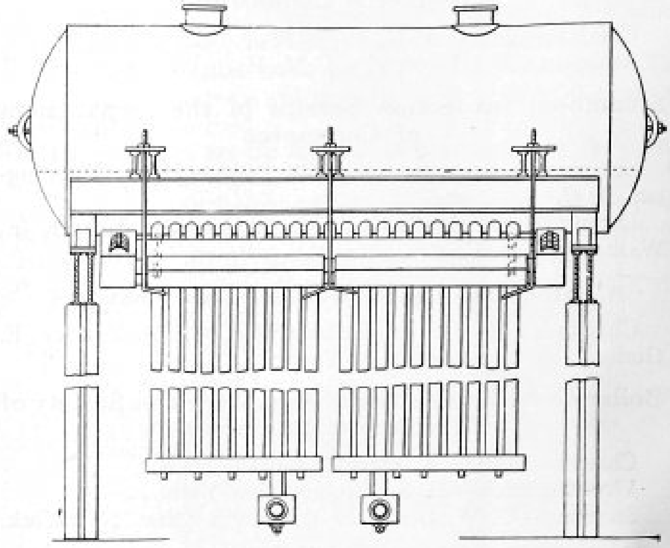
*Claim* 1.—In combination, a plurality of boilers, a plurality of economizers each having high and low pressure sections, means for maintaining the water in the sections of each economizer at different pressures, individual



tanks arranged to permit the escape of air or gas from the water and serving as detectors to indicate the formation of steam, means for conducting the water heated in the low pressure sections to said tanks, a common tank and means for conducting the water from said individual tanks to said common tank, and means for distributing the water from said common tank to the several high pressure sections of the economizers and from the latter to the boilers. Fourteen claims.

1,384,657. BOILER CONSTRUCTION. GEORGE C. BAKER, OF BAYONNE, NEW JERSEY.

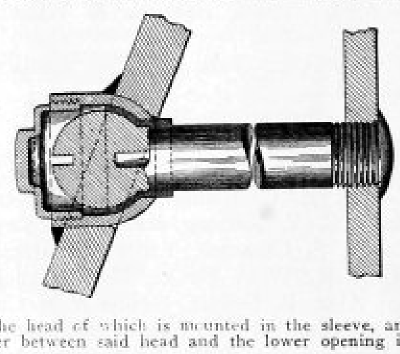
*Claim* 1.—A boiler including a frame structure, a drum carried by the frame structure, vertically extending water tubes positioned in the frame upon opposite sides of the drum and arranged in front and rear sets, lower water heads communicating with the tubes and arranged in front and rear sets, conduit means communicating with the lower water heads



for delivering water from the rear sets of water heads to the forward sets of water heads and provided with outlet means for withdrawal of water from the boiler, upper water heads communicating with the tubes and arranged in front and rear sets, and conduits communicating with the upper water heads and with the drum whereby water may pass from the upper front set of water heads to the drum and from the drum to the upper rear set of water heads of the rear tubes. Two claims.

1,342,162. STAYBOLT. JOHN ROGERS FLANNERY AND ETHAN I. DODDS, OF PITTSBURGH, PENNSYLVANIA, ASSIGNORS TO FLANNERY BOLT COMPANY, OF PITTSBURGH, PENNSYLVANIA.

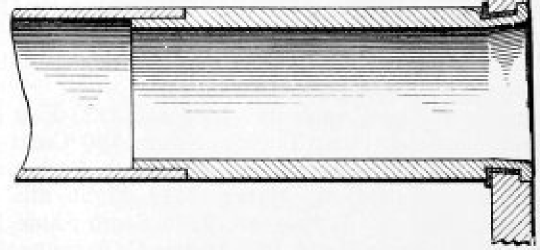
*Claim* 1.—In a staybolt structure, the combination of inner and outer sheets, a sleeve secured to the outer sheet and having a curved seat, a flexi-



ble stay bolt the head of which is mounted in the sleeve, and a destructible spacing member between said head and the lower opening in the sleeve. 3 Claims.

1,397,080. BOILER TUBE AND END PLATE CONNECTION. CHARLES S. COLEMAN, OF LOS ANGELES, CALIFORNIA.

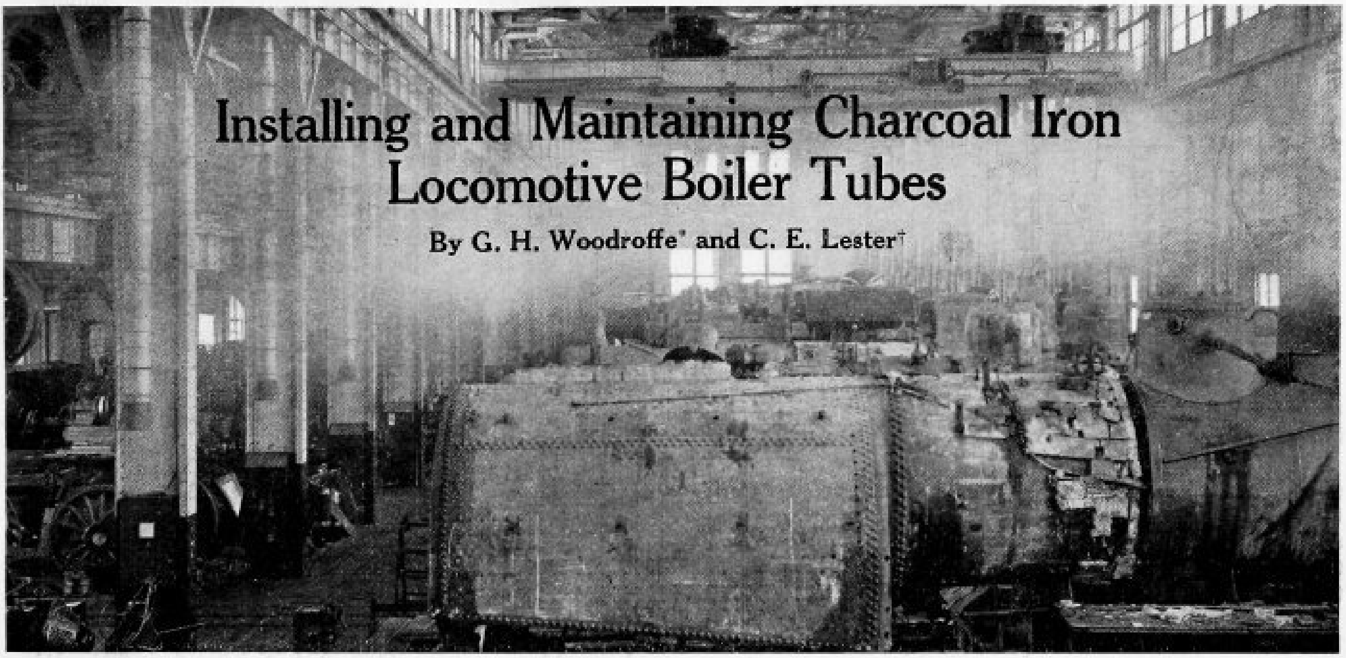
*Claim* 1.—In a boiler tube and end plate connection, a boiler end plate formed with a circular opening having a counterbore on its outer marginal edge forming a counter-sunk shoulder, an annular gasket extending around the portion of the wall of the opening between the shoulder and the inner



face of the end plate with its inner end terminating at the shoulder and positioned intermediate the faces of the end plate, and a tube end section projecting through said gasket from the inner face of said boiler end plate and having its outer end beaded over the end of the gasket onto the shoulder and filling said counterbore whereby the outer end of the gasket is covered by the bead at a point between the inner and outer faces of the boiler end plate. Four claims.

# The Boiler Maker

MARCH, 1922

# Installing and Maintaining Charcoal Iron Locomotive Boiler Tubes


By G. H. Woodroffe* and C. E. Lester†


THERE is a correct way to apply a boiler tube, and an incorrect way. With certain tools the necessary operations may be performed efficiently, with minimum time and labor costs. Done with tools less suited to the work, the application is not only unsatisfactory but the service life of the tubes is materially shortened.

In the interest of better tube service and lower tube costs we have prepared the following recommendations for the application and maintenance of charcoal iron boiler tubes, arch tubes and superheater flues. From the standard practices of a number of railroads we have taken what we believe to be the best and have incorporated it in this recommended practice. In this work we have been guided by the suggestions of practical railroad men, whose cheerful assistance and valuable co-operation are gratefully acknowledged. Methods of applying boiler tubes, and the tools employed, vary considerably on the different railroads. Whatever the procedure the various operations must be performed with care and thoroughness. The tools used must be properly maintained.

*In the 65,000 locomotives on American railroads, there are approximately 15,000,000 boiler tubes. Every year 2,750,000 tubes pit, corrode or otherwise become unfit for service and have to be removed and replaced. All boiler tubes, even those giving satisfactory service, must be taken out, inspected, safe ended, reapplied or replaced after four years' continuous service. The tube problem, an important one on any road, varies with feed water conditions and the service life of the tube used. Feed water difficulties are local ones, met by individual study and various expedients. Tube service life, while affected by feed water, depends largely on the character and quality of the tube itself and the degree of care and skill with which the tube is applied and maintained.*—The Authors.

Tubes should be made tight in the flue sheet with the least possible working. Once a tube is really tight, excessive working will not make it more secure. On the contrary, it will injure the metal and adversely affect the service life of the tube, making early renewal necessary.

A roller expander is not recommended for use on the firebox end of tubes, except possibly for a light finishing hand operation. The roller crushes the metal of the tube, thinning it out and reducing its resistance to the demands imposed by service.*

### Application of Body Tubes

*Preparation of Back Tube Sheets* — Holes for body tubes in the back tube sheet should be the same diameter as the outside diameter of the tube, both edges being rounded to a radius of 1/16 inch.

*Preparation of Front Tube Sheets*—Holes in the front tube sheet should be 1/16 inch larger than the outside diameter of the tube except that two holes, 5/16 inch larger than the outside diameter of the tube should be left about 12 inches above the bottom row of tubes in the center, in order to facilitate the removal of badly scaled tubes. All holes should be clean and the outside edges rounded to a radius of 1/16 inch.

Note.—Copyright by the Parkesburg Iron Company. This suggested practice will be published in book form later and is subject to revision.

*Mechanical Engineer, The Parkesburg Iron Company.

†Formerly General Superintendent, 19th Division, Transportation Corps, A. E. F., and Superintendent of Nievre Locomotive and Car Shops.

*The word tubes, used in the following pages, refers to body tubes. By flues are meant "superheater tubes or flues."

Ferrules for boiler tubes should be soft copper, 1/32 inch longer than the thickness of the back tube sheet.

Ferrules must be of the same outside diameter as the tube and should be 0.0625 (1/16 inch), 0.08 and 0.09 inch thick. For new work, ferrules should be 1/16 inch thick, the heavier copper being used after the tube holes have become enlarged through service. This practice permits the use of a standard swage. Copper ferrules may be softened by annealing.

*Reaming Tube Holes*—When a firebox sheet tube hole becomes ⅛ inch out of round, ream it with a straight

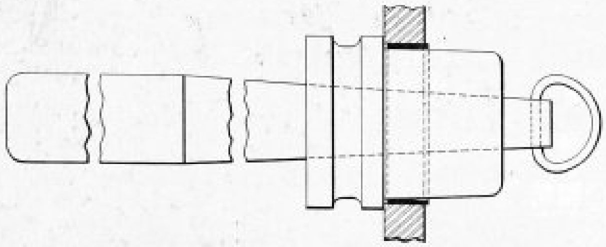


**Fig. 2.—Setting Copper Ferrule in Tube Sheet**

reamer. When it becomes enlarged through service to 3/16 inch above outside diameter of tube, scrap the sheet.

*Preparation of Firebox End of Tubes*—Swage the firebox end of the tube with a slight taper toward the end of the tube to ⅛ inch less than the outside diameter of the tube, so as to drive snugly in the ferrule after the ferrule has been tightened in the sheet. Length of swaged end should be the thickness of the tube sheet plus ¼ inch.

*Preparation of Front End of Tubes*—Cut tubes to length. The front ends should be expanded hot, to such a size that when placed in the boiler they can be driven snug in the front tube sheet. This should not be done to tubes that are to be transferred (put through one hole and set in a different location) in the boiler.

The ends of the two tubes that are to be placed in the enlarged holes may either be expanded hot to the required diameter or have a piece of tube of larger size, 12 inches long welded on.

*Setting Ferrules*—Place ferrules in the tube holes in the firebox sheet, 1/32 inch from the fire side. Tighten with

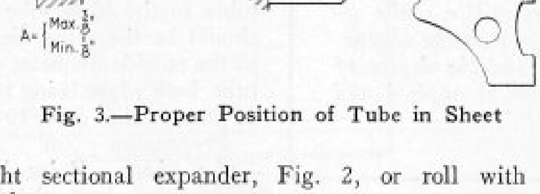


**Fig. 3.—Proper Position of Tube in Sheet**

straight sectional expander, Fig. 2, or roll with roller expander.

*Placing Tubes*—Clean the firebox ends of the tubes and place them in the tube holes in the firebox sheet, fitting them neatly into the copper ferrules.

Be careful not to injure or displace the ferrules.

Tubes should project through the firebox sheet 3/16 inch, as measured by the gage, Fig. 3. The projection through the front tube sheet should be ¼ inch. It must not be less than ⅛ inch nor more than ⅜ inch.

*Tightening Tube in Sheet*—Tighten tubes in the firebox sheet with a straight sectional expander, Fig. 4.

*Tightening Front End of Tubes*—Next tighten the front end of the tube with a standard roller expander.

*Flaring Tubes, Preparatory to Beading*—The firebox end of all tubes, and on superheater engines the front ends of the two rows of tubes just below the superheater flues and all tubes above these two rows, should be opened with a flaring tool, Fig. 6. Use a long stroke pneumatic hammer.

*Expanding with Lipped Sectional Expander*—Expand the firebox ends of the tubes with the lipped sectional expander shown in Fig. 7. Drive the expander pin lightly until it is fairly solid. Draw out the pin. Give the expander a turn equal to half a section of the expander. Drive the pin a second time. Withdraw it, and turn the expander a distance equal to one-quarter of a section. Drive the pin a third time. Care should be exercised in the use of the expander in the outer rows of tubes near the heel of the flange to avoid cracking the sheet. Use a long stroke Boyer No. 60 pneumatic hammer (a heavier hammer is not recommended) in driving the pin or its equivalent.

*Inspection for Split Tubes*—After expanding, examine the tubes carefully. Those which have split in the shoulder formed by the lip of the expander, and tubes that have opened from the end back to the sheet, should be removed and replaced before beading.

*Opening Front End of Tubes*—If the front end of the tube has not been opened hot before placing in the boiler,

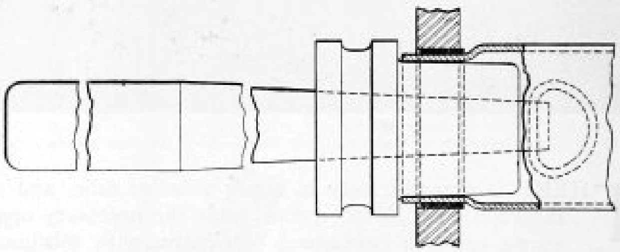


**Fig. 4.—Method of Tightening Tube in Back Tube Sheet**

a straight sectional expander should be used to tighten the tube in the sheet. The tube may then be rolled with a standard roller expander.

If the finger type roller expander is used, the use of the straight sectional expander is not required.

*Beading*—Firebox ends of all tubes must be beaded, Fig 9. Use a short stroke pneumatic hammer. Take care that nothing enters between the bead and the tube sheet. In superheater locomotives the front ends of the two rows of tubes just below the lower row of superheater flues and all tubes above these rows must be beaded similarly.

Hold the beading tool so as to give the bead an outward set and get it down to the sheet without raising a burr on the inside or marking the outside of the sheet with the heel of the beading tool. The center line of the beading tool should always be inside the line of the tube. Remove any burrs that may be raised with a small chisel and hand hammer. If necessary, the firebox ends of the tubes may be rolled lightly after beading.

*Tools*—All beading tools must be maintained within the limits of standard gages. Lipped expanders should be stamped to show the thickness of sheet on which they are to be used and should be taken out of service when worn or distorted to such an extent that they will not force the tube squarely against the sheet.

### Application of Superheater Flues

*Preparation of Back Tube Sheet*—Holes for superheater flues in the back tube sheet should be 4⅝ inches, both edges being rounded to a radius of 1/16 inch.

*Preparation of Front Tube Sheet*—Holes in the front tube sheet should be 3/32 inch larger than the outside diameter of the flue and the outside edges should be rounded to a radius of 1/16 inch.

*Copper Ferrules*—Ferrules must be made of soft copper, 1/32 inch longer than the thickness of the tube sheet. Ferrules must be of the same outside diameter as the holes in

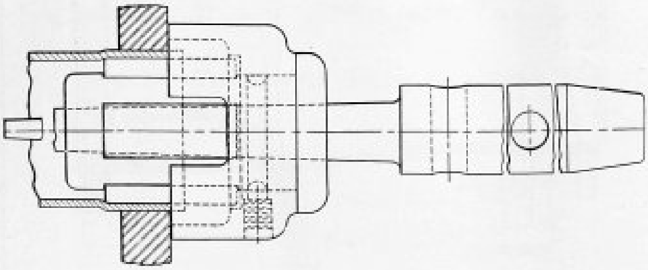


**Fig. 5.—Rolling the Tube in the Front Tube Sheet**

the tube sheet and should be 0.0625, 0.08 and 0.09 inch thick. For new work, use ferrules 1/16 inch thick, the heavier copper being used after the holes become enlarged through service.

*Preparation of Firebox Ends of Flues*—Firebox ends of flues should be swaged to a diameter of 4½ inches. The straight portion should be 5 inches and the tapered portion 3 inches long, as in Fig. 10. Remove all scale and burrs before placing the ends in the tube sheet.

*Preparation of Front End of Flues*—Cut flue to length. Expand front end, hot, to a diameter 1/16 inch greater than the outside diameter of the flue, as in Fig. 10.

*Setting Ferrule*—Place the ferrules in the flue holes in the back tube sheet 1/32 inch from the fire side and tighten with the roller expander, Fig. 11.

*Placing Flue*—Place flues in the holes in the back-tube sheet, fitting them neatly into the copper ferrules. In placing flues, be careful not to displace copper ferrules. Flues should project through both sheets ¼ inch to allow for beading, Fig. 10.

*Rolling Flue in Back Tube Sheet*—Tighten flues in the

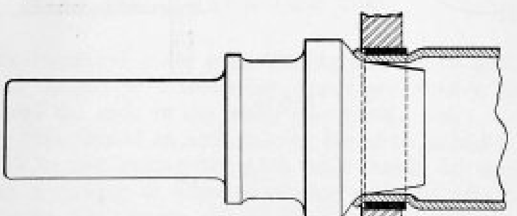


**Fig. 6.—Method of Flaring Tubes**

back tube sheet with a roller expander. The roller expander shall have not less than 5 rollers, Fig. 12.

*Flaring Flues in Back Tube Sheet*—A flaring tool, because of its size and weight and the force necessary to drive it, is not recommended for superheater flues. Superheater flues should be flared by a four-pound peining hammer.

*Expanding Flues in Back Tube Sheet*—Expand firebox ends of flues with lipped sectional expander of not less than 12 segments, Fig. 13.

Drive the expander pin until it is fairly solid. Draw out the pin and give the expander a turn equal to one-half of a section of the expander. Drive the pin a second time. Withdraw it. Turn expander a distance equal to one-quarter of a section. Drive the pin a third time. Use a long stroke pneumatic hammer in driving the pin.

*Rolling Front Ends of Flues*—Tighten the front ends of flues with a roller expander, Fig. 14.

*Flaring Front Ends of Flues*—A flaring tool, because of its size and weight and the force necessary to drive it, is not recommended for front ends of flues. Front ends of flues should be flared by careful blows of a four-pound peining hammer.

*Beading Superheater Flues*—Bead the flues at both ends, Fig. 15, using a short stroke pneumatic hammer. Take care to see that nothing enters between the bead and the sheet. Hold the beading tool so as to give the bead an outward set and get it down to the sheet without raising a burr on the inside, or marking the sheet with the heel of the tool on the outside. The center line of the beading tool should al-

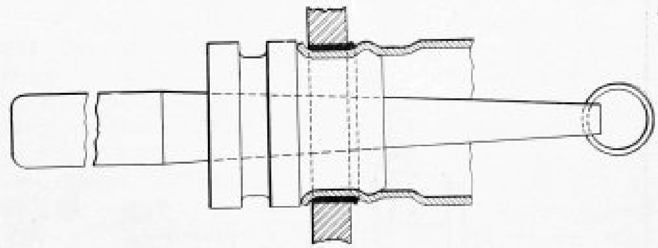


**Fig. 7.—Lipped Sectional Expander Used to Expand the Firebox End of Tubes**

ways be inside the line of the flue. Remove any burrs that may be raised with a small chisel and hand hammer.

*Tools*—All beading tools must be maintained within the limits of standard gages. Lipped expanders should be stamped to show the thickness of sheet on which they are to be used and should be taken out of service when worn or distorted to such an extent that they will not force the tube squarely against the sheet.

## Application of Arch Tubes

*Preparation of Sheet*—Sheets must be properly straightened. Holes for arch tubes must be circular and drilled 1/32 inch larger than the outside diameter of the arch tube. Outside edges should be rounded to a radius of 1/16 inch.

If the arch tube hole has become enlarged above normal size in service, measure it carefully, so that the tube can be heated and enlarged to fit the hole snugly before being applied. If this is not possible a copper ferrule may be used extending ¼ inch on the water side and flush with fire side of the sheet.

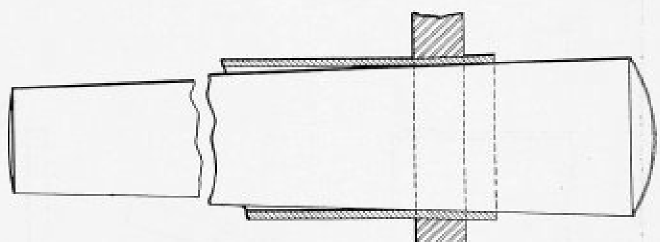


**Fig. 8.—Pinning Out the Front End of a Tube**

*Preparation of Arch Tubes for Setting*—Cut arch tubes to proper length, with an allowance of ½ inch at either end for flaring. They should be smooth at the ends and free from burrs. They should be formed in accordance with drawings for the various classes of locomotives. Particular attention should be given to bending, in order to prevent the formation of steam pockets in service due to improper bends to make certain that the arch tubes enter the sheets at an angle of

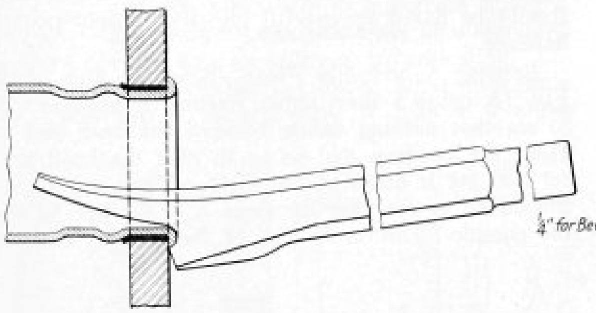


FIG. 9

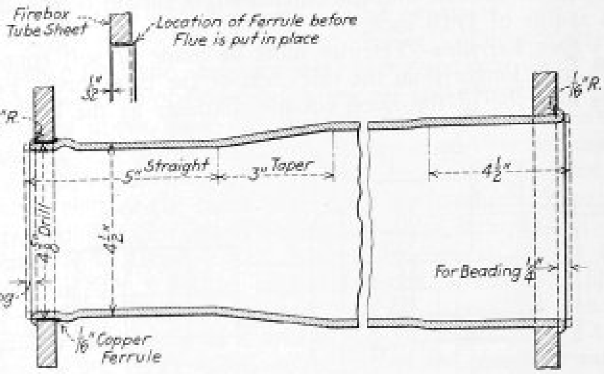



FIG. 10

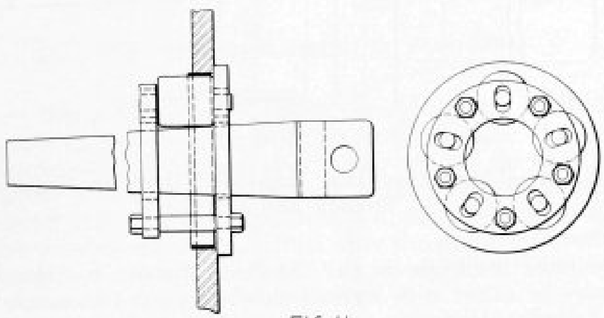


FIG. 11

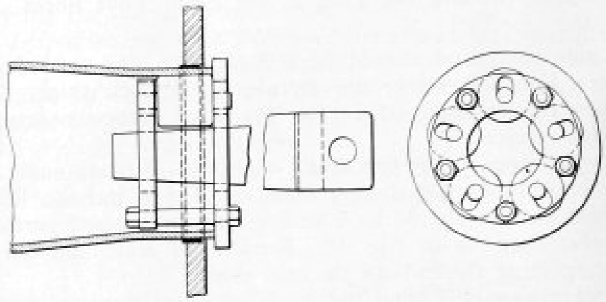


FIG. 12

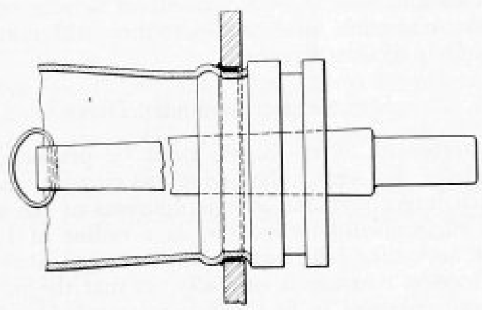


FIG. 13

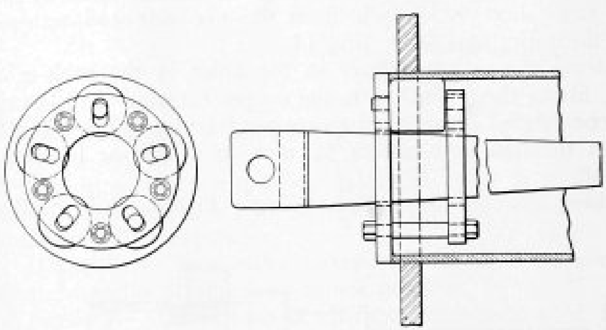


FIG. 14

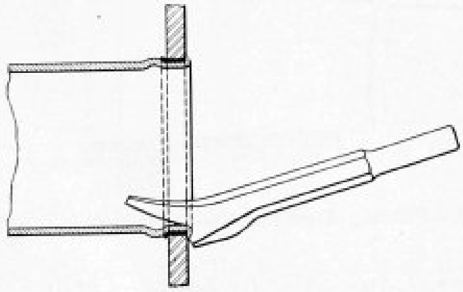


FIG. 15

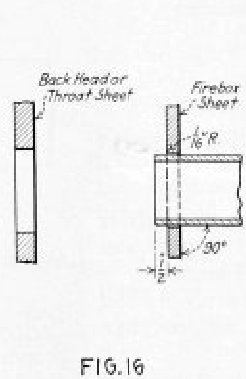



FIG. 16

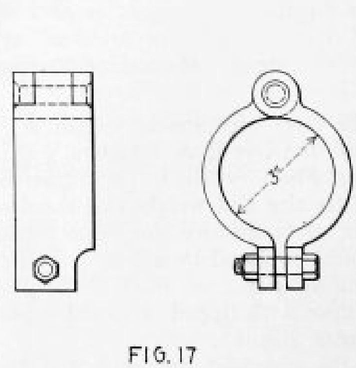



FIG. 17

**Fig. 9.—Beading Tubes. Fig. 10.—Correct Application of Superheater Flues. Fig. 11.—Setting Ferrules. Fig. 12.—Setting Superheater Flues. Fig. 13.—Expanding Flues. Fig. 14.—Rolling the Front End of Flues. Fig. 15.—Beading Large Flues. Fig. 16.—Proper Position of Arch Tubes Entering Firebox Sheet. Fig. 17.—Arch Tube Clamp**

90 degrees, Fig. 16, and to avoid flattening which would not only weaken the tube but might cause an obstruction and keep the turbine cleaner from going through.

*Setting of Arch Tubes*—Arch tubes should be set in position, the proper amount projecting through the sheet for flaring and held with a clamp similar to Fig. 17.

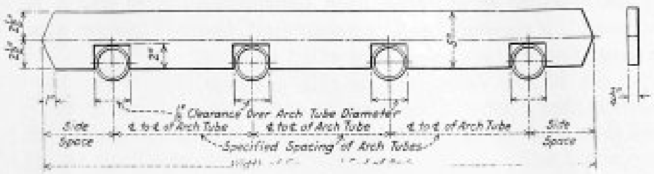



Fig. 18.—Template for Gaging Arch Tubes

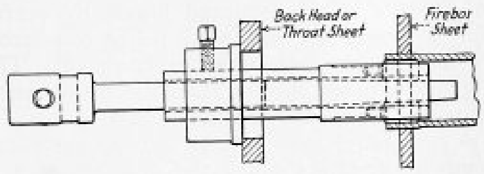



Fig. 19.—Clamping Device for Arch Tubes

It is recommended that a spacing gage, Fig. 18, be used to insure correct alinement of arch tubes.

*Rolling*—Arch tubes should be rolled into the firebox sheets, this operation being performed at the bottom end first. By using a collar on the housing shaft, as shown in Fig. 19, proper location of the rolls can be insured.

*Flaring*—Arch tubes should be flared on both ends. The tool shown in Fig. 20 is recommended for this operation.

*Inspection*—When the engine is in service the arch tubes should be inspected every trip. At every boiler washout the arch tubes should be washed out, bored out with a turbine cleaner, and the ends in the water space inspected.

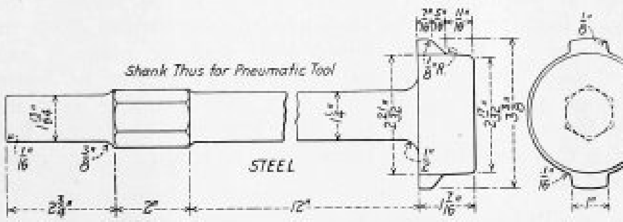



Fig. 20.—Arch Tube Tool

At any time should an arch tube be found to have a pocket, or warped to any extent, the arch tube should be removed. Whenever a clinker or other substance is found attached to an arch tube the clinker should be removed and a careful inspection made of both the outside and inside of the tube.

# Results of Testing Bare and Coated Welding Electrodes

In a comparative test of bare and coated welding electrodes, recently conducted in an industrial plant, a material increase in the amount of metal deposited per unit of power consumption and per unit of time, together with a marked decrease in the percentage loss of metal were found to accompany the use of coated electrodes.

The first two tests consisted of welding together two pieces of ⅜-in. tank steel plates the edges of which had been beveled to facilitate the welding. In the first test 5/32-in. bare electrodes were compared with 5/32-in. coated electrodes of two grades, designated as No. 1 and No. 6. In the second test ¼-in. electrodes were used. A third test was made using 5/32-in. coated electrodes in welding together two pieces of cast iron plate. In each case the plates and the wire were weighed before and after the test on a scale weighing accurately to one-half ounce to determine the loss of metal; time was taken with a stop watch and power consumption measured by an Esterline curve drawing watt meter.

Comparisons of the two types of electrodes from the standpoint of metal deposited per hour and per kilowatt hour and the metal loss per pound deposited are set forth in the table. All of the tests show an advantage for the coated wire in the matter of metal deposited per kilowatt hour and also per unit of time. If the metal deposited by the 5/32-in. bare electrodes be considered 100 per cent, then that deposited by the 5/32-in. coated electrodes showed increases of 22 per cent for the No. 1, 69 per cent for the No. 6 on the steel plate and 43 per cent for the No. 1 on cast iron. Comparing in the same manner the ¼-in. coated electrodes used on steel plate with the ¼-in. bare electrodes, the No. 1 coated showed an increase of 10 per cent in the amount of metal deposited per unit of power consumption while the No. 6 coated electrodes showed an increase of 44 per cent.

Comparing the metal deposited per unit of time in the same manner, increases of 22 per cent and 46 per cent respectively for the No. 1 and No. 6 coated electrodes on steel plate and 42 per cent for the No. 1 electrode on cast iron, were shown as compared with 5/32-in. bare electrodes on steel plate. A similar comparison for the ¼-in. electrodes showed increases of 3 per cent and 38 per cent respectively for the No. 1 and No. 6 coated electrodes as compared with the bare electrodes, all tests being made on steel plate.

Throughout the tests it was observed that with coated electrodes there was less sputtering and throwing off of metal, that the metal flowed more evenly and uniformly, that the arc did not jump off to one side and that the operator could hold the arc for a longer time than with the bare electrodes. No loss of metal in the vapor of the arc or by sputtering could be measured for the 5/32-in. coated wire but this was probably due to the fact that the scales used were not fine enough. Observation of the tests showed that there was some loss even though the scales did not show it. The advantage of the ¼-in. wire over the 5/32-in. wire is clearly shown in the table; that is, more metal can be deposited by ¼-in. electrodes with the same power consumption.

The outstanding advantage of the coated electrodes is most clearly shown in the saving of metal lost in the arc and by sputtering and to this fact are largely due the other advantages demonstrated.

RESULTS OF COMPARATIVE TESTS OF BARE AND COATED ELECTRODES

| Test No. | Electrode | Pounds of Electrode: Lost by vapor, etc., per lb. deposited | Pounds of Electrode: Deposited per hr. | Pounds of Electrode: Deposited per kwh. | Kwh. per lb. deposited | Hours per lb. deposited |
|---|---|---|---|---|---|---|
| I | 5/32" Bare | .43 | 1.543 | .336 | 2.97 | .65 |
| I | 5/32" Coated No. 1 | .00 | 1.875 | .407 | 2.45 | .534 |
| I | 5/32" Coated No. 6 | .00 | 2.560 | .568 | 1.76 | .391 |
| II | 1/4" Bare | .38 | 2.76 | .368 | 2.72 | .362 |
| II | 1/4" Coated No. 1 | .09 | 2.85 | .405 | 2.47 | .351 |
| II | 1/4" Coated No. 6 | .00 | 3.79 | .541 | 1.85 | .264 |
| III | 5/32" Coated No. 1 | .00 | 2.19 | .481 | 2.08 | .457 |
| Average for bare electrodes | | .40 | 2.15 | .352 | 2.84 | .506 |
| Average for coated electrodes | | .018 | 2.76 | .479 | 2.12 | .384 |
| In favor of coated | | .382 lb. | .61 lb. | .127 lb. | .72 kwh. | .122 hrs. |
| Advantage of coated electrodes in per cent | | 95.5 | 28.4 | 36.1 | 24.4 | 24.1 |
| Saving in dollars per lb. deposited at 9.25 cents per lb. | | $0.0353 | .... | ... | *.... | †... |

* At 3 cents per kwh. equals $0.0216.
† At 65 cents per hr., equals $0.0793.
Total, $.1362.

# Advantages of Treating Locomotive Feed Water*

*Approximately 60,000 locomotives in this country are forced to use hard water in the boilers which causes the formation of an amount of scale in each locomotive, conservatively estimated at 1,500 pounds per year. Assuming a 5 percent fuel loss from this cause the annual coal wastage amounts to the staggering total of 15,625,000 tons a year. Railway managements in general are vitally interested in this problem, but the real work of maintenance is the boiler maker's job. One way to reduce the trouble is by the proper chemical treatment of the water as outlined below.*

In an address before the New York Railroad Club on April 20, 1917, and the Western Society of Engineers at Chicago, on April 29, 1920, it was estimated that an average of 625,000,000,000 gallons of water are used on American railroads each year and of this amount, 450,000,000,000 gallons are used by locomotives for making steam. Following these figures a little further and taking two pounds per thousand gallons, which is a conservative average of the amount of scale usually found in water supplies, we have the total amount of 900,000,000 pounds, or 450,000 tons of scale annually going into our locomotive boilers, the greater part of which, unless removed by chemical treatment, will adhere to the tubes and sheets.

### Quality of Boiler Water

Very few good boiler waters are found naturally and the railroad is indeed fortunate where these possibly can be secured. The proper development of such supply warrants considerable expense as it assures constant good performance in boilers with the elimination of the cost and uncertainty of any treatment.

Water is secured from wells and surface supplies such as streams and lakes. The quality of the well waters varies considerably, even, at times, in wells of close proximity. The well waters as a rule are clear, but similar to the mythical purity of the sparkling spring water, this clearness in most cases conceals unexpected troubles in the shape of dissolved injurious, incrusting salts. Fortunately, the amount and extent of their properties can be accurately determined by short laboratory tests and it is no longer necessary in the development of new supplies to have the engineer wire back to the dispatcher from the next station that water is good and then find it necessary to renew the flues in a few months. Although the dissolved solids are low, streams at most times carry enough sediment and dirt so that there is visible evidence of portending trouble and care is taken accordingly. It is the clear waters that should warrant investigation.

The common constituents carried by water are generally known as "lime," "gyp" and "alkali." The "lime" refers to the carbonates or soft forming scale; "gyp" is applied to the sulphates or hard scale, and "alkali" to the miscellaneous dissolved salts, mainly sulphate and chloride of sodium which do not precipitate at ordinary boiler water concentration. A detailed description would involve a lengthy report in itself and is not within the province of this report.

### Treatment to Prevent Scale

A perfect boiler water is one which will allow the tubes to run the full government amount with but a white wash coating of scale, and will cause no delays to locomotives attributable to water conditions, with but minimum attention at terminals. Where impossible to obtain naturally this condition can be approximated by proper treatment as has been conclusively demonstrated. There is no question concerning the advisability of removing the scale with its corresponding trouble, chemically, thereby conserving labor and material for more important needs as well as securing the numerous attendant benefits in the improved locomotive performance.

Interior treatment by means of boiler compounds were probably the first method of water treatment. These undoubtedly accomplished efficient results in many cases. There is no "cure-all" for boiler troubles and it is usually inadvisable to put into boilers promiscuously, compounds of a secret composition except under the direction of a chemist. All compounds have the universal disadvantage of precipitating the scaling solids in the boiler and making a sludge tank out of the locomotive.

Soda ash, the commercial carbonate of sodium, is probably the most common chemical used as a scale preventive. Its action is on the "gyp" or hard scale and similar to the action of boiler compounds throws down the scale as sludge which can be blown out of the boiler. Several large western railroads have obtained remarkable results by the treatment of water in wayside tanks with this material alone and following up the results with chemical tests to see that proper amounts are used regularly. The increased flue mileage has been very marked. It has also been found a big help where used in predetermined amounts direct into boilers or engine tanks at terminals. The disadvantage is the tendency to induce foaming from the suspended matter thrown down in the boiler. It has also caused some disfavor where it has been used without chemical direction in greater or lesser amounts than necessary with the corresponding foaming troubles or lack of scale removal. However, experience has shown that very efficient results can be secured under competent direction.

### Plants Designed for Water Treating

Complete treating plants give the most efficient and satisfactory means of handling bad water propositions. In these the scale and injurious impurities are removed and settled or filtered out and a good clear, soft water given to the locomotives. The only disadvantage in this method of treatment is the high initial expenditure, but this is warranted in most cases by the large return on the investment in decreased fuel consumption, increased life of flues, staybolts and fireboxes, reduction in necessary repairs and increased availability of locomotives with the attendant improved performance.

Treatment of water for its foaming qualities is usually in the engine tank with an anti-foaming compound, which is essentially a weak acid emulsion of castor oil so prepared that it will mix uniformly with the cold water in the tank. It is prepared on some railroads by their chemical department, but in most instances, it is purchased as a proprietary compound. It is within the province of this association to call attention to the danger in the use of crude or mineral oils for this purpose on account of the large amount necessary to check foaming and the liability of formation of oil scum on the hot sheets, which is much more injurious than scale of many times the thickness and may result in bagged sheets.

In connection with water treatment as well as railroad water supply in general, it may be well to call attention to the advisability of having the responsibility for the quality

*Report to be presented at the 1922 meeting of the Master Boiler Makers' Association, to be held at the Hotel Sherman, Chicago, May 23-26. The committee which prepared this report consisted of T. P. Madden, general boiler inspector, Missouri Pacific Railroad, St. Louis, Mo., chairman; George Austin and E. W. Young.

and condition of a railroad water supply centered in one department which should work in close cooperation with the mechanical, engineering, maintenance and operating departments and so coordinate the work that the utmost advantage is taken of all conditions, and with constant and effective supervision remarkable results are assured.

### Economies Possible With Treated Water

With the advent of the heavy type of power and the large investment involved, the importance of continuous availability of the locomotives has been accentuated. The brick arch, superheater units, and front end rigging have made work on flues more difficult and requiring longer time. The advisability of so treating the water as to eliminate leaky conditions and avoid tying up this machinery, is generally recognized. Even the best of boiler work cannot eliminate engine failure on the road due to leaks, whereas experience has shown that by water treatment this is but one of the numerous advantages. Much has been said concerning the increase in foaming from the use of treated water and this argument is frequently advanced against such improvements. By proper treatment of the water in a correctly designed softening plant there is but little if any increase in foaming tendency while with compound of soda ash treatment, this tendency can be minimized by judicious use of blow-off cocks without detriment to the performance of the locomotive. Attention is often called to the evident fuel loss from hot water wasted in blowing off, without consideration being given to the much greater saving that is being made by the removal of the insulating scale from the heating surfaces, which far outweighs the slight blow-off loss, in addition to making the large boiler maintenance savings.

### Questionnaire on Water Treatment

A questionnaire was submitted by the committee to the general boiler inspectors of the leading railroads and 10 answers were received covering experience and results on most of the territory in this country with the exception of the southeastern section. It appears that the northeastern section is not greatly troubled with water quality, but in the central and western sections waters of extremely bad quality for boiler purposes are frequently encountered and treatment has been applied with good results.

The following is a list of the questions submitted with a summary of the answers immediately following the respective questions:

Q.—Do you use treated feed water in your territory; if so to what extent?

Answers show that waters are treated from occasional application of compounds to as high as 50 percent of regular treatment. There are 125 complete on the Santa Fe, 78 on the Great Northern, 73 on the Missouri Pacific, while some roads have occasional plants and others have complete equipped engine districts.

Q.—Do you treat feed water to prevent formation of scale, corrosion, or foaming?

This developed that in most cases water was treated to remove the scale and in some instances corrosion. Four of the 10 reported all three.

Q.—Is treatment applied to wayside tanks or by direct injection into boilers?

Where water is handled by the complete treatment, this is done in wayside tanks. In some cases of well developed soda ash treatments the chemical is added to wayside tanks. The Chicago, Burlington and Quincy has about 50 percent of its water treated by this method; the Wabash, 118 plants, and development is under way on the Frisco and Alton. Some compounds are applied direct to engine tanks immediately after washouts and others to the engine tanks. In some cases soda ash treatment is handled in a similar manner.

Q.—Do you find that water treatment increases or decreases the mileage between washouts?

Eight of the 10 replies indicated an increase while two advised no change. Where muddy water is treated or soft scaling waters there should be an increase in mileage. Where very heavy "gyp" waters are softened with soda ash or compounds the alkali salts are increased to such extent that more frequent washouts are required unless care is taken in blowing off.

Q.—What, if any, has been the increased life of flues, staybolts, and fireboxes since treated water has been adopted by the railroads?

This increase varies from 15 to 300 percent, depending on the character of the raw water. It appears that by proper treatment of the water no difficulty is encountered in obtaining the full government allowance in the life of flues, and in cases where but 8 to 12 months life was formerly secured the increase to three and four years makes a very considerable showing.

Q.—Do you notice any increase or decrease in the pitting of flues or boiler plates since the adoption of treated water?

The answer to this question showed some variation and it would appear that considerable pitting is being encountered. However, on the railroads where complete plants have been installed throughout entire engine districts, we are advised that the decrease in pitting has been very marked.

Q.—Do you notice any increase or decrease in the deposits of scale on the heating surface and do you get the impression that the general performance of the locomotive is better or worse on account of the use of treated water?

The replies were all in accord in advising of a marked decrease in scale deposits and better performance of the locomotives. In complete plants the scale should be practically removed before the water is delivered to the boilers if plants are properly operated, so that in such cases a marked decrease is assured. With soda ash treatment a large part of the scale is precipitated as mud and is blown out so that it will not show up on the tubes and sheets. Advice in one case of compound treatment was that scale was much thinner but harder and more difficult to remove. The only case of no improvement in locomotive performance was where treatment caused increase in foaming tendency of the water.

Q.—What are the benefits as well as injuries from using soda ash direct through the tank of locomotives?

The use of soda ash is a cheap method of reducing the scale troubles and where properly used in correct amounts will greatly decrease scale deposits. However, it has the disadvantage of leaving sludge in the tank and accentuating the foaming tendency of the water with the corresponding complaints from engine crews.

Q.—Have you any experience with mechanical devices for purifying boiler feed waters, either before or after they are taken into the tenders?

No experience given.

Q.—To what extent, if any, does the use of treated water decrease the time of locomotives at terminals?

The use of properly treated water materially reduces the time of engines at terminals in direct proportion to the decrease in leaky conditions with the elimination of the calking and other boiler repairs. This, of course, varies with the quality of the raw waters and makes a large saving in some instances while others are not so marked. Where an increase is obtained in mileage between washouts, this is an additional factor.

Q.—What is the approximate cost of treating water per thousand gallons by methods employed on your line?

Replies showed a variation of from two to 14 cents, but costs were not based upon the same conditions. A chemical analysis of the water will show the amount of chemicals necessary for treatment and the cost can then be readily calculated for individual points from current market prices.

Q.—Will the saving, if any, in cost of boiler repairs due to the use of treated water more than offset the cost of treatment?

The replies where full treatment or soda ash was used were in accord that the saving would much more than offset the cost of treatment, estimates being as high as 200 percent. In two cases where compounds were in use there appeared to be some question.

Q.—Are your locomotives equipped with blow-off cocks; if so, how many and where located?

Number of blow-off cocks varied from one to three. The favorite location appeared to be on each side near the front mud ring corner. However, several were located in the throat sheet and two in the R. B. corner connected with perforated pipe along mud ring.

Q.—What are your instructions to engineers and others in regard to use of blow-off cocks?

The instructions as a rule called for short and frequent blow-off while on the road with longer periods at terminals. Long blow-offs should be avoided. Blow-off cocks should not be used while injectors are working and preferably while the throttle is closed.

Q.—Are blow-off cocks used while on the road and at terminals?

Replies indicated both are desirable and generally in effect.

Q.—What provisions have been made on your road and at the terminals in the way of blow-off boxes or otherwise to facilitate the use of blow-off cocks?

Many terminals have been equipped with blow-off boxes while convenient locations only are selected for blowing off on the road.

Q.—Are the operating devices of the blow-off cocks so arranged that they can be operated from the cab?

It was generally agreed that this feature was very desirable and had been put into effect in many cases. The tendency appears to be to make such connections.

Q.—Does the use of treated water increase or decrease injector and boiler valve trouble?

There was some variation in the replies to this question, some advising increase and others decrease. In cases where water is properly treated throughout an entire engine district there appears to be a decrease in injector trouble. Where water is improperly treated or raw and treated water is mixed, as well as in the case of straight soda ash treatment, there seems to be an increase of this trouble.

# Principles of Riveted Joint Design—IX

## Hammer-Welding Seams for Boiler and Tank Work and Description of Welding Machine

**By William C. Strott***

The foregoing treatise covering the theory and design of riveted joints would not be complete without a few remarks bearing on the method of joining the edges of plates in cylindrical vessels by means of the hammer welding process.

Hammer welded seams are made in somewhat the following manner: A sheet of steel plate, after being beveled at abutting edges, as shown in Fig. 56 (a), is rolled in the usual plate bending machine to a cylindrical form and the abutting edges of plate brought in contact as per Fig. 56 (b). The shell is now placed on a special carriage designed to handle the shell through succeeding operations. The shell is placed on the carriage so that the longitudinal seam will be directly at the top and be true to the center line of the carriage. The carriage moves on ordinary steel rails and is driven through a rack and pinion at the center of the track.

One end of the shell is now run over a long steel horn so that the overlapping edges of the seam come directly over an anvil attached to the extreme end of this horn. About two feet in front of the anvil are suspended a pair of specially designed gas burners, one above and the other directly below the spot to be welded. These burners are of comparatively large size, having cast iron bodies and fire brick linings, the burner brick has an opening on the outer face, about 3/4 inch wide by about 10 inches in length, through which the flame is ejected. The fuel employed in this process is water gas and is generated on the premises. Such a plant is of course also equipped with a gas holder of generous capacity, for the purpose of maintaining a reserve supply of fuel and also to feed the various burners throughout the plant with gas at a constant and uniform pressure.

Thus, two powerful jets of flame, one above and one below the seam, having a temperature of about 3,300 degrees F., are caused to impinge simultaneously upon both upper and lower sides of the lap and the plates are quickly brought to the proper welding temperature.

A compressed-air hammer, operated by levers from an elevated platform, is permanently fixed on a beam track directly over the anvil and on the instant that a portion of the seam has reached the correct temperature, it is run over the anvil and by rapid blows from the air hammer, that portion of the seam is carefully welded together.

The circular seams are welded by a similar process, although the design of the supporting carriage and also the welding rig are necessarily somewhat different owing to the difference in the method of handling such seams. In this case, the carriage is equipped with motor driven rollers, on which the shell rests, and by means of which the latter is caused to roll circumferentially instead of moving lengthwise as is the case for the longitudinal seams.

Before the heads are welded on, the shell is placed in a proving press, where it is subjected to an hydraulic pressure test far in excess of the actual required working pressure of the vessel. Such a test will evidently disclose any leaks or weaknesses in the weld.

After the vessel has been completely welded up, it is placed in an annealing furnace which process restores the metal in the joint to its original strength.

### Hammer Welding and Autogenous Welding

Hammer welding has no similarity whatever with the well known electric arc and oxy-acetylene gas welding processes. Welds made by means of these two latter named processes are illustrated in Fig. 57. Such welding simply consists in bringing the edges of the plates to a *melting* temperature and literally flowing the metal together by fusing a filler of the

*Engineering department of The Koppers Company, Pittsburgh, Pa.; formerly designer, Blaw-Knox Company, Pittsburgh, Pa., and Union Iron Works, Erie, Pa.

same material into the gaps, which are formed by beveling the edges of the plates as shown in the illustration.

All such welds are left more or less brittle, with no possibility of restoring the original properties of the material by annealing. This excess brittleness is caused by an oxidation process created when the steel is brought to a fusing temperature; the carbon in the steel, mixing with the oxygen in the gas, sets up a chemical reaction resulting in a weld of practically no greater tensile strength than cast iron.

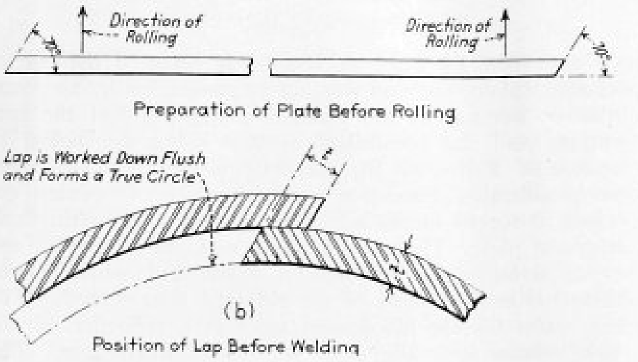



Fig. 56.—Hammer Welded Joint

This condition is not true, however, of hammered or forged welds. The chemical composition of water gas can not cause oxidation of the weld and from the fact that instead of the joint being literally fused and melted together, the overlapping edges of the plates are firmly forged into a homogeneous structure, equal in strength to that of the solid plate.

The autogenous process has its own field of usefulness, however, in which neither hammer welding nor riveting will ever be capable of competing with it, but for such portions of pressure vessels that must withstand tensile stress, welds made with the electric arc or oxy-acetylene torch should not be attempted under the present development of these processes. With regard to autogenous welding, the American Society of Mechanical Engineers' Boiler Code at present states that "it 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."

Although there has been considerable discussion recently to that effect, it is hardly probable that hammer welding will ever entirely replace riveted seam boiler construction. In the first place, the hammer welding process, by means of water gas as was here outlined, is at once an exceedingly expensive process, not only in performance of the operations required in making such welds, but also in the initial outlay involved in the construction of a plant for properly and economically handling this class of work. Not many plants are in position to do work of this kind.

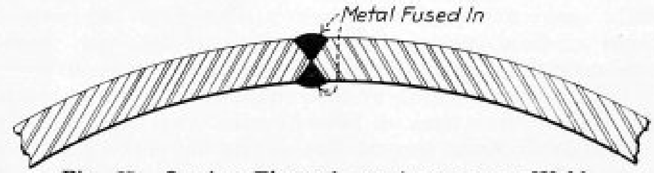



Fig. 57.—Section Through an Autogenous Weld

The American Society of Mechanical Engineers' Boiler Code has, however, recognized the entrance of hammer welding in the construction of boilers and pressure vessels. The following paragraph is reprinted from the latest edition of the Code (Edition of 1918):

"*Welded Joints:* The ultimate strength of a joint which has been properly welded by the forging process, shall be taken at 28,500 pounds per square inch with steel plates

(*Continued on page* 88)

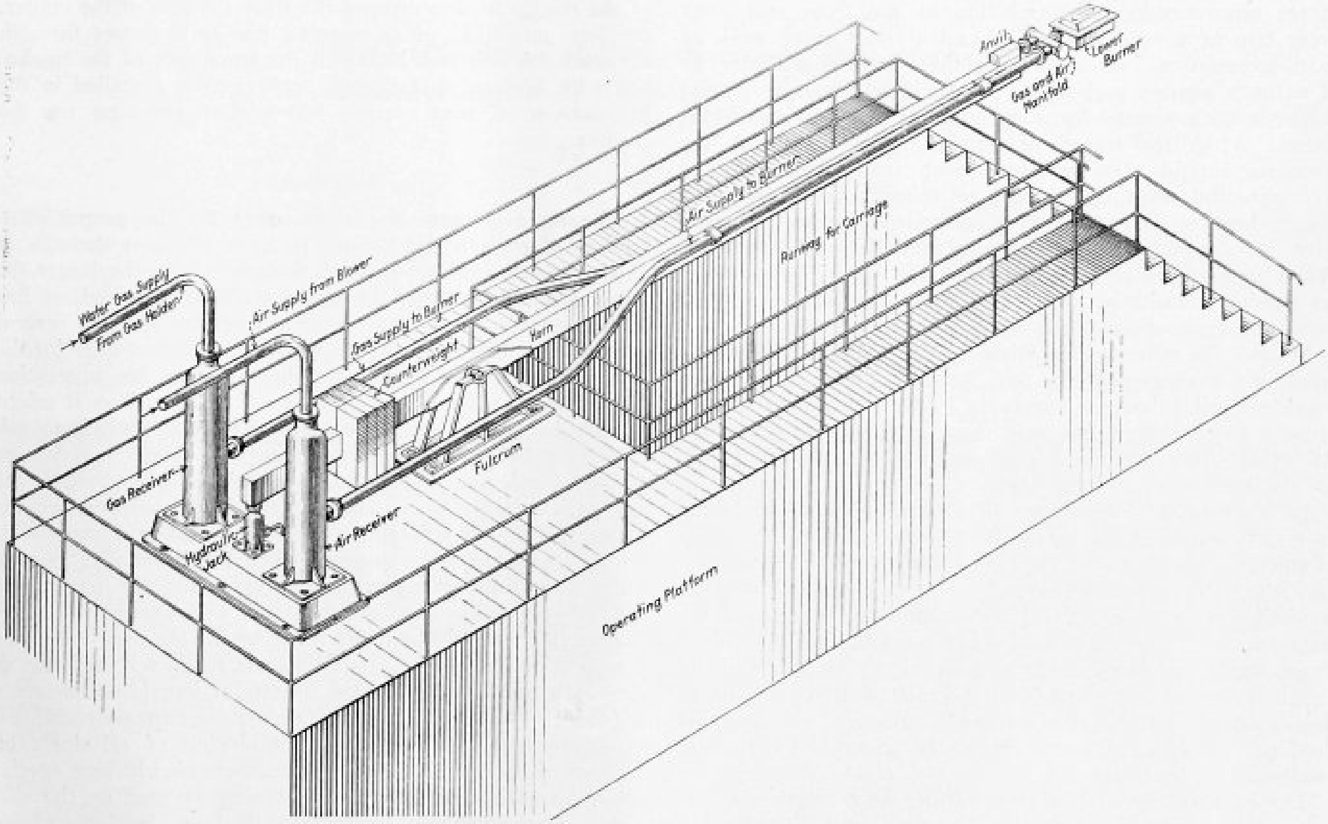



Fig. 58.—Type of Hammer Welding Machine Used for Welding Boiler Shells and for Tank Work

# Reducing Locomotive Fire Hazards

## Attention to Details of Design and Maintenance Will Eliminate a Large Portion of Fire Losses

AMONG the committee reports submitted at the eighth annual convention of the Railway Fire Protection Association held at Chicago, October 18, was one presented by E. N. Floyd (C. C. C. & St. L.), chairman. This report comprised a comprehensive discussion of the various mechanical features of locomotives with respect to their connection with the fires attributed to locomotives. Some of these constructive suggestions, if followed, would tend materially to the reduction of fires caused by locomotives.

Information procured by the committee from 58 railroads reporting with a total of 144,440 miles and approximately 40,000 locomotives, showed that during the year 1920 there were 6,006 fires attributed to sparks from locomotives. It must be borne in mind, however, that many of the fires along the right-of-way which are blamed to sparks from locomotives may have been due to other causes, such as lighted cigarettes, carelessness of trespassers, careless handling of caboose fires of trainmen, burning of old ties and disposition of waste from journal boxes.

### Front Ends

As a safeguard against the throwing of sparks, the committee recommended an inspection of the front end after every trip of a road locomotive and at least every week of yard locomotives. In order that these inspections may be of value, a written and signed record should be kept by the inspector on a printed form embodying the actual conditions found. A written record of repairs made, signed by the foreman, should also be kept. Such inspections must be thorough and must cover loose or missing bolts, rivets or hooks, bent or warped netting, corroded netting, distorted wire, etc., causing openings larger than the standard area. When repairs are necessary the netting should be renewed, no patches should be allowed as they are liable to work loose and make poor joints with the original netting.

Most of the railroads reporting used the Master Mechanic's front end arrangement on coal burning locomotives. This spark arresting device, if properly installed and maintained, appears to give as efficient results as any now on the market. At present, however, there is no uniformity as to the details of installation, maintenance, etc.

It is of prime importance to secure tight fitting joints, especially where the angle iron is fitted around the inside of the smokebox; where the table plates join the smokebox and where they are fitted around the steam pipes and nozzles. A band washer should be placed around the contour of the smokebox over the edge of the netting and securely bolted to the angle iron with a sufficient number of bolts to insure a tight joint. Less than half of the railroads reported using this band washer, but the feature is strongly recommended to insure a tight fit of the netting to the frame and to prevent loosening of the screen.

The manhole opening for permitting access inside of the screen should be framed with bar iron and likewise the manhole door. This door should be tightly fitted to the opening by means of bolts.

Reports indicated a variation in the size of mesh of netting and wire but for railroads using the ordinary grade of bituminous coal, a netting of two and one-half mesh to the inch, No. 11 wire, appears to be most generally used and has been found to be efficient. However, in a few instances where lignite or an exceptionally poor grade of coal is used, it is necessary to install netting as fine as four mesh to the inch with No. 14 wire. A few roads reported the use of perforated plate, but this was not recommended by the committee on account of the gradual enlargement of the perforations and the possibility of this being overlooked in inspections. Following the presentation of the report, there was considerable discussion and difference of opinion expressed in regard to the relative merits of wire netting and perforated plate. There are a number of patented front end netting screens, the outstanding feature of which is an oblongated mesh instead of the old type square mesh. The chief claim for the oblongated mesh is a reduction of the spark volume with the same or greater draft area. The committee believed that the claim was well founded but that the size of opening should be limited to 3/16 in. by ¾ in. The table plates should preferably be of solid sheet metal as the front end netting provides ample draft area. Some roads reported the use of perforated plates and netting instead of solid sheets, but their use was not recommended.

The reason for having in the front end of a locomotive, a number of devices for breaking up cinders that pass through the tubes and limiting the size of the mesh in the screen, is to reduce the size of the spark passing through and out of the stack. In this manner the finer the size of the cinder, the less possibility of it carrying fire as it passes through the stack. A cast iron lining on the front door of the smokebox with horizontal saw-tooth projections is installed in the locomotives of some roads, for further breaking up the cinders.

### Ash Pans

The large amount of air necessary for the proper combustion of coal in the locomotive must all come through or above the ash pan and through the grates. As the larger the locomotive, the greater the amount of air required, it has been necessary on modern power to drop the ash pan several inches below the mud ring to provide a sufficient area for the inlet of air. It has been contended by some fire prevention inspectors that this space created a fire hazard as it might permit the dropping of live coals. Fire dropping from ash pans may be due to the door being left open, to improper fitting of ash pan and doors, to a hole burned through the ash pan, to absence of deflectors on shaker bars or to pans being full and overflowing. As it is a standard order that no ash pans are to be dumped when the locomotive is running, providing arrangements for operating the pans from the cab, as used on some roads, is a dangerous practice. No provision should be made for dumping the pans except by a man standing on the ground. Some roads reported two or three ash pan doors operated by one action, but this is not a good practice. As in such cases, it is extremely difficult to secure and maintain the tight closing of all doors on account of the warping of the pans, there should be a special action to each door. A rigid fastening as used on the majority of roads should be provided to keep the doors closed and prevent the vibration of the locomotive causing them to open and allow fire to drop. The ash pan wing should be so arranged that for each inch of space below the mud ring, the ring should extend at least one inch out with an upward flange one or two inches high so that ashes falling from the grates will not be liable to fall out of the sides on account of rocking of the engine. The front of all ash pans should fit tight to the mud ring or to the plate supporting the boiler. Shaker bars should be protected by deflectors supported at the back part of the ash pan about one-half inch above the shaker bars so that clinkers riding the shaker bars will be knocked into the ash pan instead of coming out through the opening and dropping down. Vent holes when they are not winged, should be covered by heavy screen. Solid doors are considered preferable to screen doors.

### Fire Doors and Combustion Tubes

Reports show that during 1920, 18 fires resulting in a loss of approximately $9,000 resulted from back fire through fire doors. Such back fires occur when the boiler is being fired up and may be the result of the blower being too weak to support the combustion in igniting the fire or to careless handling of oil in starting the fire. This is something that can be prevented only by proper care on the part of the man starting the fire.

A number of fires have been caused from flames coming out of combustion tubes through the side sheets, the trouble generally occurring when the engine is being fired up. The flame may set fire to the cab floor and if not discovered in time, may result in serious damage. As a precaution, all pipes passing through the cab floor should be fitted with metal collars flanged on the inside so that there will be no temptation for the engineer to close the openings by waste. The irregular opening between the cab floor and the side of the boiler also should be covered with metal or other fire resisting material.

### Oil Burning Locomotives

In connection with oil burning locomotives, there are a number of precautions which should be taken to reduce the danger of fires. When filling oil tanks, care should be taken to see that sufficient room is left for the expansion of the oil when it is heated. Tanks should never be filled to within more than two inches of the top. Flame or an open light should never be brought nearer than 10 ft. from the oil tank, manhole or vent. The arrangement of flash walls and side walls in the firebox and the adjustment of the burner should be such that soot does not collect in bunches and, when dislodged, pass through the stack. Great precaution should be taken in starting fires, particularly where there is no external source of steam to operate the oil burning apparatus and the blower. When sanding flues on the road, a place should be chosen where the burning soot will not start fires. The sand used should be free from all particles of charcoal, wood or waste. When putting the engine in the roundhouse, fires in all burners should be put out by closing the tank oil outlet valve and allowing the oil in the pipe to burn out. The burners should then be blown out and the oil regulator valve closed.

# Causes of Locomotive Boiler Explosions*

## Defects in Steam Boilers That Cause Explosions, with Examples of Locomotive Boiler Failures

By A. G. Pack†

THE process of the generation of steam from water is simply an increase of the natural vibration of the molecules of the water caused by the application of heat until they lose all attraction for each other and become repulsive, and unless confined fly off into space, but, being confined, they continually strike against the sides of the vessel in which they are confined, thus causing the pressure which steam exerts when under confinement.

The generation of steam by the addition of heat is accomplished in two steps; heat added to water first increases the activity of the molecules and is indicated by a rise in temper-

*Taken from the annual report of the Chief Inspector, Bureau of Locomotive Inspection.

†Chief Inspector, Bureau of Locomotive Inspection.

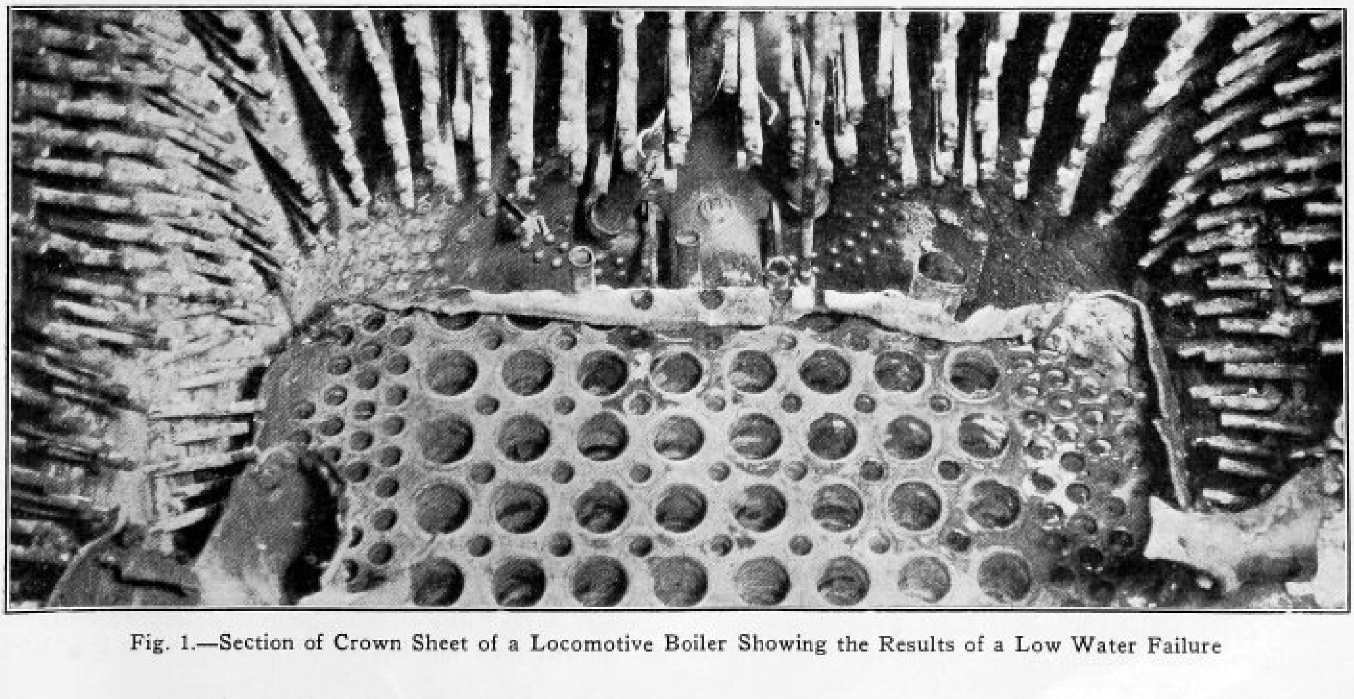


Fig. 1.—Section of Crown Sheet of a Locomotive Boiler Showing the Results of a Low Water Failure

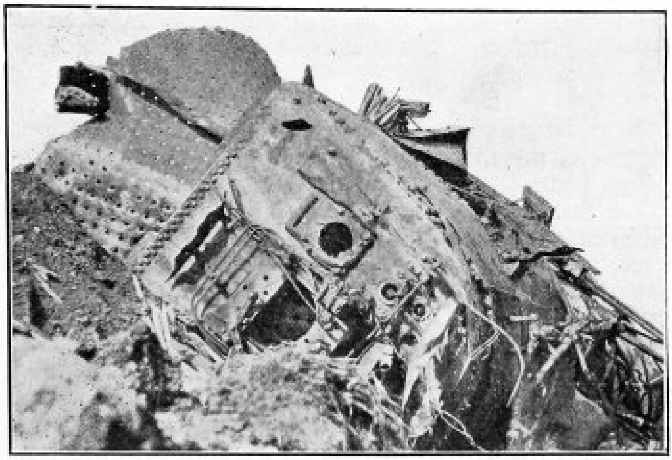


Fig. 2.—Low Water Indicated by Defective Water Glass Caused This Disaster

ature. Heat which warms the water and causes the rise in temperature is called "sensible heat." When sufficient heat is added to water, its temperature continues to rise until about 212 degrees F. is reached, the temperature of boiling water under atmospheric pressure at sea level. The temperature of boiling water varies directly with the pressure to which it is subjected; the greater the pressure the higher the temperature. Under 200 pounds' pressure the boiling temperature is 388 degrees F., while under a nearly perfect vacuum water boils or becomes in ebullition and gives off a vapor at 32 degrees F., at which temperature ice begins to form under atmospheric pressure.

A British thermal unit is the quantity of heat required to raise the temperature of 1 pound of water 1 degree; therefore

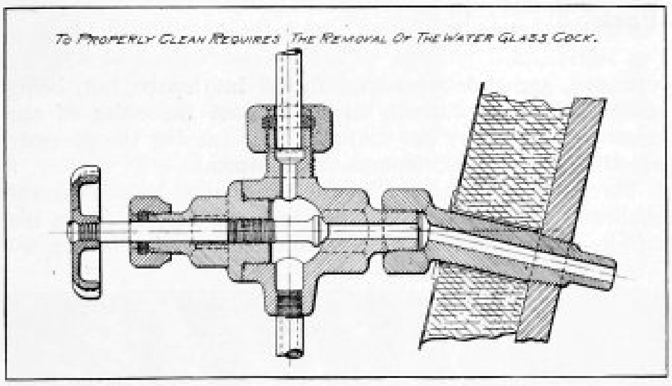



Fig. 3.—Method Used in Applying Water Glass Cock to Boiler

it takes 180 units to raise 1 pound of water from 32 degrees F., to 212 degrees F. Water does not flash into steam as soon as the temperature reaches 212 degrees, but, on the contrary, 970 additional heat units are used in forcing the molecules apart against their mutual attraction or cohesion, which additional heat is known as "latent heat."

It will be seen from this that every pound of steam in the boiler at atmospheric pressure contains 1,150 heat units. As steam is generated and the boiler pressure increases, the heat energy in the steam also increases until each pound of steam under 200 pounds' pressure holds within itself 1,199 units of heat, and the temperature of the water in the boiler is increased to 388 degrees F.

When shell sheets rupture or crown sheets fail and the boiler pressure is suddenly reduced to atmospheric, a tremendous amount of heat energy stored in the water is instantly released and causes a large part of the water to suddenly flash into steam, while the volume of the steam expands many times. The capacity of the boiler is then wholly inadequate to accommodate the increased volume of steam so suddenly generated, nor will the rupture permit it to escape fast enough to avoid a tremendous reaction. As a result of this reaction, we have the appalling explosions which are from time to time so forcibly brought to our attention.

### Force of Boiler Explosions

The force of a boiler explosion is in proportion to the size and suddenness of the initial rupture and the temperature and volume of the water in the boiler at the time of the rupture. The average modern boiler has a capacity of approximately 500 cubic feet of water below the crown sheet and has a steam space of about 150 cubic feet. If such a boiler with 200 pounds' pressure ruptures from any cause, so as to suddenly reduce the pressure to that of the atmosphere, the released energy will amount to approximately 700,000,000 foot-pounds and if the explosion took place in two seconds approximately 690,000 horsepower would be developed.

This gives some idea of the force which accompanies many boiler failures, with their serious and fatal results, and supplies the reason for the violence which in many cases is suf-

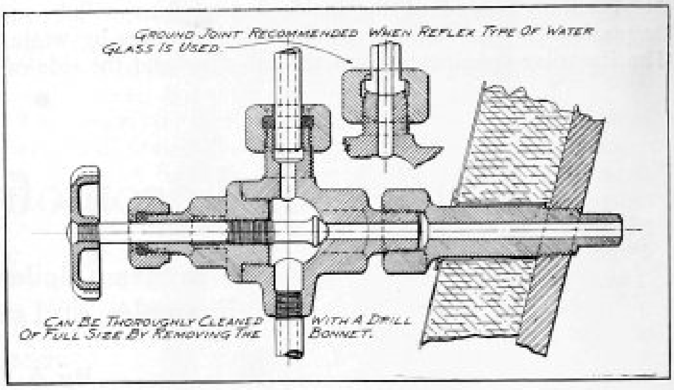



Fig. 4.—Horizontal Connection of Water Glass Cock to Boiler Recommended by Inspection Bureau

ficient to hurl the entire boiler several hundred feet or tear it into fragments, scattering them in every direction.

As previously stated, explosions result because some part of the vessel is too weak to withstand the pressure to which it is subjected. This weakness may be caused by:

1. Abnormal steam pressure.
2. Weakness in design or construction.
3. Improper workmanship.
4. Corrosion or wasting away of material.
5. Broken or defective stays.
6. Overheated crown or firebox sheets.

A remedy for the first three causes is provided for in the law and rules by requiring that the working pressure be fixed, after careful consideration of each individual boiler by competent authorities, and by fixing a substantial factor of safety for all parts of the boiler to provide against hidden defects of material and construction.

To protect against failure due to corrosion or other defects caused by wear and usage, the law requires that regular inspections, both interior and exterior, be made and that all boilers be subjected to a hydrostatic test at regular intervals and a sworn report filed showing the conditions found and repairs made.

Failure of crown or firebox sheets, due to overheating, may be the result of scale or grease on the firebox sheets or from low water. The firebox sheets and tubes are in contact with the fire, and would become heated to that temperature if it were not for the presence of water in the boiler. As previously explained, the temperature of the water in the boiler depends on the boiler pressure, but rarely reaches a temperature greater than 400 degrees F.; therefore while the plates

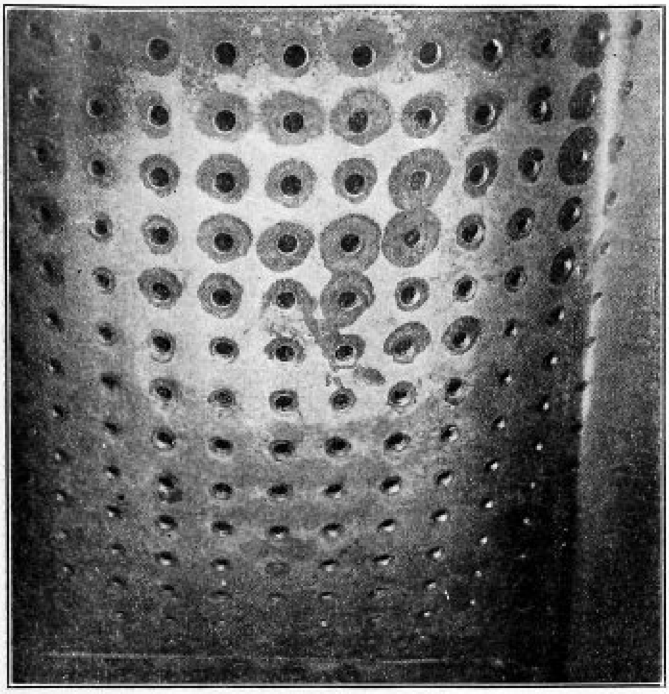


Fig. 5.—Low Water Caused Crown Sheet to Pull Away from Stays and Bag to a Depth of 16½ Inches

are in contact with the water on one side they can not greatly exceed this temperature, although the temperature in the firebox may exceed 2,500 degrees F., which is about the fusing point of firebox steel.

The heat in the firebox is conducted through the plate to the water in the boiler, where it is absorbed, the sheet thus being prevented from heating to the temperature of the fire and burning gases. If, however, the transmission of the heat to the water is obstructed by scale or grease, or if the water fails to absorb the heat, due to being foamy, the plates will retain the heat and may become red hot; or if the sheets are unprotected by water from any cause they become overheated. Metal loses strength when heated and if heated to a high temperature has comparatively little strength to resist the pressure within the boiler, when as a result the sheets are forced off of the stays and failure occurs. It is a well-recognized fact that scale or grease may be the direct cause of an explosion. Scale may indirectly cause an explosion by restricting or closing the openings in the water-indicating appliances, thereby causing a false level of water to be registered, deceiving the enginemen.

One of the most perplexing problems which has presented itself while operating the modern locomotive is that of securing a correct indication of the height of water over the crown sheet under all conditions of service.

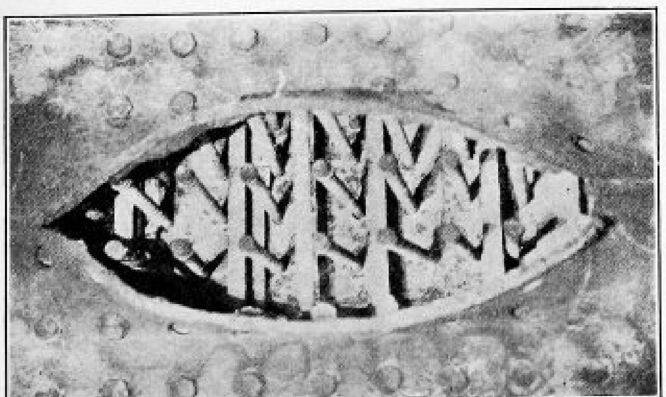


Fig. 6.—Failure of a Welded Seam Resulting from Low Water

### EXAMPLES OF LOCOMOTIVE EXPLOSIONS

A case of low water which resulted in the death of three people and in the demolition of a locomotive and fifteen cars occurred while the locomotive was hauling a freight train consisting of forty-four cars at an estimated speed of 28 miles per hour. The force of the explosion was sufficient to tear the boiler from the frame and hurl it 350 feet ahead with the result shown in Fig. 2.

In this case, the firebox was of the semi-wide radial stay type with combustion chamber equipped with arch tubes and a brick arch. The firebox crown sheet was supported by ten rows of buttonhead radial stays lengthwise and twenty-five rows crosswise 1⅛ inches in diameter spaced 4 inches by 4 inches, the balance being hammerhead radials. The combustion chamber crown sheet was supported by 1⅛ inch radial stays with driven heads spaced 4 inches by 4 inches on centers.

The seam between the crown sheet and combustion chamber was welded and tore for a distance of 80 inches. The locomotive involved in this accident was equipped with two water glasses. The opening in the right hand bottom glass cocks, on examination, was found to be entirely closed with hard scale, rendering this water glass inoperative and misleading. This condition was found notwithstanding the fact that a sworn report had been filed eighteen days prior to the accident stating that the water glass cock spindles were

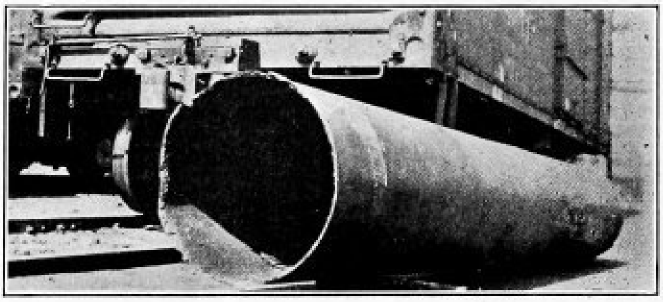


Fig. 7.—Main Air Reservoir Head Blew Out in Service

removed and the cocks cleaned. It is evident that this statement was in error since a hole of this size could not become entirely closed within a period of eighteen days by the formation of scale in the water district where this locomotive was used.

There can be little doubt that this condition was a strong contributing cause, if not the direct cause, for this disastrous accident and could not have existed had the water glass cocks been thoroughly cleaned when the boiler was last washed. The water indicating appliances from the viewpoint of safety and economy of operation are among the most important devices on the locomotive and too much care cannot be exercised in seeing that they are properly inspected, applied and maintained.

In Fig. 3 is shown the manner in which this water glass cock was applied to the boiler, their being a sharp angle bend between the water glass and boiler, making it necessary to dismantle the water glass and remove the cock from its connection into the boiler in order to properly clean it. The manner of applying a water glass cock and its connection to the boiler horizontally is indicated in Fig. 4 and this method renders the water glass less liable to be affected by the circulation of the water in the boiler and also makes it possible to clean the valve and opening into the boiler to its full diameter with a drill of proper size by removing the valve bonnet and without disturbing the alignment of the water glass cocks.

It is recommended that bottom water glass cocks, bottom water column connections and gage cocks have a straight opening and be applied horizontally.

### Boiler Explosions Mainly Caused by Crown Sheet Failures

Another instance of a fatal boiler explosion due to low water was caused in an engine by the failure of the crown sheet. At the time of the accident the water was approximately 5¼ inches below the highest part of the crown. Sufficient force was generated to break both engine frames and to tear the boiler from the frame and hurl it 160 feet ahead. The firebox was semi-wide of 5-piece construction with all seams originally riveted. The rivets had been removed from the seams adjoining the crown and side sheets, the inside lap cut away from the line of rivet holes, excepting 4 feet at the front end, with the holes filled and the calking edge on the fire side welded over by the autogenous process.

At the time of failure, the seam on the right side gave way for practically its entire length. The lowest reading of the water glass and gage cocks could not be determined owing to the distortion of the boiler. The hole in the bottom water glass cock was closed with scale to a ⅛-inch opening at the boiler end. The top end of the water glass was practically closed by the gasket squeezing past and over the end of the glass. The top gage cock was stopped up.

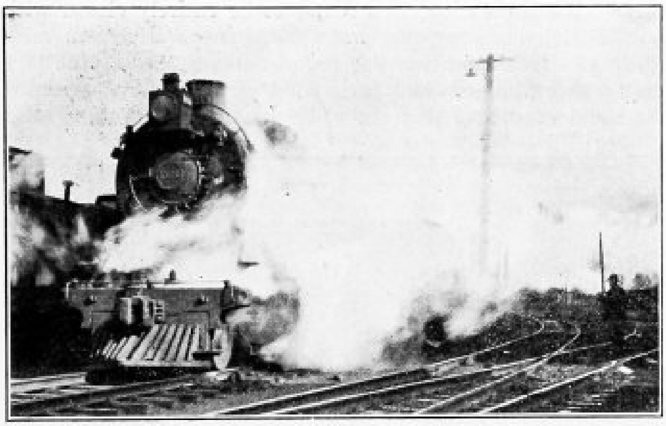


**Fig. 8.—Leaking Badly, but Reported Ready for Service; Cylinder Cocks Closed**

Both injectors were damaged by the accident to the extent that they could not be tested out under steam. The water inlet to the combining tubes of the right intake was closed by scale, reducing the diameter of the holes from ⅝-inch to ⅜-inch.

Fig. 5 illustrates a crown sheet failure due to low water which resulted in injury to one person. The crown sheet was overheated its entire length and pulled away from 313 radial stays, having hammered heads and tapered on the firebox end 1½ inches in 12 inches. All firebox seams were riveted. The crown sheet pocketed to a depth of 16½ inches; the tops of both the flue sheet and door sheet for a distance of 36 inches were bent downward to an angle of 45 degrees.

The result of another crown sheet failure is shown in Fig. 6. In this case the crown sheet combustion chamber seam failed where it had been welded, causing an aperture 36 inches in length by 12 inches at its greatest width. This boiler was equipped with an automatic fire door which remained closed at the time of the failure. Because of this fact it is believed that the injuries caused were less severe to those in the cab of the locomotive than would otherwise have been the case.

The head of a main air reservoir carrying a pressure of 115 pounds blew out with the result shown in Fig. 7. This reservoir was constructed in the railroad's own shops and had a shell 5/16-inch thick; heads, ½-inch thick; length, 10 feet, and inside diameter, 18 inches.

The necessity of eliminating steam leaks on engines in service is demonstrated in Fig. 8. In this instance a special notice for repairs was issued by the Federal inspector which caused the locomotive to be returned to the engine house since it was unsafe to operate it on the road. The photograph was taken with a high wind prevailing, which reduced the density of the steam and with the cylinder cocks closed. Such conditions are not compatible with efficiency and economical management.

In addition to the foregoing accidents, a recent report issued by the chief inspector of the Bureau of Locomotive Inspection gives the results of an investigation of an accident to Pennsylvania Railroad locomotive 2599, which occurred at Gould Mine, Pa., December 6, 1921. The report states that the accident, which resulted in the death of the locomotive engineer, was caused by grooving of the outer firebox sheet directly above the mud ring in conjunction with fractures of the staybolts in the adjacent area.

The suggestions made for increasing the safety of locomotive operation, by the chief inspector in his annual report should be given careful consideration by all the roads, in order that the number of failures during the coming year may show a marked decrease.

## 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, C. W. Obert, 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.

Below are given the interpretations of the Committee in Cases Nos. 375 and 376, as formulated at the meeting of December 6, 1921, and approved by the Council. In accordance with the committee's practice, the names of inquirers have been omitted.

CASE NO. 375.—*Inquiry;* Is it permissible, under the requirements of the Boiler Code, to weld a seam in a vertical firebox not over 38 inches in diameter, and in length ranging from 20 inches up, by the autogenous or fusion process where the firebox has no support other than the tube sheet, mud ring and fire door?

*Reply;* It is the opinion of the Committee that, under the requirements of the Code, autogenous or fusion welding is not permissible for the seam in the firebox of a vertical-tubular boiler unless the sheet containing the seam is supported by staybolting.

CASE NO. 376.—*Inquiry:* An interpretation is requested of the limitation of 50 horsepower in Par. 318 of the Boiler Code to different classes of boilers. Is it the intention that the horsepower capacity be based on water heating surface as specified in the requirement in Par. 274?

*Reply;* It is the opinion of the Committee that the intent of Par. 318, relative to the determination of the feeding devices required for boilers, will be met if boilers having over 500 square feet of water-heating surface are provided with two or more feeding devices.

# Special Meeting of Boiler Manufacturers' Association

## Reports Cover Details of Relations With Stoker Manufacturers, Observances of Boiler Code and Work of the National Board

THE winter meeting of the American Boiler Manufacturers' Association was held at the Fort Pitt Hotel, Pittsburgh, Pa., Monday, February 13, with A. G. Pratt, president of the Association, in the chair. The attendance at the meeting was excellent considering business conditions which made it impossible for some of the members to be present.

At the opening of the meeting President Pratt addressed the meeting, in part, as follows:

### President Pratt's Address

The monthly sales reports which are being submitted by members of the association have come to be of great value and are worthy of considerable thought and study. Unfortunately, our figures for 1920 are not complete, as they do not contain reports of certain companies that furnished statements in 1921. The 1921 reports, however, include the sales of 27 companies for the entire year.

The sales for 1921 follow:

| | |
|---|---|
| Watertube | 310,239 horsepower |
| Horizontal return tubular | 172,224 |
| Locomotive | 26,740 |
| Vertical fire tube | 38,302 |
| Total | 547,505 horsepower |

This, as nearly as I can estimate, is between 25 percent and 30 percent of what we are pleased to call normal.

It is interesting to compare sales for the different periods of 1921; monthly variations are hardly indicative of average conditions and for that reason I have taken totals for each quarterly period. These show:

| | Watertube | Horizontal Return Tubular | Locomotive | Vertical Fire Tube | Total |
|---|---|---|---|---|---|
| 1st quarter | 57,987 | 38,054 | 10,058 | 12,258 | 118,357 |
| 2nd quarter | 80,982 | 40,021 | 4,764 | 7,811 | 133,578 |
| 3rd quarter | 77,751 | 53,717 | 7,018 | 7,953 | 146,459 |
| 4th quarter | 93,499 | 40,432 | 4,900 | 10,280 | 149,111 |

Since making these figures our secretary tells me that the total January sales will slightly exceed 57,000 horsepower. This is the highest total since November, 1920, and is at a rate of 25 percent greater than 1921 sales and 15 percent greater than sales during the fourth quarter of that year.

The foregoing sales statements, better nation-wide conditions, lower money rates, the improvement in European conditions and in foreign exchange rates, lead one to look for better business and more business in 1922 than during the past sixteen months. I do feel that improvement will be gradual and that we shall do considerably more business in 1922 than we did in 1921.

In preparing for this greater volume, we must watch our costs, even more carefully than heretofore. Unless there is a very great reduction in labor costs there is likely to be an increase in boiler costs, for the following reasons:

Most of the materials which we use are at present sold to us at less than their cost of manufacture. In the event of reasonably good business, these costs will be increased and we shall have to guard against losses from this direction. Labor has not yet been liquidated and it cannot be in fairness to our employees under today's working conditions. A greater volume of work in our shops will do much toward enabling us to solve this problem of reasonable labor costs coupled with good wages, but we must go at it intelligently to arrive at the proper conclusion.

We have all benefited by this period of depression in reducing our overhead and we must not lose sight of the necessity of following these costs carefully in the somewhat better business period which we are apparently about to enter.

I want to lay particular stress upon one other point. There seem to be a relatively few members who carry on the greater part of the work of the association. This association can never become the agent for good to the industry that it should be unless each member makes it his business to actively enter into the work of the association.

Following this, W. G. Merritt, of the League for Industrial Rights, gave a very complete outline of labor conditions in the country.

Ralph M. Easley, chairman of the executive council of the National Civic Federation, then spoke of the need of guarding against socialistic tendencies in business.

Secretary H. N. Covell reported that the association was financially in good condition and that the present membership included 77 active members and 20 associates.

George B. Bach, of the committee on Ethics, reported that the conduct of the members of the organization had been such that no action on the part of the committee had been necessary. The fact that no complaint has been registered against any member indicates that all are carrying on their business in a manner to bring credit to themselves and to the association.

### Relations With Stoker Manufacturers

A. G. Pratt, speaking for the conference committee with the Stoker Manufacturers' Association, stated that the committee had not had a meeting recently for the reason that the stoker people had not been able to agree on two or three specific points.

One big point that the stoker people have settled among themselves is that of the stoker setting height—they have agreed as to what constitutes a proper boiler setting height—but the old question of who furnishes the panel between the stoker front and the boiler front has come up for settlement. What the stoker people undertook to do was to agree, or try to agree, to a fixed height above the floor line, the idea being that all under-feed stokers should be built so that the top was six feet above the floor line, so that when we found that an under-feed stoker was going to be purchased we would know that we had to come down to that six foot point. The under-feed stoker manufacturers are pretty well agreed on that particular dimension. We will have to have a meeting of the committee, however, to accept and agree upon that point.

The main trouble seems to be with the side feed stoker, such as the Murphy and Detroit, and again, there are two or three of the under-feed manufacturers; that is, those who manufacture a single retort stoker, whose ideas seem somewhat different and the chain grate manufacturers vary to some extent. There is one thing that I would like to get on record here, and that is as to whether or not it will be satisfactory to this association if we, as representatives of this association, come to an agreement with the stoker manufacturers to the effect that if they will in all instances come to a fixed height above the floor line, that that will be satisfactory to us and that we will undertake to furnish the panels between the boiler front and the stoker. I would like to get an expression of opinion from the membership on that point because it will guide us a great deal in our dealings with the stoker manufacturers.

E. R. Fish of the Heine Boiler Company: It not infrequently happens that when a boiler is purchased the purchaser has not as yet determined what sort of stoker he is going to use—he does not know whether it will be an underfeed, chain grate, or what other type. It would seem, therefore, that if different classes of stokers have different heights, that the boiler manufacturer is still not in a position to know just what to figure on, if there is going to be a difference in the height to which the several types of stokers furnish their front; so it would seem that in order to put the boiler manufacturer in a proper position the stoker people ought to all have the same height and then fill in between that in case some of them do not use that height.

A. G. Pratt: We are getting nearer to the point where the purchaser knows what type of stoker he is going to buy at the time he purchases the boiler. If we can first get each group of stoker manufacturers to come to given heights, then we can try to get them all to come to a single height. I think that even if we are unable to do that at this time, we will be a great deal better off than we are at present, because with the four generally used types of under-feed stokers today there are differences in heights which are in most instances only inches—one comes to 6 feet, another 6 feet 3 inches, another 6 feet 6 inches. We must try to get them all down to 6 feet.

E. R. Fish: Heretofore it has been a point of contention as to who was going to furnish the panel above the stoker. I think the stoker people should be specific and say what they do furnish, and to what height.

A. G. Pratt: If we can get the stoker people to commit themselves, come to a certain point above the floor line and it works out so that we know what that height is in advance, we will always be in position where we can include the panel. Then if we know how high the panel will be it seems to me that it is fair for them to expect us to come down to that height.

F. G. Cox: We have had considerable trouble in regard to buck-stays. The different stoker manufacturers put levers and gears and other things on the side walls and allow no place for the buck-stays except opposite the bridge wall.

A. G. Pratt: One of the points which we are covering in a questionnaire which we are getting up that will be exchanged between the stoker and the boiler manufacturers, is the location of buck-stays and by whom they are furnished, so that that question should be settled right at the start.

### Observance of the Boiler Code

W. C. Connelly, of the D. Connelly Boiler Company, reported for the commercial committee on matters dealing with the observance of the A.S.M.E. Boiler Code. He stated that the committee had formulated a questionnaire which had been sent to the members of the association January 13 regarding the question of uniform tensile strength in figuring allowable working pressures and also regarding whether or not a maximum thickness of boiler shells for return tubular boilers should be drafted in the Code. Out of the 77 members in our organization, we received 54 replies. The questionnaire was as follows:

1. Are you complying with the A.S.M.E. Code par. 14, 28, 36, 180 and interpretation No. 295? Of the 54 replies received 50 were "Yes," 1 "No," 3 "Not always."

2. Do you believe that a maximum thickness of shell plate should be fixed by the Code Committee?

Of the 54 replies 26 were "Yes," 10 "No," 18 did not build that type of boiler.

3. If so, what thickness of plate do you favor as a maximum? Seven answered 5/8; 6 answered 9/16; 3 answered 3/4; 2 answered 7/16; 4 answered 1/2; 1 answered 1 1/4. Others were indefinite as that thickness depended upon size and other conditions.

4. If you do not believe in a maximum thickness, what are your reasons for opposing same?

Some did not think that experience had shown such limitations to be necessary; one replied that the girth seam may be protected over the fire; one that such details should be settled by the application of engineering principles; another that it depended upon local conditions. One thought that there should be no limit to progress and development.

5. Are you building all of your high-pressure boilers in accordance with the Code?

Answers: Forty "Yes," 10 "No," 4 "Partly."

In building commercial boilers, that is, boilers that are not built to A.S.M.E., state or municipal standards or special specifications, are you then complying with the A.S.M.E. Code, par. 14, 28, 36 and 180, and interpretation of case No. 295, which states, "The minimum tensile strength under the A.S.M.E. Code must not exceed 55,000 pounds when figuring allowable working pressure?"

To this 31 replies were received—27 that 55,000 pounds was always used; 4 that it was not.

One objected very strongly to the fixing of a maximum thickness, claiming that it was the result of propaganda by the builders of watertube boilers.

One said that he had had no trouble with the fabrication of boiler plate since adopting the A.S.M.E. specifications, although trouble had been experienced before.

One manufacturer of externally fired multi-tube boilers cited boilers with thin sheets alongside of those with thick sheets, both burning oil. They had trouble with the thick sheets, but not with the thin ones, and he advocated thin sheets with 60,000 tensile strength. G. S. Barnum, of the Bigelow Company, explained that the trouble from thick plates came all in the seam. The Code requires the thickness at the seam to be reduced to 1/2 inch. He told of a 72-inch boiler built by the Bigelow Company of 3/4-inch plate planed down in this way, upon which especial care was exercised and which was found to be perfectly tight under 200 pounds. Two years later it was leaking at every girth seam.

E. C. Fisher: In my reply to the questionnaire I stated 3/4 inch as the limit of thickness, because I wanted to go to what I felt was the extreme limit. Our own practice is 5/8 inch. We never build a return tubular boiler with more than 5/8 inch thickness of plate for our district.

Now as to the planing down of girth seams, I am not entirely satisfied that it is a good practice. It has been my experience that where you plane plate down from 1 inch to 1/2 inch, at the portion that is planed down you have changed the position of the neutral axis in the plate and you set up a bending movement between the neutral axis in the plate, which is an inch thick, and that portion which is 1/2 inch thick, which causes a crimping of that portion which is planed down. It is extremely hard when you come to fit your courses together to get those plates to fit and get a real close fit. Now if you don't get an almost perfect fit in a girth seam over the bridge wall, you are going to have trouble and your girth seam is going to start and leak.

My own personal feeling would be that if we could get away from that planing down it would be a good thing and I would be perfectly willing to see it increased to 5/8 inch instead of 9/16 inch, so as to let a 5/8 inch boiler go by. I think, however, there is great danger in trying to get a real tight joint if you plane from 1 inch down and it was for that reason that I said 3/4 inch in my answer to the questionnaire, so as to take care of territory where they are using very good water and at the same time not to go to 1 inch where you would get a change in the neutral axis in your plate.

Replying to an inquiry as to whether the trouble could not be avoided by using a single sheet for the bottom of the boiler, Mr. Fisher said that with clean metal the conductivity was sufficient to convey away the heat, but with thick metal and the least bit of oil or scale there was likely to be trouble. A fusible plug would sometimes melt out until it was only about ⅝ inch deep, then it would hold. The association might go on record as considering the planing down of plates 1 or 1½ inches thick as bad practice.

Mr. Brink of the American Hoist and Derrick Company: It seems too bad that we have to limit at the present time the tensile strength of material. I would recommend that our committee to the A.S.M.E. advise some sort of research. I know absolutely that you can take a thick plate and heat it with a blow torch without any water back of it and you can make one side of that plate red hot and the other side will be black. There should be some limit to the thickness of a plate, but it seems to me that we ought to recommend more research.

Isaac Harter of the Babcock and Wilcox Company: I had occasion not very long ago to inquire for plate that figured about 3 inch at 55,000 pounds for special service and feeling that 3 inch plate was getting more into the class of armor plate, I made inquiry of a number of steel companies as to what could be done in the way of armor material. We have been building some drums with 2¼ inch material and apart from the difficulty of handling plate of that thickness, I think we are getting pretty close to where the quality of the plate itself is not in proportion to its thickness. That is, I don't believe that one 2¼ inch plate has by any means the total strength of two plates that add up to that same thickness.

While you are talking about the question of heat transfer in thick materials, I might bring up a test that we made not long ago on the matter of thick and thin boiler tubes. For the test we picked out a boiler and put in alternate tubes, thick and thin and ran the boiler under purposely exaggerated bad water conditions. The light tubes were No. 10 four inch, the heavy tubes were No. 6, and in another test were ¼ inch. It was a surprise to me, and it may be a surprise to some of you, to see that the heavy tubes under those conditions lasted much longer than the light ones—almost in a ratio of 2 to 1 in time.

F. C. Burton, Erie City Iron Works: We assume that 150 pounds pressure is high enough for a return tubular boiler with ⅝-inch plate, which will give good service.

M. F. Moore of the Kewanee Boiler Company: Speaking of the minimum tensile strength as adopted by the Code, I remember, and Mr. Fisher will agree and Mr. Fish also, that in formulating the Code, in securing the specifications for steel, the largest and best manufacturers, the most experienced manufacturers of steel in this country were consulted in all of those matters, and it was the consensus of opinion by these gentlemen, who had to place their stamp upon the steel, that they did not want to use a higher tensile strength than 55,000 pounds. Then the fact that one boiler manufacturer would figure 55, another 62, another 60, another 70, and so on, confused the whole situation, and it was thought best by the manufacturers of steel and by the inspection representatives, that is, the insurance companies, as well as the boiler manufacturers, that a minimum tensile strength of steel as adopted by the Code is the proper thing.

John A. McKeown, John O'Brien Boiler Works: In answering the question of our committee as to what we would recommend as a thickness of material to be used, we tried to base our answer upon the construction of the Code as to what was permissible by planing the plate to ½ inch. We haven't built any heavier than ⅝ inch and we have found that since we have been planing those to ½ inch, we have experienced no fire cracks, but prior to that there have been fire cracks in seams.

### Cost Accounting

In reporting on cost accounting, G. S. Barnum emphasized the importance of taking up the matter along the lines of the pamphlet distributed in June, 1920, to members of the association. It will be of advantage to those members of the association who have not already done so to install some such system in their plants as suggested in this pamphlet.

### Report of Committee on Construction Tolerances

The report of the committee which was appointed to cooperate with the subcommittee on Inspection of the Boiler Code Committee, was read by F. G. Cox.

"Following the annual meeting of this organization at Bedford Springs, Pa., in June of last year, our president appointed from our membership the following committee to represent the American Boiler Manufacturers' Association, who were to work with the sub-committee of the A. S. M. E. Boiler Code on the subject of boiler construction tolerances. These are Messrs. Frank G. Cox, of the Edgemoor Iron Company; Starr H. Barnum, of the Bigelow Company, and Lawrence E. Connelly, of the D. Connelly Boiler Company. On November 15, 1921, a letter was addressed to all of the members of our committee by Charles H. Blake, chairman of the sub-committee of the A. S. M. E. Boiler Code Committee, who has been in charge of this particular work. We find their committee has been in existence for the past three years. The letter requested a meeting of all members of our committee with their committee at the A. S. M. E. building, at 29 West 39th Street, New York, for Tuesday morning, November 29, 1921. I am pleased to report that all members representing our organization on this committee were present, and at 10:00 o'clock on that morning the entire committee went into session and we worked all day on November 29, and all day on November 30.

Mr. Blake, chairman of the committee, opened the meeting and informed us that he had been in charge of this work for about three years and that he had been very disappointed up to that time, due to the fact that they had been unable to proceed with the subject with any degree of interest. He stated that their committee had held several meetings to consider this proposed code, but due to the fact that the members of their committee lacked sufficient knowledge pertaining to the subject, none of their committee seemed anxious to assume an initiative position, consequently up to the time your committee met with them nothing had been accomplished.

Your committee is pleased to report that after a full two-day session a great deal of work had been accomplished and in fact a preliminary draft of the code was completed. The draft of this code has not as yet been put into such shape as your committee feels it should be before presenting to this association for consideration, but it is the hope of your committee that the proposed draft will be worked up in proper shape to submit to this organization at their annual meeting which we understand, will be in June next."

Now the object of this Inspection Code is to tell the inspector what to do and how far to go in making an inspection. Each inspector has his own ideas as to how far to go in interpreting the Code and this will be a means of telling him where to stop and where to start. The Code will be submitted to the committee of the American Boiler Manufacturers' Association for discussion and approval before it goes to the Code committee of the A. S. M. E.

In the absence of Mr. Drake, Mr. Covell read the following paper:

## Limitation of the Use of Cast Iron Boilers

**By W. A. Drake**

Some of the members will remember that there was some discussion at one of our recent meetings covering the advisability of installing large cast iron boilers for heating purposes. There was no conclusion arrived at and the question was not further pressed, which, no doubt, was the best way to leave it.

It is not my purpose in this short paper to try to present detailed argument for the limiting of the field for the sale of cast iron boilers, but rather to call up the question again for further discussion and at the same time to mention some more or less recent observations.

The question is one which is influenced more or less, perhaps, by the salesman or the man in the field. He is an aggressive person, or should be, and always does what he can to meet the situation. If he represents a manufacturer of cast iron boilers, and frequently runs into specifications for heating boilers a little larger than his company manufacture, he will advise his home office and, perhaps, urge that a boiler of such larger capacity be built. This is repeated from time to time until the boiler is finally designed and built.

Other larger boilers follow until they get out of their natural field and become a heavy burden on their purchasers. This same thing is true of other equipment, and it sometimes requires a term of years before a proper balance is effected.

As manufacturers of steel boilers, it is the writer's opinion that all of us should inform ourselves sufficiently to successfully hold in check the tendency of some salesmen to sell such equipment. An example of installing a cast iron boiler of too large a capacity came to our attention during the past year. The upkeep on it was, in one year, about equal to the total cost of a new steel boiler which was finally purchased.

We are largely responsible for this condition. We have not given enough attention to this phase of our work and have been satisfied to work out power problems only.

The cast iron boiler manufacturers have gone into detail, giving to the architects and heating engineers all the data necessary for the use of their boilers. Many engineers follow the path of least resistance and make use of these data.

Similar information covering steel boilers should be in their hands so that they can as easily make their drawings and prepare their specifications for heating equipment.

The manufacturers of cast iron boilers are alert and have taken advantage of new ideas and pushed them to the front. It is true that some of these new features have been abandoned after a time; however, they have served to stimulate purchases to an extent and attract more or less attention.

In addition to the above, there are financial inducements offered to the dealers not now enjoyed by those who handle steel boilers. Whether this will continue in the face of stiff competition remains to be seen.

We are more concerned, however, with the engineering features of the problem than anything else, and considered from this standpoint, it would seem to the writer that cast iron boilers in the larger sizes should not be installed. Owing to the nature of cast iron and the uncertain structure, the risk is entirely too great. I can see no objection to an installation of small size, for the conditions are much different and the risk less and I hope that you will not get the impression that I think there is *no* place for the cast iron boiler.

A few of the facts which have a bearing on the problem, it may be well to mention. As just stated, the quality of cast iron is such that it will not stand great strain and, therefore, will crack under sudden and extreme changes of temperature. A boiler is subject to extreme changes of temperature, and the greatest changes come during the coldest weather, or when the boiler is being forced and when most needed. The securing of repairs often requires considerable time and in the meantime much suffering may result.

Owing to shifting of cores, the metal may vary in thickness, which causes undue strains and often failure of sections.

Because of the rough surface, soot more readily collects on the surface exposed to the fire and being a poor conductor of heat, reduces the efficiency of the boiler.

The usual design of cast iron boilers, with their irregular outlines, is such that cleaning either outside or inside is difficult and, therefore, the operator neglects it.

In many cases to increase the capacity of the boiler, sections are added and the firebox increased in length to such an extent that they cannot be properly fired.

Where used with indirect heating systems, their response to the demand for steam is too slow and their use in some cases has had to be abandoned.

If you will compare in your own minds the above with the qualities of the steel boiler, its ability to withstand strains due to unequal temperatures, the possibility of making repairs in a few hours at comparatively small cost, the uniform thickness of metal, the smooth surfaces making cleaning possible, the proper proportion of grate surface to heating surface, the quick response of a clean boiler to the demands for steam, and the more efficient transfer of heat, I believe you will agree that the field for cast iron boilers is the smaller installations, other conditions, such as space available, having a bearing on the subject.

What I have said covers the question in brief form only and touches only the high spots. A further discussion would be profitable, no doubt, in order to reach a better understanding of the problem and to give our purchasers of boiler equipment the kind of outfit they should have.

DISCUSSION

Mr. Dixon of the Kewanee Boiler Company: It is of vital interest to the steel boiler manufacturers of the United States to take some decided action in connection with steel versus cast iron boilers at this particular time, for the reason that industrial work is at an extremely low ebb and it will be necessary for you, if you are going to do any volume of business, to sell horizontal return tubular boilers for heating purposes. The Cast Iron Boiler and Radiator Manufacturers' Association, some of the members of which I see here, is a very energetic association and, among other things, it sends out propaganda to the effect that steel does not last. I think that some propaganda from this association to the effect that steel does last would be of benefit to the members of the association.

Another thing that the members of this association do which interferes with their best interests—heating boilers are sold through heating contractors as a general proposition, but the members of this association, as a general rule, sell to the owner. They disregard the heating contractor. Necessarily he doesn't feel kindly towards them. He is a very vital factor in the determination of the boiler that is to be used in any building and naturally, if you are not his friend he is against you.

Now the cast iron boiler people within the last four or five years have increased the size of their boilers almost double, until they will offer a man for a building a boiler of 200 horsepower, cast iron, something that is an absolute crime to install in any big building. They don't pay much attention to the engineering feature of the boiler. The important thing to them is to sell cast iron at so much a pound, and the bigger the boiler the bigger the order.

The steel boiler people have spent their time, their life, along engineering lines rather than along lines of salesmanship. It is time for them to do something along the sales end of it.

I am very much in favor of this association doing something toward driving home the fact that steel boilers are the only thing for large work. There isn't any question about it. You can go to any high grade engineer that knows his business, and he knows that he should not put in a cast iron boiler, but it is often a matter of convenience. They furnish him with all the data, lay out the stacks, the boiler room and everything is arranged for him; they try to get the building sewed up so that you can't get a steel boiler into it.

C. W. Gorton of the Uniform Boiler Law Society then spoke as follows:

## The Advantages of the National Board of Boiler and Pressure Vessel Inspectors

### By C. W. Gorton

I do not think it is necessary to go back and explain the reasons why the American Society of Mechanical Engineers felt it advisable to draft rules and regulations, governing the construction of boilers; but in passing I might say that the primary reason was this—that they realized the chaotic condition into which the states were rapidly drifting in drafting their rules. Some of these were good, some bad and others indifferent. The result of this line of reasoning was the drafting of a set of rules, which is now known as the Boiler Code. In the course of time, those who were vitally interested in this movement realized that the powers of the Boiler Code Committee were limited to revisions and interpretations of the Code; they did not feel that they could pass upon specific designs and specifications that were presented to them, but felt there should be some avenue by which these questions could be taken up and, in a way, definitely settled.

There was a general feeling that a board should be organized, that would be general in its scope and operation; and acting upon this thought, the National Board was organized, the membership of which was to be composed of representatives of the Inspection departments of the states and cities that had legally adopted or accepted the A. S. M. E. Boiler Code as their standard.

As you all know, the National Board was organized with three distinct ideas in view: first, one Code; second, one stamp; third, one inspection. You will appreciate the fact that it was almost impossible to get uniform action on interpretations by state boards, as some of the boards were deciding cases without making any effort to ascertain whether the case in hand had been previously passed upon by the Code Committee through an interpretation. While we do not expect to entirely overcome this condition, we do have a reason to believe that it can be reduced to a minimum by securing the voluntary cooperation of all the state and city representatives through the medium of the National Board. Many requests have been made to the Boiler Code Committee, to approve specific designs and boiler appurtenances, either covered or not covered by the Code; and as they are not in a position to take action upon such cases, they now refer such matters to the National Board.

The National Board submits the designs and specifications to the committee on specific designs and appurtenances, with a request that the members report as to whether they meet the Code requirements and, if not, to make such recommendations as are deemed advisable. If the committee reports favorably, the case is then referred to the members for their consideration and a 90 percent affirmative vote is required to obtain final approval. When this approval is given, the device may be used in the states and cities that are represented in the National Board. The question of stamping has been a serious one to the manufacturer, as it was necessary for him, in order to meet the requirements of the various state boards to place upon his boiler state stamps, ranging all the way from 1 to 15, which on the face of it would indicate poor cooperation and a lack of uniformity.

The purpose of this stamp is to show: first, that the boiler is built to a certain standard; second, that it has been inspected throughout construction by qualified inspectors; third, that a complete report is on file in the department indicated by the stamp.

The stamp of the National Board is a combination, embodying this information. In stamping a boiler, the first stamp to be used is the A. S. M. E. symbol, showing that the boiler is built in accordance with the A. S. M. E. Code. Second, the stamp is to be placed upon the boiler in the presence of an inspector holding a National Board commission. Third, the words "National Board," a serial number and the abbreviated manufacturer's name. A data report covering a boiler so stamped is to be filed with the secretary-treasurer, in duplicate. When the destination of the boiler is known, the builder may file a copy of the report with the state department, or it will be the duty of the secretary-treasurer to furnish the state with such data. In this way you will readily see that you always have a record of the boiler, no matter where it goes, or from whence it came. The information given in this form of stamping will show the inspector in the field, where he may obtain complete data covering such boiler.

The use of the National Board stamp is particularly an advantage to the manufacturer who builds boilers for stock or distributing centers, as they do not know at the time the boiler is manufactured where it may be installed.

I would call your attention to the fact that there is a difference existing at the present time in the several states relative to the qualification of inspectors. Some states are very lenient, while others realize the importance of able, qualified inspectors. It is the intent of the National Board to secure inspectors who are well qualified to apply the rules as embodied in the Code by means of a uniform examination, the questions being prepared by a committee for this purpose; and it might be well to state at this time that these questions are now being used by four or five of the states.

In order to protect both the A. S. M. E. symbol and the National Board stamp, the Board requires that persons who may witness this stamp being placed upon the boiler, must first secure a National Board commission.

The National Board has now in preparation a penalty for the inspector who does not honestly live up to the requirements of the Code. This penalty, in all probability, will be the suspension of the inspector. This is one of the greatest needs and will be of advantage to the boiler manufacturer, in that it will insure him that his competitors are required to live up to the same conditions as he. It might be of interest to know that the National Board has already commissioned 165 inspectors and that 35 boiler manufacturers have made application for and been authorized to stamp boilers in accordance with the by-laws of the National Board. Also 11 states out of 17 have officially accepted the approved stamping, and there is every reason to believe that all of the states will eventually accept boilers stamped with the National Board stamp in lieu of their own state standard.

Discussion

H. N. Covell: What states permit the use of the symbol and what states insist on their own state recognition?

C. O. Myers, secretary-treasurer of the National Board: The states that will accept the National Board's stamp are Rhode Island, New Jersey, Maryland, Ohio, Indiana, Wisconsin, Minnesota, Oklahoma, Oregon and California.

C. V. Kellogg was then requested to open the discussion on taxation.

# Taxation

**By C. V. Kellogg**

I received a letter from the secretary asking me to start a discussion on taxation. I realize that it is a subject that is going to be with us for some time. We have had a tax law in existence; there have been many modifications of it but nobody seems to understand it. Last year Congress endeavored to pass a new law. They have passed a new law, but so far as the present conditions are concerned their entire act was trying to eliminate as far as possible the misunderstandings that existed in the present law, and it seems to me unnecessary to take up that subject and discuss it, unless somebody has some questions to ask that will aid in interpreting the law, because the present existing law, so far as the normal tax and the profit tax is concerned, only exists for the earnings of 1921. After 1921 there will be only two taxes—the tax of the individual and the tax of a corporation.

The tax of a corporation, as I interpret the law, although there is some question still unsettled, is 12½ percent nominal tax on the earnings regardless of the capital invested or other questions that have existed heretofore.

Taxation has been and is felt at the present time to be a burden and a detriment to business. For example during the last two years I have had five different tax examiners from the department at Washington trying to solve the problem of tax so far as I was personally concerned in my own company and notwithstanding the fact that they have spent 18 months in trying to solve the different questions that arose, I have not yet succeeded in getting a report from the Government as to what taxes I should pay. I think, however, that owing to the conditions which existed in 1921, those questions are all settled, because beginning with 1922 your tax, as I interpret the law, will be 12½ percent of the net earnings.

There may be many questions as to the question of capital invested or the question of how you figure your taxes, or as to what should be considered income, etc., that you may like to have enlightenment on. If I can do it I would be pleased to do so, but as to the general subject I don't see what there is to be said.

SPECIAL COMMITTEE APPOINTED

A. G. Pratt: We have a communication from the American Society of Mechanical Engineers, asking us to send a representative to their sectional committee on Bolt, Nut and Rivet Proportions. The question is whether or not we wish to take advantage of this opportunity. I would like to get the consensus of opinion of the meeting.

E. R. Fish: It is a thing we should by all means take advantage of. Anything that relates to the boiler industry and the materials that we have to use, we are interested in, and if there is an opportunity to take part in any discussions and any actions that affect our interests we should certainly take advantage of it.

## Welding of Boilers and Pressure Vessels

**By E. R. Fish**

The Boiler Code Committee of the American Society of Mechanical Engineers found, after several years' experience with the Boiler Code itself that there was beginning to be a demand for a Code covering unfired pressure vessels, of which there is a great variety. We didn't know there were so many until we came to look into the matter. Many of those vessels are made by boiler manufacturers but a greater number are built by separate industries, as tank concerns. It also became apparent that the states were gradually tending toward improving such tanks in their rules, bringing such pressure containers under their jurisdiction, making them subject to inspection and, if the great chaos that existed in the boiler trade was to be avoided in the case of tanks, it was desirable to have a Code covering the construction of such pressure vessels. It was with that idea in mind that the Boiler Code Committee appointed a subcommittee on "Unfired Vessels" to look into the question and, if possible, draw up a Code.

The inspectors of many of the states expressed a very definite desire for a specific Code of that sort which, if drawn up, would tend to become the uniform basis of construction, just as the Boiler Code has become a uniform basis for construction for boilers. That subcommittee was appointed almost three years ago and gradually it got under way. A Code was suggested and a hearing was held at the Spring meeting of the American Society in St. Louis in May, 1920. At that meeting it developed that the question of welding was really the paramount one. It was the crucial point on which the Code really depended. I wasn't aware myself that so much welding was done on pressure vessels.

Everyone knows, of course, that there have been many failures of pressure vessels, particularly of the welded type, and it was the failure of these that stimulated the activity on the part of the many municipalities and states to include such vessels in their inspection requirements. The question was finally referred to a sort of a coalition committee of the American Welding Society, the welding committee of the Boiler Code Committee and the Unfired Pressure Vessel Committee.

After dragging along for some time, it developed that there was great difficulty in getting the various interests together. The electric welders were antagonistic to the oxyacetylene men, and vice versa, and the forge welding people came into it, and finally the people who make brazed tanks, so that it got to be exceedingly complicated and it was with great difficulty that any sort of an agreement or understanding of any kind could be arrived at as to what specifications, what limitations, should be imposed upon welded construction.

The final result was that we concluded to have another hearing at the annual meeting of the society in December and the Code as it had been submitted was published and some tentative requirements for covering welding were written out. It was all put in pamphlet form and published and put in circulation and distributed as widely as possible. The hearing was held on December 5 in New York and I think I may say that it drew the largest audience of any of the hearings that were held, indicating the tremendous interest that people had in it. Incidentally I might say that it provoked, perhaps, the greatest difference of opinion and discussion of any of the hearings that were held.

One of the principal considerations in connection with welded work, it seems to me, is that brought out by one of the speakers, that the welded part is not homogeneous, has not the same physical characteristics as the plate, and that in the case of any pressure vessel in which there are changes in temperature, changes in pressure, or weaving actions of any sort, in the course of time the weld is bound to fail, not because of lack of inherent strength under a constant tension, but because of the fatigue of metal that is concentrated at that point.

That, perhaps, may give you a general idea of what the committee has been up against in trying to evolve a Code for the unfired pressure vessels. It is easy enough outside of welding, but unfortunately welding seems to be the principal stumbling block that is holding back the final promulgation of the Code.

## Abusing the Steam Locomotive

ONE of the most important advantages of the steam locomotive is its reliability. It is inherently a very flexible machine; the load can be varied over a wide range and the power output adjusted to take care of it. The steam locomotive can stand a tremendous amount of abuse. It may have numerous mechanical defects and yet will pull its load where a less sturdy machine would fail. Railroad men are so familiar with this fact that they are apt to regard the ability of the locomotive to produce results under unfavorable conditions as a matter of course and to take advantage of it by operating power that is not in the best condition. This may be permissible in an emergency, but the practice of persistently running locomotives with minor defects to keep down maintenance charges cannot be too strongly condemned.

No machine can be expected to operate economically unless it is maintained in first-class condition and laxity of inspection or maintenance practices which permits defective locomotives to continue to operate without repairs is false economy. Yet this condition probably exists to a considerable extent. In some cases maintenance standards are very high, but inspection inadequate. For example, a locomotive was taken from regular service to be tested and a thorough examination showed the superheater joints had been leaking badly for some time. When such conditions exist would it not be advisable to develop methods for preventing these losses by the use of superheat pyrometers and steam engine indicators and by thorough, consistent inspection?—*Railway Age.*

# The Boiler Maker

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In line with the general slight improvement in business, the report of an increased demand for boilers brought out at the recent meeting of the American Boiler Manufacturers' Association is encouraging for with it comes the promise of further gradual improvements in 1922. During the period of depression, progress has been made in stabilizing the various cost factors of the industry, but, as President Pratt of the association pointed out, care must be exercised in keeping down overhead charges in the period ahead.

In connection with the prediction of better business, the value of the monthly sales returns made by the member companies is quite apparent, for without them no definite comparison of present with 1921 conditions could have been made. This should act as a strong incentive for all companies who have not been supplying the information regularly to the secretary to do so from now on so that complete figures for the industry in this country will be available to the members of the association.

It has been interesting during the last two years to watch the rapidly increasing scope of the association and its active interest in problems either directly or remotely connected with the industry. Definite action has been taken in conjunction with the Stoker Manufacturers' Association to decide exactly how contract requirements shall be met by the boiler manufacturers and by the stoker companies. The standing and special committees have broadened their scope to include a variety of commercial and scientific questions which have come up for settlement.

The association in its present membership seems intent on carrying the idea of cooperation in the industry for the mutual benefit of all as far as it is possible to go. However, the ultimate object of the association cannot be attained until all of the steel boiler manufacturers have become members actively interested in the proceedings of the association.

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In a paper read before the New England Water Works Association, F. W. Dean calls attention to a prevailing policy of placing boilers too high. Just what is responsible for this is not generally understood, but it may be that it is done for the purpose of obtaining room for combustion on the assumption that a great amount of room is necessary. Actually, horizontal space when available for gas travel is quite as good as vertical.

With the exception of watertube boilers having transverse baffles, practically all other types of horizontal watertube and horizontal return tubular boilers have sufficient space for the best combustion even with low settings. In fact, the narrower the combustion chamber, if the air is admitted where it will penetrate the combustible gases, the more perfectly will the gases mix. It is apparent from this that the greater the elevation of boilers with horizontal gas travel the more uncertain the gas and air mixture becomes.

The elevation of boilers with transverse baffles improves the gas and air mixture to a slight extent only. This is true because the currents are almost vertical and parallel and have but little opportunity to mix and burn.

Another matter of uncertainty in boiler design appears to be the height of the bridge wall. Bridge walls are intended to limit the fuel bed and to prevent coal from being thrown over it. In marine boilers, bridge walls are only about nine inches high because of the small size of the furnaces. This height seems to be quite sufficient and it is safe to assume that no bridge wall need be over twelve inches or fifteen inches high at most.

One possibility of a high wall is that a great quantity of hot gas might be projected on a section of the boiler in which dirt had lodged, thus causing overheating and injury.

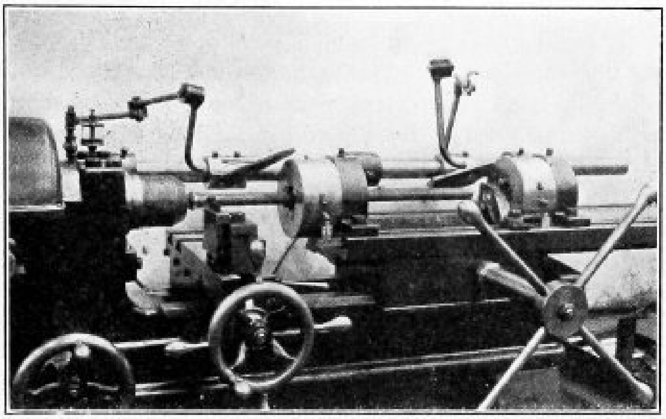
The foregoing are points in boiler work open to differences of opinion and we would like to have our readers interested in the matter write to us about their experience in connection with the height of boilers and the height of bridge walls.

# Engineering Specialties for Boiler Making

**New Tools, Machinery, Appliances and Supplies for the Boiler Shop and Improved Fittings for Boilers**

## Staybolt Attachment for Turret Lathe

Staybolt and crownstay threading, especially in repair shops, can be handled with less loss of time and without tying up two different machines by means of the staybolt threading machine illustrated, which has been designed for that purpose by the Warner & Swasey Company, Cleveland, Ohio. The new staybolt machine is made up of the standard Warner & Swasey No. 4 turret lathe with a special attachment instead of the regular turret slide and saddle. When not used for staybolt threading, the regular turret slide and saddle may be replaced instead of the staybolt attachment and used for the production of the many miscellaneous studs and bolts which are found necessary in railroad shops.



Warner & Swasey Crown, Button Head and Swivel Staybolt Threading Machine

This machine handles crown stays, button head stays and swivel stays up to 40 in. in length and for any size of thread, because larger or smaller self-opening die heads may be used to answer the requirements of the particular shop in which it is installed.

Present day practice seems to lead principally toward the use of upset forgings and also toward the use of an increasing number of taper head staybolts. In a recent demonstration test button heads as shown in the picture were taper formed under the head and the thread cut on the end and under the head at the rate of one a minute.

In operation, the rough forging is passed through the back of the forward die head for insertion in the square collet in the automatic chuck. The die has an enlarged hole in the shank and the chasers have an especially large opening movement to pass the button head which was used in the demonstration.

After being chucked, the staybolt carriage is fed forward until the end of the bolt is supported in the steady-rest between the two heads. The head end is formed by a forming cutter on the cross slide while the other end is supported in the steady-rest. Then the staybolt carriage is fed forward, the die heads operated by the cams on the rear bar close automatically and cut the threads.

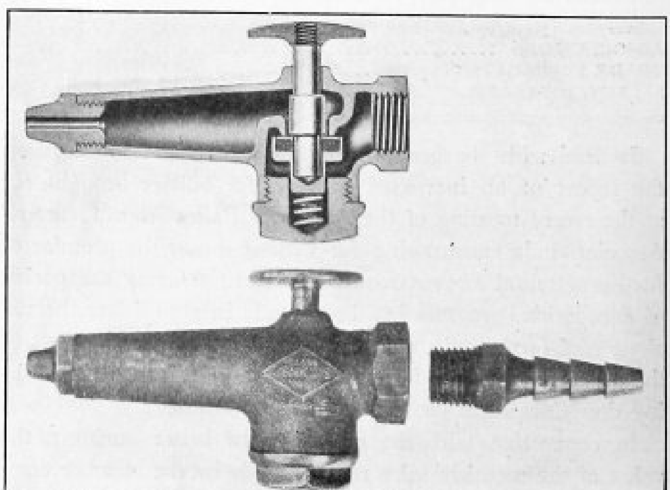
As soon as the die heads reach the end of the cams both die heads open. The cams may be made to cut any type thread desired, as the action of the head is dependent upon the contour of the cam. The carriage is then brought back and is ready for the next staybolt.

## Air Gun Designed to Prevent Waste of Air

Everyone is familiar with the more or less wasteful methods of using compressed air about shops, foundries and mill rooms owing to lack of appreciation by many shop men that it costs money to compress air. One common method of wasting air is in the use of a ½-in., or larger, flexible hose attached to the shop air line just back of a valve which controls the supply of air. When for any reason it is necessary to blow off some machine part or casting, for example, the operator turns on the valve admitting air to the hose and after directing the blowing operation from the end of the hose goes back to the valve and shuts it off again.

The above method results in considerable waste of air which it is proposed to prevent by means of an air gun recently designed and placed on the market by Jenkins Bros., New York. An assembled and cross sectional view of this valve is shown in the illustration, giving a good idea of the construction. The main advantage claimed for the valve is economy in the use of air. By means of the small tip no more air than necessary is allowed to go through the valve and the control of the air supply is by means of the button immediately under the hand of the operator. In other words, the air can be started or shut off directly at the work while the valve is held in one hand and without going to a wall or post to operate the globe valve which is commonly used.

The Jenkins air gun is simple and is said to be durable in construction with an entire absence of complicated parts likely to get out of order. It is designed to hold tight under pressure, and quickly respond to a pressure of the button which freely emits the air. The renewable disc is made especially for air service and forms a durable contact for the seat taking up automatically the wear due to frequent usage.



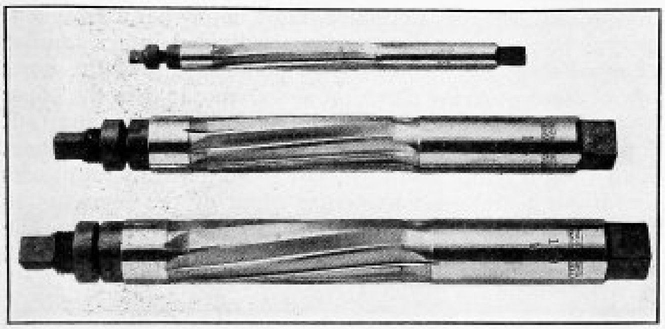
Jenkins Air Gun Featured by Air Economy and Control Button Located at Nozzle

The disc can be quickly and easily renewed if necessary. These valves are made of bronze and are adaptable to use in foundries, machine shops, mill rooms and wherever air is used for blowing purposes.

## Spiral Fluted Expansion Hand Reamers

The Pratt & Whitney Company, Hartford, Conn., has added to its line of small tools a spiral fluted expansion hand reamer. Expansion reamers have always found favor because of their long life and the adjustable feature that permits covering a range of sizes with one tool. Oversize or undersize holes can be reamed by simple adjustments. The advantages of the spiral flute with its free and clean cutting characteristics are obvious.

All reamers are equipped with lock nuts to hold the size and safety stops which prevent over-expansion and indicate positively when the maximum limits have been reached. Three sizes of spiral fluted expansion hand reamers are shown in the illustration, including ½-in., 1-in. and 1⅛-in. These reamers are made in all the regular sizes.

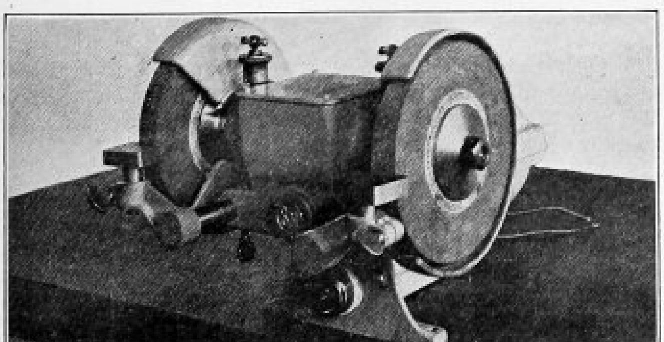


Pratt & Whitney Spiral Fluted Expansion Hand Reamers

The spiral flutes afford a distinct advantage in reaming holes having keyways in them. The straight flutes catch and bind on the edges, but the spiral continuous shearing cut rides safely over the corners assuring a hole cut to size.

## Eight-Inch Electric Bench Grinder

The Black & Decker Manufacturing Company, Baltimore, Md., announces a new model grinder known as the eight-inch electric bench grinder. This is a substantial two-wheel grinder, driven by a ¾-horsepower motor of the universal type similar to motors used in Black & Decker portable electric drills. It operates on alternating or direct current at will. Among the features of this new model is the arrangement of the grinding wheels, which are set well forward of the motor casing and arranged so that they overhang the bench. This makes it possible to grind long pieces and odd shapes with unusual facility and also makes it possible to wear the grinding wheels down to the clamp washers, thus avoiding wheel wastage.



Black & Decker 8-inch Bench Grinder

The motor is air-cooled and arranged so that the air intake is located 12 inches from the grinding wheels in order to reduce the possibility of grit being drawn into the machine. The machine is grease lubricated throughout.

The grinder is furnished complete with two grinding wheels, one coarse and one fine, 8 inches in diameter and ¾ inch wide; two wheel guards, two adjustable tool rests, an electric cable fitted with attachment plug and switch. A grinder of this type is particularly adapted to use in machine shops, and when installed at convenient locations on the benches will undoubtedly save many steps and a large amount of time formerly spent going to grinders located at a distance.

## Combination Portable Drill and Grinder

A new portable combination machine for hand drilling and grinding operations has been developed by the Wodack Electric Tool Corporation, Chicago, Ill. The tool is so designed that the motor has the correct speed for both drilling and grinding. The drilling capacity is ⅛-inch to ⅝-inch holes in steel and when used as a grinder it is fitted with a 6-inch by ¾-inch wheel. The complete weight of the machine is 18 pounds and the motor under service develops ½ horsepower.

## OBITUARY

Albert C. Ashton, treasurer of the Ashton Valve Company, East Cambridge, Mass., died on January 31, at St. Petersburg, Fla., where he had been for several weeks on account of ill health. He was born in England, 52 years ago, and was a son of the late Henry G. Ashton, founder of the Ashton Valve Company. Albert C. Ashton graduated from Chauncey Hall School, Boston, and the Massachusetts Institute of Technology where he pursued a course in engineering. For over 20 years he had served as treasurer of the Ashton Valve Company and part of this time served also as general manager. Mr. Ashton took a constant and active interest in the local affairs of Somerville, Mass., where he had resided since his schoolboy days, and he was a member of many social and business organizations.

## BUSINESS NOTES

After several weeks' idleness Sotter Brothers' boiler works at Pottstown, Pa., has resumed operations.

The Wager Furnace Bridge Wall Company, Inc., announces the removal of its office at 149 Broadway, New York, to new and enlarged quarters at the plant, 108-110 Academy Street, Jersey City, N. J.

J. W. McCabe of the Chicago Pneumatic Tool Company sales organization, 6 East 44th Street, New York, has recently returned from a three years' tour around the world in the interest of the company's foreign business.

The Wilson Welder & Metals Company, Inc., 132 King Street, New York, N. Y., manufacturers of arc welding machines and certified welding metals, announces the appointment of R. L. White as district manager in charge of Detroit office, 809 Kresge Building, Detroit, Mich.

As part of Greenfield Tap and Die Corporation's service to its customers, a carefully compiled and comprehensive telegraph and cable code has just been published. The code is included in the new 46A catalogue just issued as well as in a separate bulletin. It may be obtained from the Greenfield Tap and Die Corporation, Greenfield, Mass.

# Questions and Answers for Boiler Makers

## Information for Those Who Design, Construct, Erect, Inspect and Repair Boilers—Practical Boiler Shop Problems

**Conducted by C. B. Lindstrom**

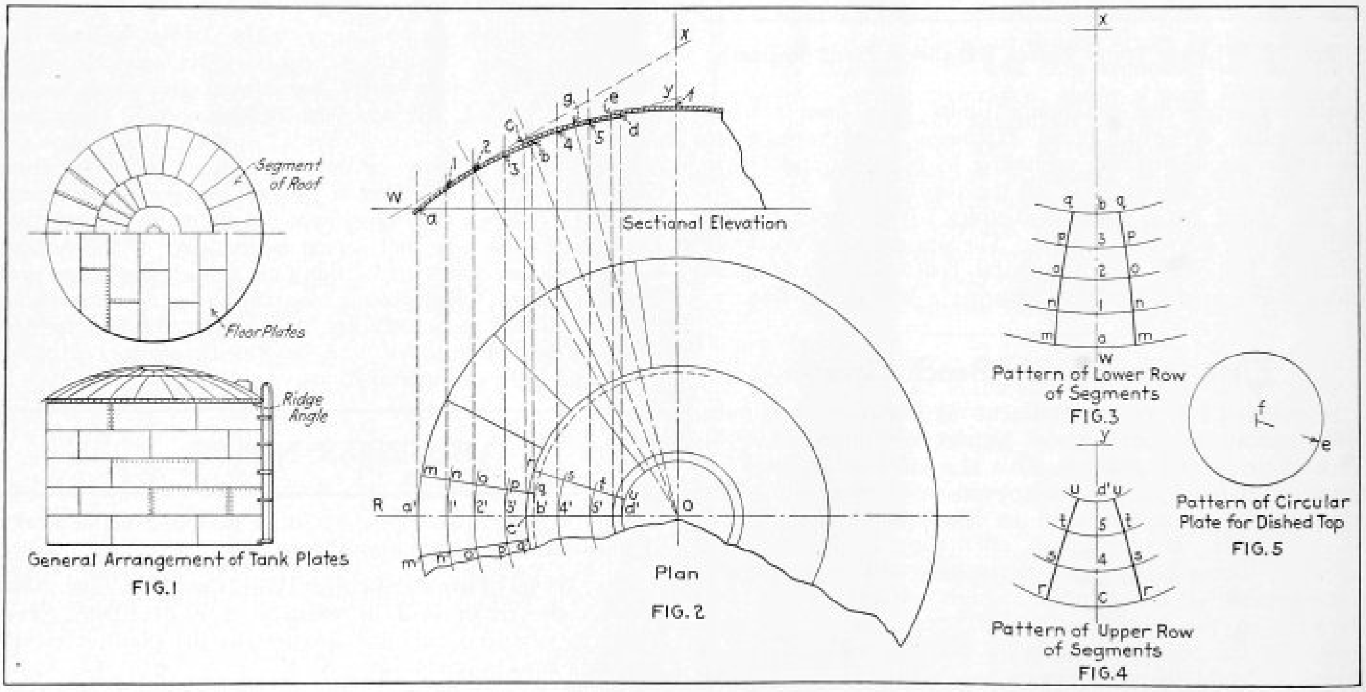
*This department is open to subscribers of* THE BOILER MAKER *for the purpose of helping those who desire assistance on practical boiler shop problems. All questions should be definitely stated and clearly written in ink, or typewritten, on one side of the paper, and sketches furnished if necessary. 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 permission to do so.*

## Umbrella Roof for An Oil Storage Tank

Q.—May we ask that in the next issue of THE BOILER MAKER you give a layout of an umbrella roof for an oil storage tank 25 feet in diameter or larger? H. A. C.

A.—The general arrangement of the respective plates for the bottom, roof and cylindrical shell of an oil tank of large size is shown in Fig. 1. The roof is made up of segments or gores assembled with overlapping seams or butt jointed with the use of cover straps. The top piece is circular and dished to conform with the curvature of the roof. All lap seams should be made so that the water does not flow against the lapped edges. A ridge angle of proper shape is riveted to the shell plate and to this angle the lower segments are fastened.

Fig. 2 illustrates a method of developing the segment patterns. In view of the double curvature to which the roof sections are made, the pattern layouts are an approximate development, but the work can be so carried out that their shape conforms practically to the exact form required. A section of the plan and elevation is laid off to show one of the segments in each row and also the outline of the dished top connection. For convenience in the development work, if possible, bring the center lines of the segments to lie on the line R-O. The roof curvature for each row is laid off in this instance from center O, but in actual cases the roof dimensions for the respective radii must be used. The neutral layer of the plate section is divided into a number of equal sections as shown from point a to b of the lower row of segment of the elevation and from c to d in the upper row. Projection lines are drawn vertically to the line O-R from the points 1-2-3-4 and 5, as indicated in the plan view. With O as a center and O-1′, O-2′, O-3′, etc., as radii, arcs are drawn to intersect the outer edges of the segments as represented at m, n, o, p, q, r, etc. In the elevation the line w-x is laid off at right angles; that is, square to the radial




**Details of Umbrella Roof Layout**

line O-2, and from the point 2. The line y-c is also laid off square to the radial line O-g. These lines are used in the pattern layouts. Sufficient data are now given for the pattern constructions.

### LAYOUT OF PATTERNS

In Fig. 3 the pattern for the lower segments is laid off as follows: Draw the straight line as x-w, making it equal to x-w of the elevation, Fig. 2. With x as a center and from point w draw an arc. Set off the arc lengths a-1, 1-2, 2-3, etc., from the elevation, Fig. 2, locating them as shown on x-w, Fig. 3. Draw arcs through the points 1-2-3 and b, using point x as a center. Make m-m, n-n, o-o, p-p and q-q of Fig. 3, equal respectively to the corresponding arc lengths in Fig. 2. The allowance for laps on the side must be made if the segments are jointed in this manner. If butt seams are used no allowances need be made. The corner q laps under the next row of segments and to make a snug fit where lap seams are used they should be scarfed; that is, thinned down.

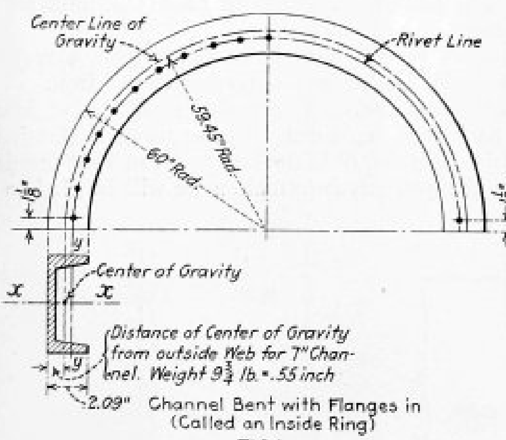
The construction of the pattern, Fig. 4, is similar to that described for Fig. 3. The radius y-c in this instance is used, and the arc lengths c-4, 4-5 are set off from the point o. The arc lengths r-r, s-s, t-t and u-u equal those of the plan view.

The pattern for the dished head is drawn with a radius equal to f-e of Fig. 2. The line f-e is a dotted diagonal connecting the extremities of the plate as taken from the outer edge at the neutral layer of the plate and the center of the disk. In forming the plates where the curvature is compound or double it is necessary to do some preliminary experimenting so as to get the segment to the proper shape. This is advantageous from the standpoint of saving time in handling the work. When the curvature is deep and the plate heavy, it will be necessary to heat each segment for forming. Where a large quantity of this work is to be handled, forming dies should be employed.

## Method of Determining Stretchout of Channels Formed into Rings

Q.—What would be an acceptable formula for laying out a channel straight so that there are 10 holes spaced equally in one quadrant of a circle and 12 spaced equally in another quadrant? Fig. 1 shows a 7-inch channel weighing 9¾ pounds per foot, which is to be rolled to a 5-foot radius with the web facing the center. The rivet holes are to be ⅝-inch through the web and both flanges. R. E. D.

A.—There are a number of methods applied in determining the length of angle bars, tee iron, channels, etc., which give very close results. For irregular sections, the neutral axis, that is, the axis on the center of gravity of the section of the structural member, should be found first. The structural handbooks give this information; thus, for a 7-inch channel weighing 9¾ pounds, the distance of the center line



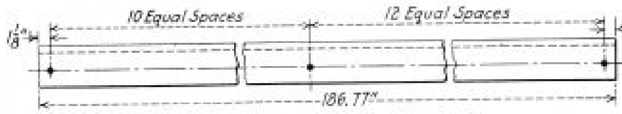

Channel Bent with Flanges in (Called an Inside Ring)

FIG. 1

of gravity $Y$-$Y$, Fig. 1, measures 0.55 inch from the outside face of the web of the channel, as shown in the illustration. Fig. 1 shows a channel bent with the flanges inside the ring, the back of the flange being on the outside. Such a ring is called an *inside ring*, as it would fit inside a cylinder.

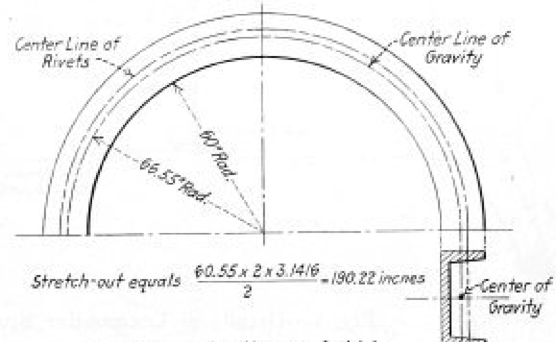
The length of the stretchout is calculated by assuming that the length will not increase or decrease along the neutral axis as taken on line $Y$-$Y$ of the section. Basing the diameter from the viewpoint it equals $59.45 + 59.45 = 118.9$ inches. For a complete ring, the stretchout equals $3.1416 \times 118.9 = 373.54$ inches, and for the half ring the length equals $373.54 \div 2 = 186.73$ inches. To lay off the rivet holes, establish the center of the channel bar, and in this case space off from this center rivet the required number of equal spaces. The center line of rivet holes is laid off at the middle of the inside of the flange.

In Fig. 3 is shown a half ring rolled so that the back or face of the channel would fit on the outside of a cylinder. The respective dimensions are indicated for this arrangement




Stretch-out of Channel in the Straight

FIG. 2




Channel Bent with Face of Web in (Called an Outside Ring)

FIG. 3

and by noting the position of the cross section of the channel, I believe the conditions will be readily understood. The length of the channel required is figured, as in the preceding example, from the neutral axis. Thus, $\frac{60.55 \times 2 \times 3.1416}{2} =$ 190.22 inches, the required stretchout. The rivet holes would be laid off as previously explained. It should be borne in mind that it is essential to heat the channel so that it is uniformly heated throughout its entire cross section, otherwise the parts that are not thoroughly heated will produce an irregular flow of the metal during the bending operation that may lead to buckling of the flanges or web.

## Pressure on a Nozzle Stand

Q.—Will you please advise me how much pressure is on a nozzle stand of a locomotive boiler carrying 200 pounds steam when the engine is working at full capacity handling a train?—W. A. J.

A.—At the front end of the locomotive type boiler is arranged a conical shaped blast pipe or nozzle, as it is often called. The exhaust steam from the cylinders passes through the nozzle and in so doing is expanded in its upward rush through the nozzle and stack. This action of the steam produces a partial vacuum in the smokebox, thus causing, due to the many impulses of the exhaust, a draft for increasing the flow of gases from the firebox to the stack.

The pressure acting within the nozzle depends on the exhaust pressure which can be measured by connecting a pressure gage to the nozzle stand. This pressure decreases as the steam expands and passes through the stack. We have no specific data on this condition but possibly some of our readers can provide more definite information.

## Flue Welding Forge

Q.—Can you give me some idea how to build a flue welding forge? I have been having a great deal of trouble getting my flues hot enough to weld on a Hartz flue welding machine.—J. P. M.

A.—In your case it would be advisable to take this matter up with the manufacturers of tube furnaces listed in THE

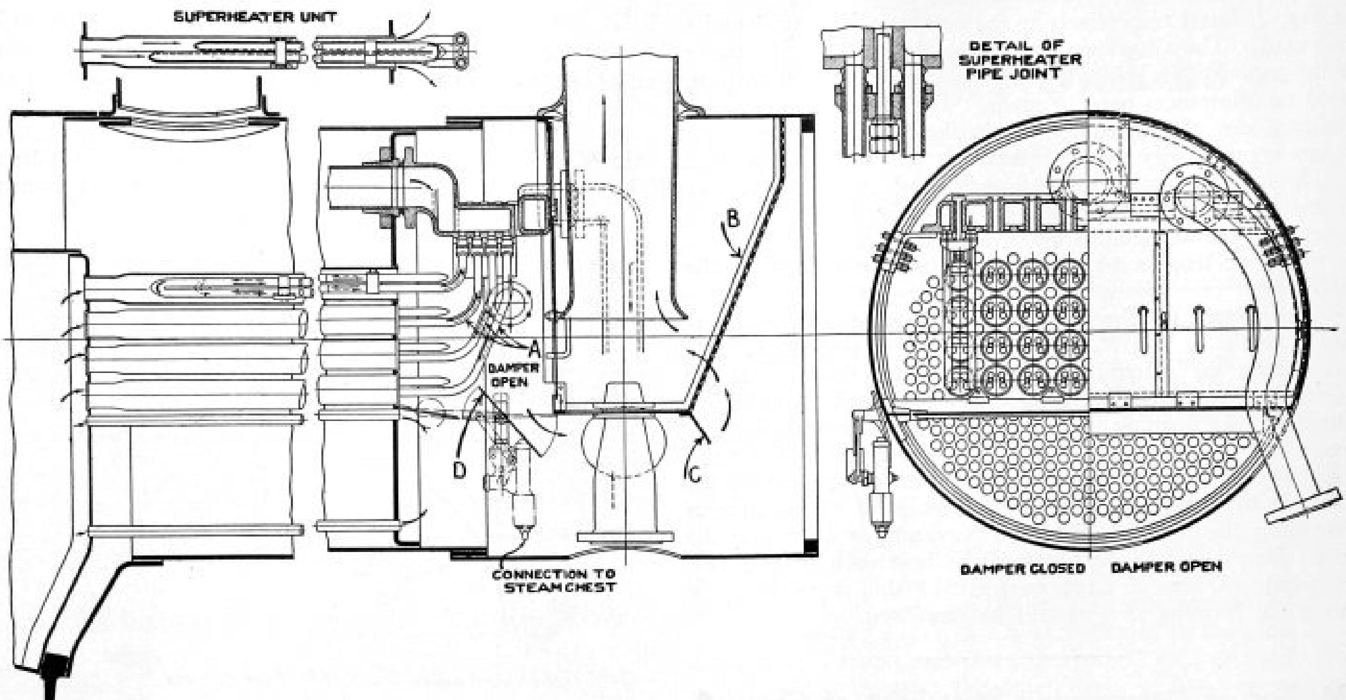



Fig. 1.—Details of Locomotive Front End Equipped with Through-Bolt Superheater

BOILER MAKER, who will gladly help you with your problem of getting the proper heat for welding. In one of the recent issues of THE BOILER MAKER an example of furnace construction is given (page 24, January issue), showing an arrangement for heating three tubes at one time.

## Laying Out Front Ends of Locomotive Boilers

Q.—Please publish the layout of a new front end in a superheater engine. Give details on how to get the height for the exhaust pipe, and also for a front end in a saturated steam engine. I would also like to know how to plug a large flue to stop the draft where there isn't any unit, as the header has been cracked where this unit came out and the holes in the header were stopped up with brass studs. I wish to do this, as there is extra wear on the back angle iron that the back plates are resting on.—H.E.C.

A.—The drawing, Fig. 1, illustrates a side and end view of the front part of a locomotive boiler arranged with a superheater. Superheater tubes are shown at A, the deflector plate at B, the draft plate C is placed below the deflector. By raising and lowering the plate the draft in the tubes can be regulated. A damper is arranged at D which is closed and opened by the steam throttle located in the cab.

The sketch, Fig. 2, shows the layout for the pattern of the deflector plate, draft plate and damper. View (a) is a front view and (b) a side view. Line *m-n* is divided into a number of equal parts and projectors from these points are drawn to pass through the end view (a). The pattern for this piece can now be laid off. Draw first a straight line *x-y* equal to the length *m-n* of the side view and space it into the same number of equal parts. At right angles to *x-y* and through the points on this line draw projection lines. Transfer the lengths 1-2, 3-4, 5-6, etc., from the end view (b) to the pattern locating the points 2′-4′-6, etc. Draw an outline of the curved section through these points, which is a part of an ellipse. The pattern for the draft plate C is laid off in the same manner.

The pattern for the damper in this case is a rectangular piece, 16 inches by 70 inches, riveted to bar iron.

The deflector plate of a saturated steam boiler would be laid off as herein explained. Please make a sketch of the part you are referring to in the latter part of your inquiry and if we can give you any information we will be glad to do so.

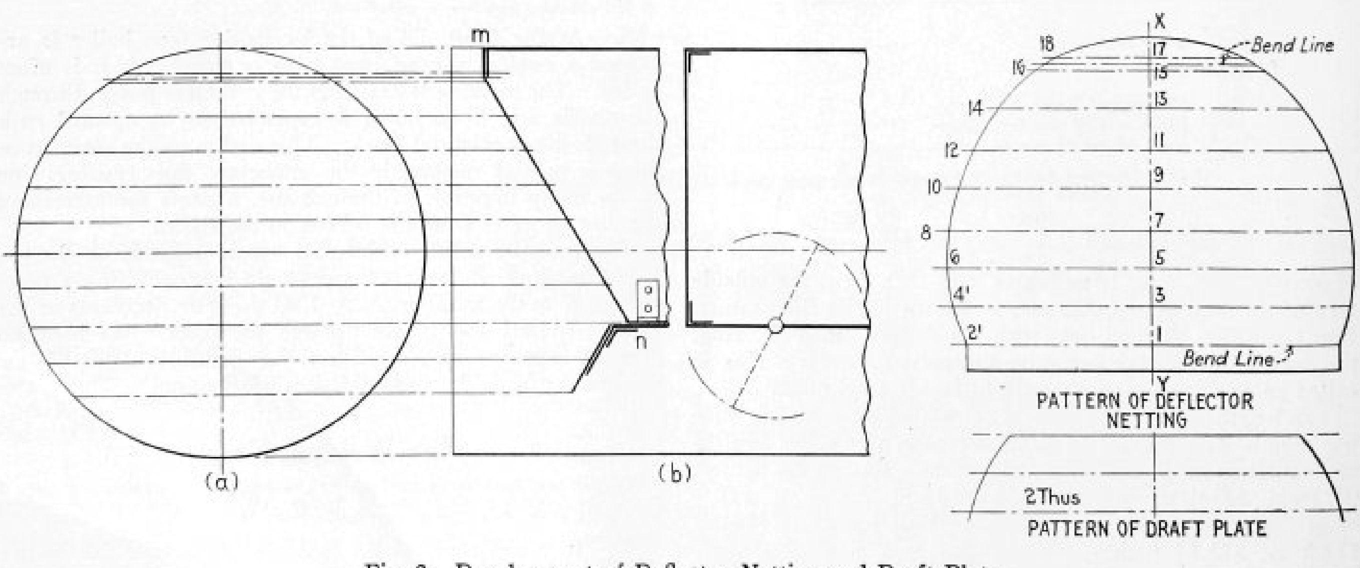



Fig. 2.—Development of Deflector Netting and Draft Plate

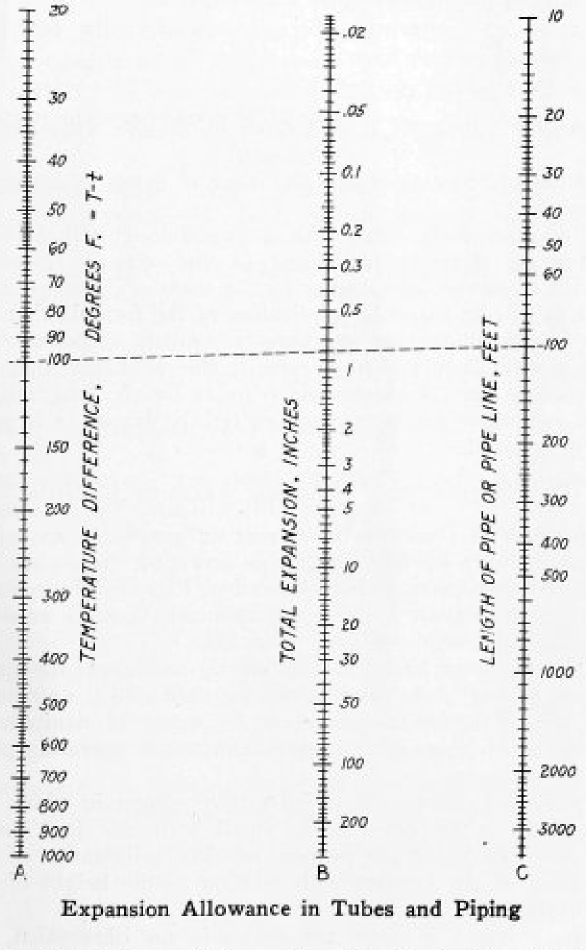
# Letters from Practical Boiler Makers

**This Department Is Open to All Readers of the Magazine —All Letters Published Are Paid for at Regular Rates**

## A Useful Expansion Chart for Boiler Makers

Boiler makers will find the accompanying chart useful for determining the expansion to be allowed in piping, rods, tubes, etc., for various temperature differences without doing any "long hand figuring" whatsoever.

To use the chart, simply lay a straight edge across it once, or stretch a fine black thread across it, as indicated




**Expansion Allowance in Tubes and Piping**

by the dotted line and the problem is solved without further ado.

For example, a certain pipe line is installed which is 100 feet long. It will be subjected to a temperature variation of 100 degrees F. What will be the total expansion in inches?

Connect the 100 degrees temperature difference, Column A, with the 100 foot length, Column C. The intersection with Column B gives the answer as 0.8 inch. That's all there is to it. Very simple indeed.

Inversely the chart can be used for determining the allowable temperature difference where a definite amount of space is available for expansion and contraction. Thus if the length of the pipe line is 100 feet and the allowable expansion is 0.8 inch, the same line would show that a temperature difference of 100 degrees F. would be the limiting amount.

Also, if the factors in Columns A and B are known, the unknown in Column C is immediately found. In other words, if any two of the factors are known, the third factor is very quickly found and without any computing whatever.

It will be noted that the range of the chart is wide enough to take care of almost any expansion or contraction problem that the boiler maker may have to contend with. The temperature difference, Column A, varies all the way from 20 degrees to 1,000 degrees. It is very seldom, if ever, that we have as high an amount as 1,000 degrees. The length of pipe line, also, is great, varying all the way from 10 feet to 3,000 feet, or more than half a mile. And the total expansion between these limits varies all the way from 0.02 inch to 200 inches. It is interesting to note that, if we had a pipe line 3,000 feet long, with a temperature difference of 1,000 degrees, the expansion would be over 200 inches.

Newark, N. J. N. G. Near.

## Importance of the Telltale Hole

Telltale holes in staybolts are drilled for good and sufficient reasons, but oftentimes in the rush of an inspection as careful an examination of the bolts is not made as should be for safety's sake. The writer has seen many broken staybolts discarded in time only because they were carefully examined through the telltale hole. The following example of carelessness in shops indicates that it is not only necessary to find trouble, but also to remedy it at once.

In this instance the foreman in charge of a railroad repair shop neglected his duty after he was told of a broken staybolt in a boiler, by not having it immediately renewed. The boiler maker on the job reported in good faith that the sheet was leaking around one of the bolts. Orders were given to plug the hole until the bolt could be renewed, but the work was overlooked and the job not carried out when the engine was taken out of shop on what proved to be a fatal trip.

### Details of Explosion Which Resulted

The back head on this boiler was pitted along the mud ring for a considerable distance and to a minimum thickness of 1/8 inch. The broken staybolt was located in the bottom row and was the second bolt from the right. While the engine was on the road, the sheet ruptured at a point 6 inches to the right of the center line of the back head and for a distance of 23 inches along the mud ring, throwing the plate back a distance of 1 5/8 inches from its original position.

After the accident an investigation was held and the following findings made: 14 broken bolts next to the door sheet after the accident, 26 bolts in the two bottom rows which were fractured from very slight to approximately two-thirds of the cross sectional area prior to the accident and 6 broken bolts in the bottom row prior to the accident. It was found impossible to apply the hammer test to the staybolts that were in the bottom row as they were behind the grate bearings, and it was also impossible to get at the outside end of the bolts to hammer test.

Rule 25 of the Interstate Commerce Commission reads as follows: "No boiler shall be allowed to remain in service when there are two or more adjacent broken or plugged bolts in any part of the firebox or combustion chamber nor when three or more are broken or plugged in a circle, four feet in diameter, nor when five or more are broken or plugged in the entire boiler."

The rule is a good one, but why not specify that whenever a staybolt is cracked or broken it shall be renewed immediately and not give time between the discovery and correction of trouble for a disastrous accident. The telltale hole is there for the purpose of giving a warning and its warning should be heeded.

Olean, N. Y. INSPECTOR.

## Everyday Questions Answered for Apprentices

Q.—Of what benefit are the heads of crown bolts?

A.—The head of the crown bolt adds nothing to the strength of the bolt itself, but aids in preventing the deformation of the crown sheet between the bolts.

Q.—About what is the proper length required for a bead on a flue?

A.—This always depends upon the size of the flue and the beading tool you are working with. Some railroads advocate large beads, some small; however, generally on small flues allow from 1/4 to 3/8 inch.

Q.—About how far should a staybolt project beyond the sheet for a staybolt head?

A.—About 2 1/2 or 3 threads. Excessive allowances make it difficult to upset the bolt in the sheet.

Q.—If you discover a thin place in the boiler shell what course would you take?

A.—Order the defect properly repaired and order the boiler out of service until the repairs had been made, or perhaps permit the boiler to remain in service by reducing the working pressure per square inch. This, however, would depend upon the location of the defect.

Q.—When rivet holes are punched should they be punched small and reamed out?

A.—When rivet holes are punched they should be punched 1/4 inch less in diameter than the size of the rivet hole desired, and then reamed out to the required size. After the holes are reamed, the sheets should be taken apart and the burrs removed between the sheets. Burr ream the rivet holes, or in other words chamfer the holes.

Q.—What is the smallest size staybolt that should be used in boiler construction?

A.—It is not advisable with high pressure boilers to use staybolts smaller than 7/8 inch in diameter.

Q.—Where should the lowest gage cock be located to give the best results?

A.—The lowest gage cock should be located about 3 inches above the highest point of the crown sheet.

Q.—What causes priming?

A.—Priming is caused by the following: water too high; insufficient steam space; misconstruction of the boiler, and engine too large for the boiler.

Q.—What effect has cold water on hot plates?

A.—Liable to fracture them.

Q.—Of what use is the steam dome?

A.—For the storage of dry steam.

Q.—Why do we have safety valves on boilers?

A.—To relieve the boiler of all pressure above the required amount.

Q.—What causes foaming?

A.—Dirty and impure water.

## Principles of Riveted Joint Design

(*Continued from page 69*)

having a range in tensile strength of 45,000 to 55,000 pounds per square inch."

Although nothing is said with regard to the efficiency of the longitudinal joint, it may be seen from the foregoing paragraph that by allowing an ultimate tensile value of 28,500 pounds per square inch for material that is actually good for a breaking stress of 45,000 pounds per square inch, the joint has really been allowed an efficiency of:

$$\frac{28,500}{45,000} = 63.25 \text{ percent}$$

PRACTICAL EXAMPLE OF PRESSURE VESSEL HAVING HAMMER WELDED LONGITUDINAL JOINT

Problem: Given a pressure vessel, 60 inches in diameter, shell plate 3/8 inch thick and having its longitudinal seam welded by the forging process, to determine the maximum safe working pressure allowed under the American Society of Mechanical Engineers' Boiler Code rules.

Solution: Substituting values in the formula for safe working pressure we have:

$$P = \frac{28,500 \times 0.375}{30 \times 5} \text{ or } 71.25 \text{ pounds per square inch.}$$

(It should be noticed that the factor of safety is employed as usual.)

This same shell, fitted with a riveted longitudinal joint, having an efficiency equivalent to that actually given a welded seam and also employing the usual "55,000 pound" steel, it will be found by application of the formula that the resulting maximum safe working pressure is 87 pounds per square inch, from which we come to the conclusion that the restrictions upon hammer welded joints for the longitudinal seams of steam boilers are not as tightly drawn as is generally believed.

DESCRIPTION OF A HAMMER WELDING MACHINE

In order to convey to the reader in a general way, just how a hammer welding machine is arranged, the author has prepared the accompanying illustration, Fig. 58, which shows the more important parts of the apparatus usually entering into the construction of such a machine.

Only the lower burner and its piping are shown; the upper burner, piping, and operating rig, together with the air hammer, are all carried from overhead supports and manipulated by means of levers placed convenient to the operating platform.

Particular attention is called to the manner in which the long horn is supported. The small hydraulic jack under the rear end is for the purpose of close adjustment of the elevation of the burners with relation to the height of the seam above the floor.

Stop-valves and cocks, not shown in the illustration, are placed in the air and gas lines for properly controlling the supply of fuel to the burners.

The movable supporting carriage for the cylinder being welded is not shown in the illustration. It travels on the lower floor in the runway indicated and has a traverse of approximately 40 feet.

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The Bureau of Mines has undertaken an investigation of the mechanism of scale formation in steam boilers. The object of the investigation is to determine if the character of the precipitates forming in boilers may be made to assume a form in which they do not attach themselves to the walls.

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# TRADE PUBLICATIONS

Pipe Machines.—Stoever pipe machines for cutting and threading steel or wrought iron pipe are illustrated and described in a neatly arranged booklet of 16 pages recently issued by the Treadwell Engineering Company, Easton, Pa.

Generator Cooling Apparatus.—The B. F. Sturtevant Company, Boston, Mass., has issued Bulletin No. 246 describing and illustrating in detail its generator cooling apparatus. A psychrometric diagram showing the percentage of relative humidity has also been included in the bulletin which contains 27 pages.

Gasoline Power Units.—The Buda Company, Chicago, has issued bulletin No. 388, describing a four-cylinder gasoline power plant, which it has recently developed for use in driving electric generators, arc welding sets, triplex or other types of pumps, hoists, concrete mixers, air compressors and for similar uses in machine shops, etc.

Locomotive Boosters.—The Franklin Railway Supply Company, New York, has issued a new bulletin, No. 976, describing the locomotive booster and showing how it helps in railroad operation. The possibilities of increased tonnage and greater revenue earning capacity from locomotives equipped with a booster are pointed out and diagrams are given which graphically show the increased tractive power in starting and at slow speeds.

Oil Boilers.—A 32-page illustrated booklet has been published by the Denver Fire Clay Co., Denver, Colo., in which oil burners are described and illustrated. According to the foreword of the booklet, the purpose of the catalogue is to aid in the selection of fuel and oil burning equipment by describing what has been found through experiments, much study and competition to be the best methods of burning liquid fuel. Complete description and specifications are given.

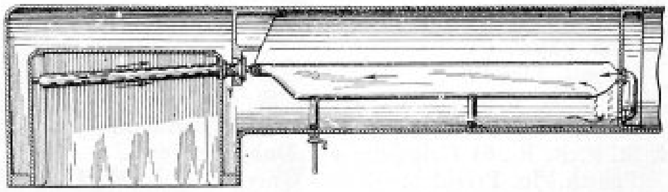
# SELECTED BOILER PATENTS

Compiled by
GEORGE A. HUTCHINSON, Patent Attorney,
Washington Loan and Trust Building,
Washington, D. C.

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

1,403,534. BOILER CIRCULATING DEVICE. VITTORIO ANDRIOLI, OF NEW YORK, N. Y.

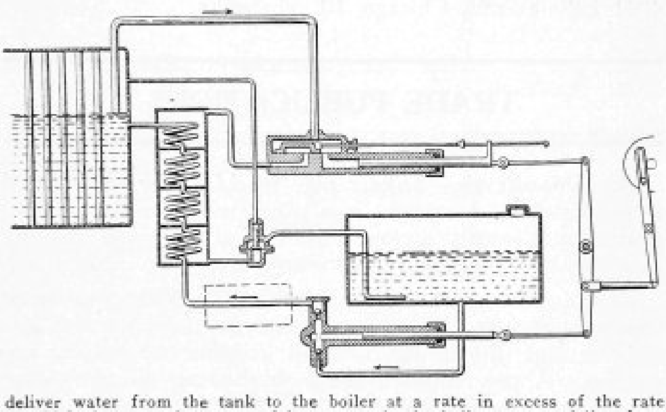
*Claim* 1.—The combination in a device of the character described, with a boiler having a firebox, cages attached to the firebox and boiler and com-



municating with the interior of the boiler, collector tubes positioned at opposite sides of the boiler exterior of the firebox, feeding tubes communicating with the collector tubes and passing through the cages into the firebox, heating tubes surrounding the feeding tubes and carried by and communicating with the cages, and means for conveying water separately to the collector tubes from opposite sides of the boiler. Three claims.

1,401,892. WATER LEVEL REGULATOR FOR STEAM BOILERS. FRANCIS I. DU PONT, OF WILMINGTON, DELAWARE, ASSIGNOR TO DELAWARE CHEMICAL ENGINEERING COMPANY, OF WILMINGTON, DELAWARE, A CORPORATION OF DELAWARE.

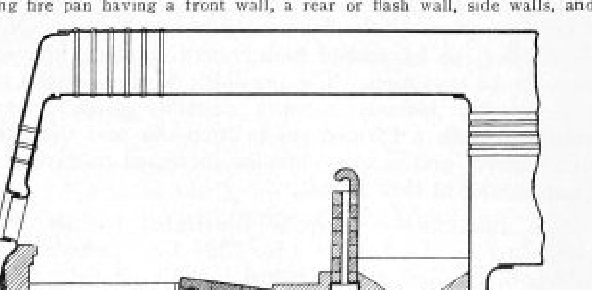
*Claim* 1.—In an apparatus for regulating the water level in a steam boiler, the combination with a water supply tank, of a water line extending from the tank to the boiler, means in said line between the tank and boiler to



deliver water from the tank to the boiler at a rate in excess of the rate at which the water is converted into steam in the boiler, a second line from the boiler to the tank to which passes the water from the boiler which rises above a predetermined level, means in the second line between the tank and boiler for withdrawing a predetermined volume of fluid from the boiler in a given time and transferring it to the tank, and a heat interchanger in said lines to transfer heat from the outgoing fluid from the boiler to the ingoing water without intermingling in the interchanger. Twenty-three claims.

1,340,202. OILBURNING LOCOMOTIVE. JAMES T. ANTHONY, OF EAST ORANGE, NEW JERSEY, AND GUY M. BEAN, OF LOS ANGELES, CALIFORNIA, ASSIGNORS TO AMERICAN ARCH COMPANY OF NEW YORK, N. Y., A CORPORATION OF DELAWARE.

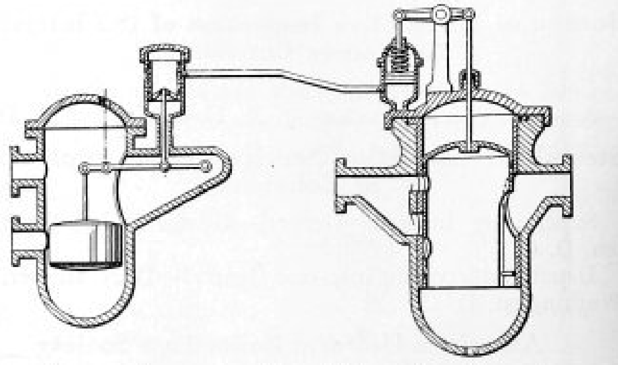
*Claim* 1.—In an oil burning locomotive, the combination of a firebox, a depending fire pan having a front wall, a rear or flash wall, side walls, and



a floor, a traverse wall in the firebox ahead of the pan, a refractory arch at the forward end of the pan between the firebox and the pan, an air inlet in the front wall, a burner projecting there-through, and openings in the side walls for admitting additional air. 6 Claims.

1,383,936. BOILER FEED WATER REGULATOR. WILLIAM E. GUISE, OF RITTMAN, OHIO.

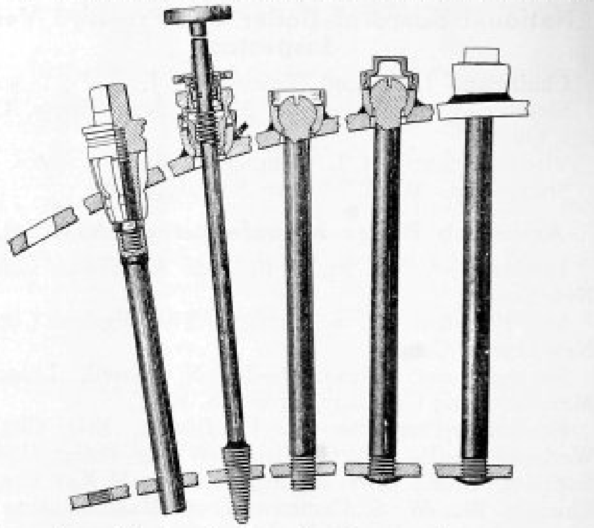
*Claim* 1.—The combination of a valve casing having an inlet and an outlet port, a sleeve valve mounted to reciprocate in said casing and having an inlet port always in register with the inlet port of the casing



and an outlet normally out of register with the outlet of the casing, pressure controlled means for holding said valve in normal position, a receptacle having a float, a valve connected to reduce the pressure in said means on the lowering of the float to a predetermined point thereby moving the sleeve valve to bring its outlet port into register with the outlet of the casing. Three claims.

1,401,611. TOOL FOR APPLYING STAYBOLT SLEEVES TO BOILERS. FREDERICK K. LANDGRAF, OF PITTSBURGH, PENNSYLVANIA, ASSIGNOR TO FLANNERY BOLT COMPANY, OF PITTSBURGH, PENNSYLVANIA.

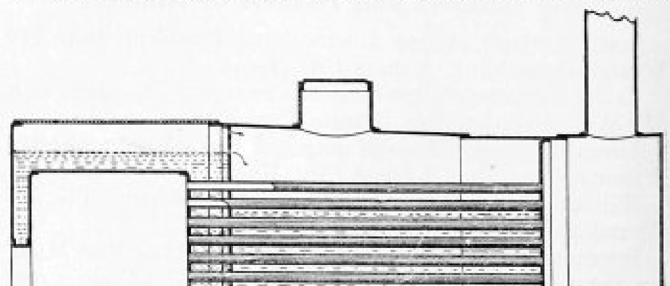
*Claim* 1.—In a tool for applying staybolt sleeves to boiler sheets and holding the sleeves while they are welded or otherwise secured to the



outer sheet, the combination of a bar adapted to pass through two sheets of a boiler, a centralizer mounted to slide on said bar and adapted to engage the staybolt sleeve and means within the centralizer for locking the latter at any point on the bar. Fourteen claims.

1,385,386. LOCOMOTIVE BOILER. JOHN P. MONGAN, OF MINNEAPOLIS, MINNESOTA.

*Claim* 1.—A combination with a boiler of the locomotive type, of a baffle plate applied within the boiler forward within the rear end of the flues and through which the flues are passed to the flue sheet of the fire box,



said baffle plate having a water passage above the level of the flues and above the top of the fire box, whereby a higher level of water may be maintained in the rear compartment of the boiler than in the front compartment of said boiler, all of said flues being covered with water at the rear of said baffle plate, but certain of the upper flues, forward of said baffle plate, being above the water level in the front compartment of the boiler, so that they will be exposed in the steam chamber thereof. Two claims.

# The Boiler Maker

APRIL, 1922

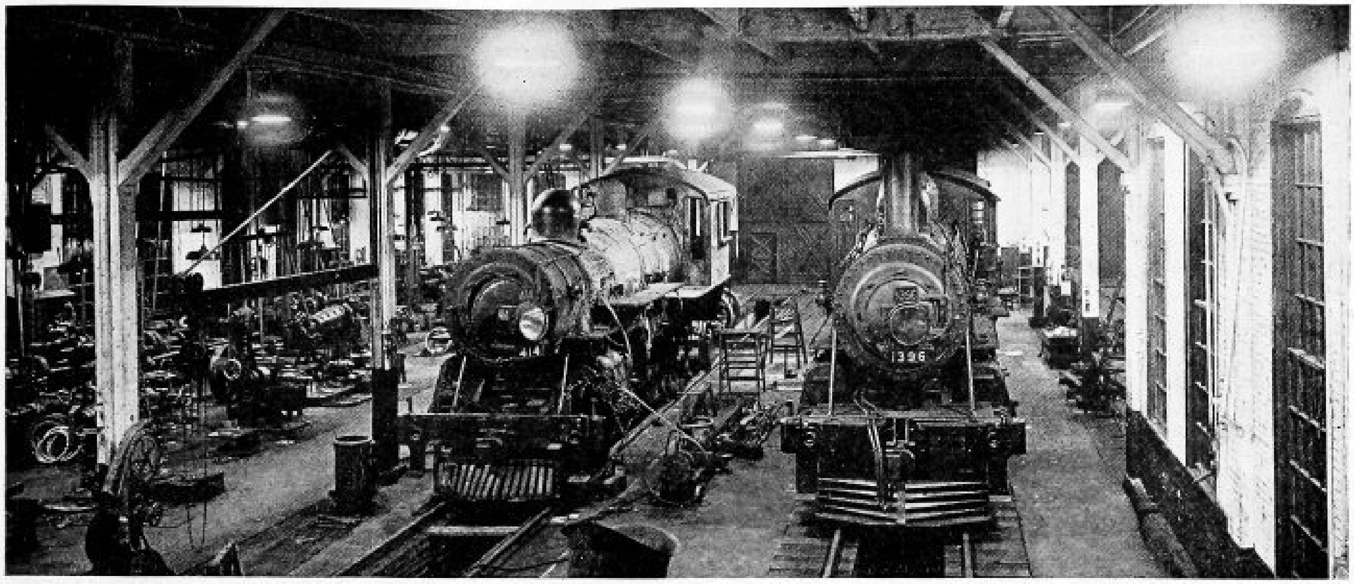


**Fig. 1.—Night View in Railroad Shop, Lighted by 400 Watt Mazda C Lamps in Standard Dome Enameled Steel Reflectors Spaced 20 Feet Apart and at a Height of 17½ Feet**

## How Good Shop Lighting Aids Production

*The accompanying article has been compiled from various sources with the object of pointing out the effect of poor shop lighting and the steps that have been taken, and the means that are available, to eliminate a great deal of the production loss due to inadequate systems of illumination. As an introduction to the technical data on shop lighting, the following story points out the very great effect that lighting had on Jim Howells, who is typical of every good workman forced through necessity to labor under poor lighting conditions.*

JIM HOWELLS was an old man, a layer-out in a boiler shop, who wore, when on the job, two pairs of spectacles. He wore two pairs because he had to wear two pairs. And he was so old in the business he could not remember the time when he did not have a piece of chalk somewhere about him in his clothes. Jim was stooped and slow of movement and he walked about the shop with an abstractness and lack of interest in things other than his work that somehow set him apart from the other workmen. His hair was gray and his eyes were gray—when these could be seen, which was not often, because Jim always carried his head down. You've seen Jim's type in a good many boiler shops around the country—most of them poorly lighted.

The plant where Jim worked was an old institution. It stood on the edge of the town, where all such plants usually stand. Viewed structurally it was anything but pleasing. Its scattered frame buildings, not more than hulks, were weather-beaten and tilting; the doors and windows of these buildings were crumbling at the sills or else hanging askew on rusted and broken hinges; the whole plant gave the impression of being on its last legs and beckoning for the sheriff. Yet this was only an impression. For the organization was a good one and had declared dividends regularly for years; and moreover gave promise of doing so for many years to come. A man might not believe this, but you've seen boiler shops like it around the country, just as you've seen boiler makers like Jim Howells employed in these shops.

The shop in which Jim worked was exactly the kind of place you'd think it would be from the outside. Its walls were dark and though once in so often the management gave the interior a coating of whitewash, the coating soon wore off, leaving the gloom of the place darker than ever, it seemed.

And the lighting arrangement was a joke. Single-drop incandescents, spaced about two miles apart, with the globes of these lights thick with grime and dust, summed up the lighting facilities of this plant. Under these lights, for longer than he could remember, Jim had squinted his eyes reading blueprints, and otherwise trying to keep a focus upon his work in order to serve the organization. Of late, owing to the pressure of work, Jim had done a great deal of squinting in this fashion, in order to get the work out on time.

It was becoming steadily more apparent to him and to his foreman that there was a change coming over him. Yet he said nothing, though often he found himself snatching

Note—The photographs used to illustrate this article are published through the courtesy of the Illuminating Engineering Society, the Westinghouse Lamp Company, the Edison Lamp Works of the General Electric Company, the Staten Island Shipbuilding Company and the Truscon Steel Company.

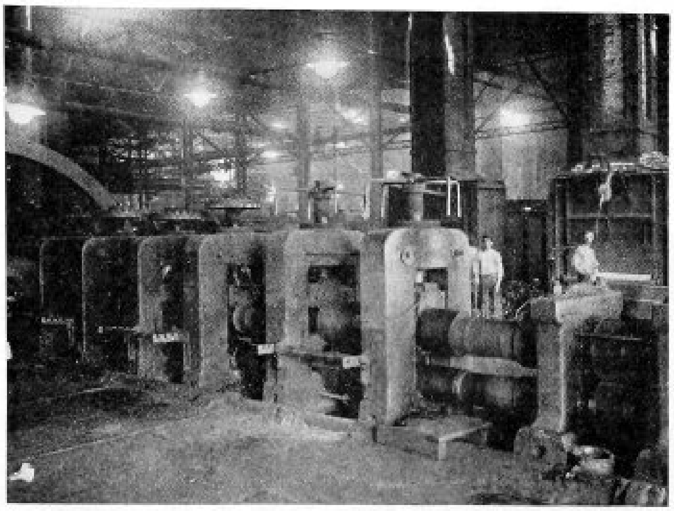


Fig. 2.—Lighting Steel Rolls With Gas Lamps

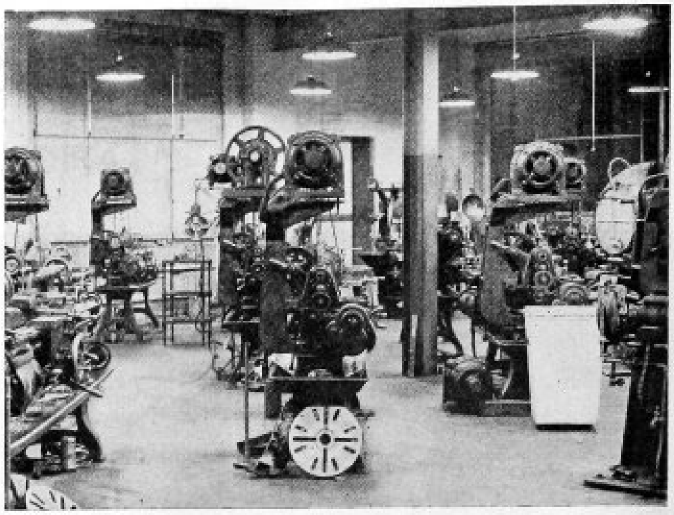


Fig. 3.—An excellent Arrangement of Machine Shop Lighting

off his two pairs of spectacles and peering through them up at the single drop incandescent over his head. Jim certainly was suffering from the quality and the quantity of the light he was compelled to work under. Candles he was much too nervous to juggle with; and one day in a fit of temper he threw down his chalk and went to the foreman.

The foreman well knew Jim's circumstances. Jim had not been exactly improvident, but he had been unfortunate in certain small real estate ventures and the foreman knew that he could not well retire off the payroll. He said nothing of this, however. But he did try to talk Jim into resuming work at the layout bench, all the while trying to determine Jim's real trouble. He could see, as Jim's fellow-workmen saw, that Jim was not himself. Jim proved this himself, directly, by opening up on the foreman with an irritable outburst of temper never known before to come from his thin lips.

Jim quit the job.

One evening some weeks later, the foreman sent for Jim, at about the time that the night shift was supposed to report for duty. Jim kissed his wife dutifully, and wondering greatly at the call, left the house. As he stepped out at the gate, his head was bowed as usual, but he was thinking more deeply than ever. Debts had piled up on him in his period of idleness and, cost him what it might, he was resolved, if the foreman mentioned it, to return to work. But he dreaded it and yet he did not know why. In loafing around the house he had found his health and usual good nature returning and in this at any rate he was glad. But he needed work—must have it to subsist—and so he was resolved to go back to the shop.

As he trudged along, his thoughts took shape on many things. Sometimes he found himself pondering on his apprentice days, days when he was young and vigorous and capable of a big day's work and when with the close of the day's work he would return to the little woman—then a rosy cheeked lass—tingling all over pleasantly with a feeling of honest and well-earned weariness. Again his thoughts would flash ahead of him, to the shop and the dragging hours he had spent there since the nightwork was established and he would almost pause in his stride. He was getting old and useless. Whether he wanted to or not,

Fig. 4.—Mercury Vapor Lamps, Spaced 20 Feet Apart Are Used to Illuminate This Plant

he perceived that the day was not far distant when he would have to quit work for good and all.

Now, there was in store for Jim Howells a pleasant surprise. Jim did not know it, of course, and he did not notice the change coming to pass, because the thing was being introduced while Jim himself was sleeping his restless slumber at home. But the management had waked up. The subject of light in that shop had been well gone into and even as Jim now was making his laborious way to the shop for his customary night of toil, the shop itself had undergone a wonderful change.

Group lights had been installed freely about and the best lamps on the market were blazing forth a radiance never before known to that establishment. A light equal almost to daylight had been installed, and it was lighting up the surrounding territory about the shop through the windows in a great brilliancy. Yes; Jim was in store for a surprise.

Head bent, steps dragging, Jim rounded the last corner but one from his work. He did not see the unusual splendor of the place. Indeed, it is doubtful, he being of an introspective nature anyway of late, that it would have made any impression upon him if he had. He stepped along with his eyes on the ground, gained the employees' entrance to the shop, entered the shop with his usual calm sobriety, rang up the time clock and made his way down the side to his work bench.

Here—as he had been doing for nights without number—he sought out his overalls and jumper and prepared to put them on. And he did put them on, after placing his lunch basket in its customary place free from flying chips and the grease and grime of the work. All this done, he adjusted his two pairs of spectacles and looked over the parts of a layout which he was working upon for one of the boilers.

Slowly something dawned upon him. It was a long time sinking in, because Jim was a man of absent temperament anyway—had become so through the long years—and consequently the big change that had transpired in the shop was slow to make an impression. Probably he got his first inkling of this change through the unusual activity of the men around him—I will not say. That the other workmen were stepping about their tasks with an unwonted vigor and elasticity of step could not be denied.

Every man among them moved around corners in the shop, corners theretofore draped in a gloom that naturally made the men cautions, fearful lest they run into somebody or something, with a dash and a spirit that promised well for the quantity and quality of the output that night. They did indeed. And possibly it struck Jim as being a little unusual—as surely it was.

At any rate, file in hand, Jim suddenly stayed his arm and after a long moment lifted his eyes to the ceiling above him. He looked a long time, the while over his lean, lined face there crept a slow kind of rapture. Finally he laid down his file and again swept the brilliantly lighted shop with a look of pleased surprise in his watery eyes. Then he gave utterance to speech.

"Gosh," he breathed, in his homely way, and there was a note of awe and reverence in his voice, "that's fine!—that is certainly fine! It—it—"and he swallowed a something in his throat—"it sort of makes a man feel better! Mebbe—mebbe I won't have to quit work after all!"

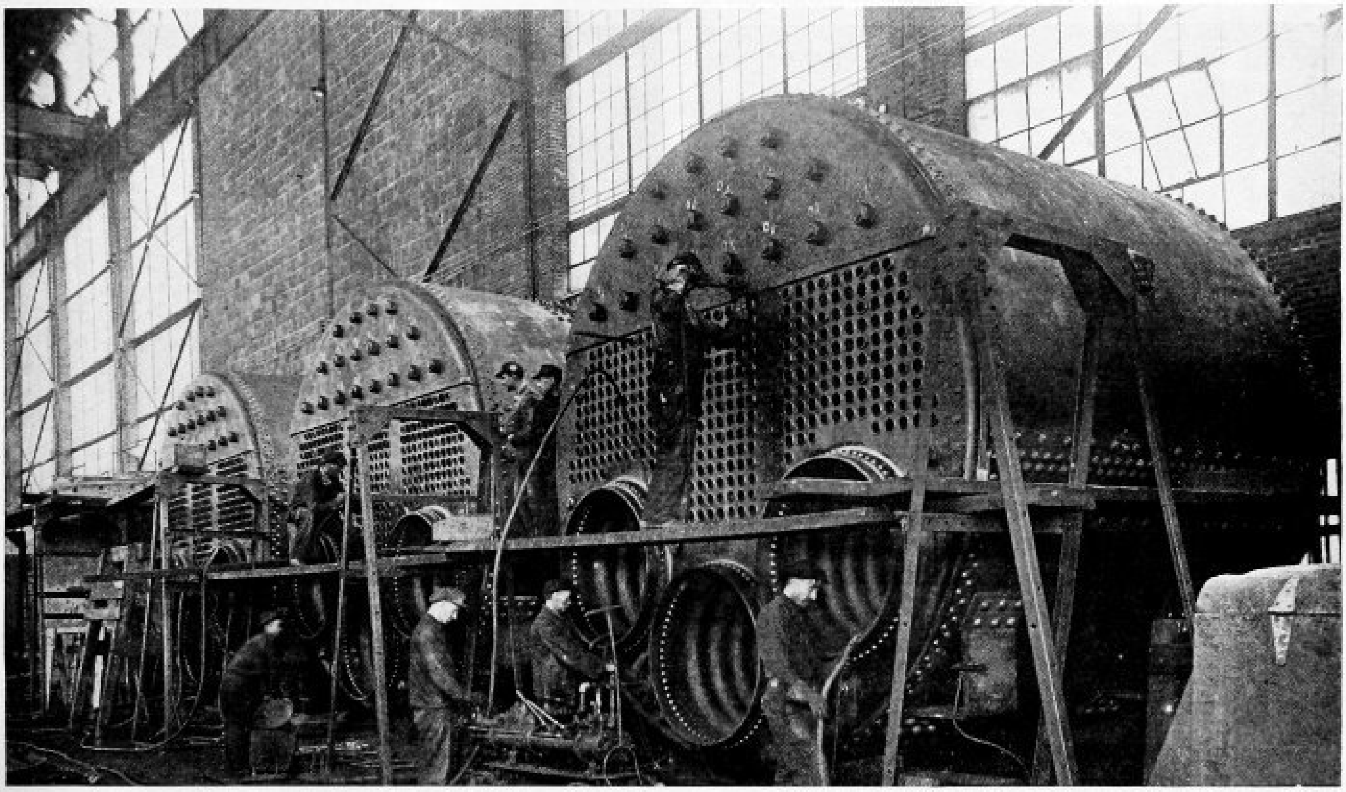


**Fig. 5.—Marine Boiler Shop at the Staten Island Shipbuilding Plant, Where Work Is Carried on Under Natural Lighting Conditions**

### Efforts Made to Improve Shop Lighting

Various agencies have been active during the past few years to bring about an improvement in shop lighting throughout the country both in the interests of the individual workman and for the benefit of industries in general. The Eyesight Conservation Council of America and the Illuminating Engineering Society have worked to eliminate this phase of waste in productive efficiency.

The eye as a factor in the consideration of waste in industry is of prime importance, entering directly into the subject of the efficiency of the individual. It is proper that special stress should be placed upon eye defects as contributing greatly to fatigue and waste. Unnecessary fatigue, the waste of human energy and the waste of material resulting through defective vision and the loss of time from eye injuries through lack of protection are potent factors in industrial waste which demand consideration viewed from the cold-blooded standpoint of economics to say nothing of the humanitarian aspect.

### Accidents to Eyes

In the United States the total number of industrial blind is approximately 15,000, or 13.5 percent of the total blind population; this type of injury being the leading causative factor of blindness. Some rather interesting estimates of the cost of maintaining these blind artisans have been compiled, but actual economic loss cannot possibly be estimated.

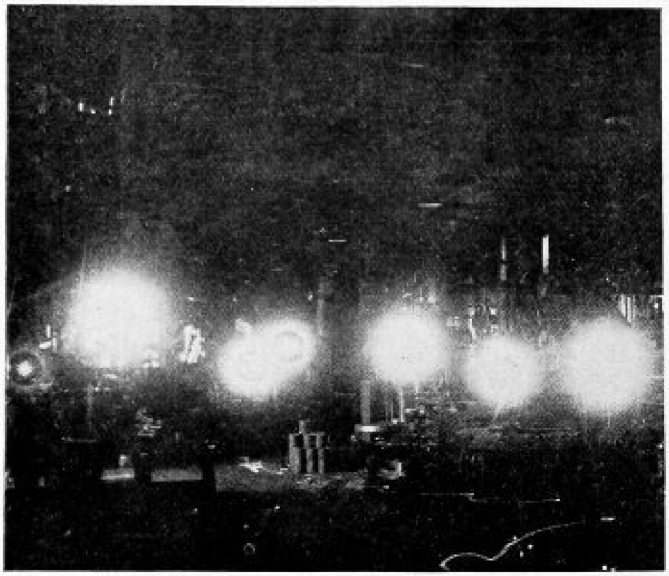


**Fig. 6.—Unshaded, Low Hung Lamps Make Working Conditions in This Plant Very Unfavorable**

Certainly the personal loss from blindness is far greater to the individual than from other kinds of defect.

The eye was involved in 10.6 percent of all permanently disabling accidents. Statistics as to number, severity and time-loss are, however, quite unsatisfactory owing to the irregularity in the reporting that still exists, in spite of uniform forms recommended and urged, but are complete enough to demonstrate that the continuing sacrifice is very large and should be prevented.

### Improvement in Lighting Conditions Desirable

Even the most superficial survey of lighting conditions reveals that in the majority of plants there is much improvement possible, in spite of the actual increase in production quantity and quality, when poor illumination is corrected to standards now considered satisfactory.

There seems to be no question of loss due to faulty conditions. One observer estimates the loss in this country as above the entire cost of illumination. Again it has been shown that improved lighting systems increased output 2 percent in steel plants and as much as 10 percent in factories and mills where work is more exacting.

Codes prepared by state industrial commissions, by the Illuminating Engineering Society and by the large manufacturers of lighting equipment, make it possible to determine suitable installation even when an illuminating engineer is not employed, while new simplified apparatus makes the testing of results practical.

### Requirements for Efficient Shop Lighting

The simple requirements on which efficient illumination is based are:

1. Light enough to see by to do work—too little or too much producing discomfort.
2. Diffusion to avoid sharp contrasts and deep shadows.
3. Elimination of glare.

### Types of Lighting Systems

The three principal types of lighting systems may be briefly and practically summed up as follows:

The advantages of the direct system are low cost of installation and maintenance, economic distribution of lamps and little loss by absorption. The disadvantages include a tendency to over-light the work and leave sharply contrasting dark areas around it. Such localized lighting with

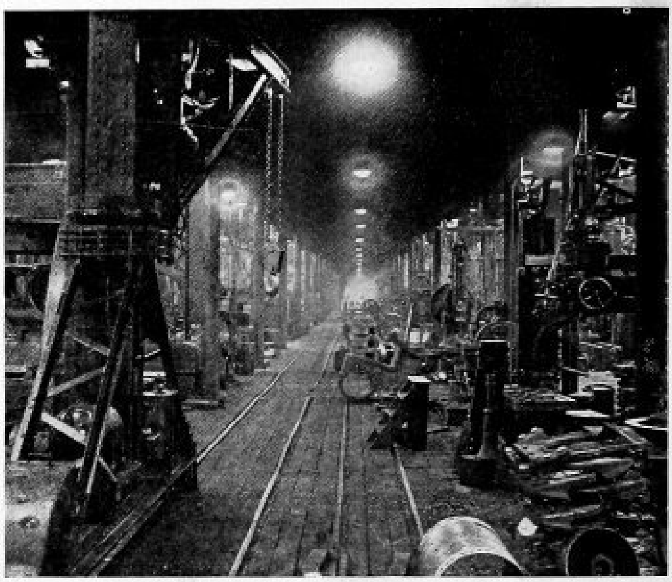


**Fig. 7.—In Contrast With the Shop at the Left, Excellent Light Is Obtained With Proper Lamps and Reflectors**

opaque reflectors should only be used in connection with some good system of generalized lighting.

### The Semi-Direct

The semi-direct system meets certain requirements. The reflectors in this system are best when made of dense glass or similar material, highly polished on the inside so that the globe gives about the same brightness for equal area as the reflecting ceiling. This requires a greater wattage than the direct systems, but there is a reduction of the glare and a much better diffusion.

### Indirect Lighting

In this system the source is hidden by an opaque bowl and all illumination comes from ceiling reflections. The glare is reduced to a minimum, shadows are practically abolished and the greatest diffusion is assured. Fatigue is much slower than with either of the other two systems for work that requires reading.

### Natural Daylight in the Shop

Daylight from windows is superior to other systems. The window area should be as large a percentage of the total wall area as possible. Translucent shades to cut out direct sunlight should be fitted to windows where needed, working from the bottom upward or from the top as conditions indicate. Ground glass and the like should be avoided in window sashes that are at or below the level of the eye, as

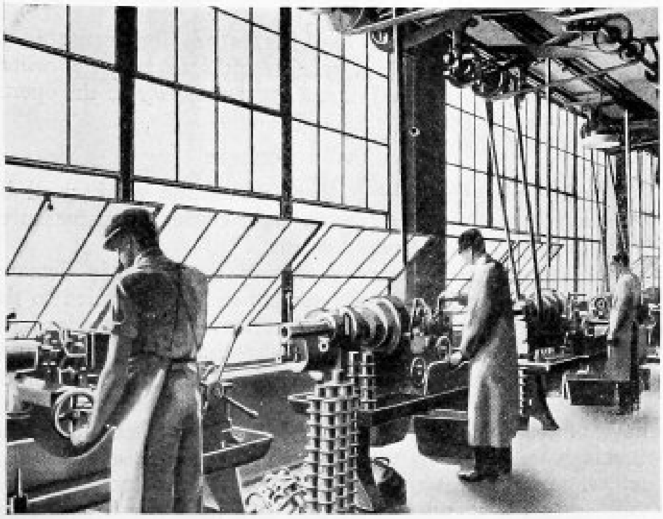


Fig. 8.—Machine Tool Operation Under Natural Daylight

Fig. 9.—Type of Steel Sash Windows in a Daylight Shop

they introduce a brightness equal to or greater than that of the sky on a part of the retina which is particularly susceptible to irritation from glare. The contrast to the adjoining walls and floor is also much too great. Fireproof glass is used to a great degree at the present time, making this a common condition. Clear glass gives an area of brightness only equal to that of the landscape. When the adjoining building makes the angle from the sky very sharp, prism glass (there are several commercial forms) may be used, preferably only in the upper half.

### Placing of Machines

The position of machines is of great importance in getting the best results from window lighting. The north exposure, "saw tooth" roof illumination meets most requirements, but is available only where low property values permit the use of one-story plants. It has to a great degree been taken for granted that daylight supplied the best illumination and up to the present time this is probably true, where it is of proper intensity and properly controlled, for the diffusion is more easily secured, the limits of comfortable intensity are much wider apart and fatigue is much slower in developing than with most artificial lighting. This may not continue to be, when lighting practices develop efficiency; and the perfect uniformity, obtainable only with artificial means not influenced by weather changes, may bring a sufficient advantage to make it the superior form. Certainly the daylight is the cheaper and will continue to be so for a long time.

### Boiler Shop Lighting by Artificial Means

In the boiler shop the lamp locations are limited by overhead cranes and, except for occasional fittings, no very exacting demands as to lighting exist. Illumination on vertical surfaces must be as good as, if not better than, that on horizontal planes in many cases and light must penetrate in nooks and corners not often encountered even in machine shop work. There are some places where local lights, either of the portable incandescent lamp type, or a hand oil torch, must be used. Where work is being performed on the inside

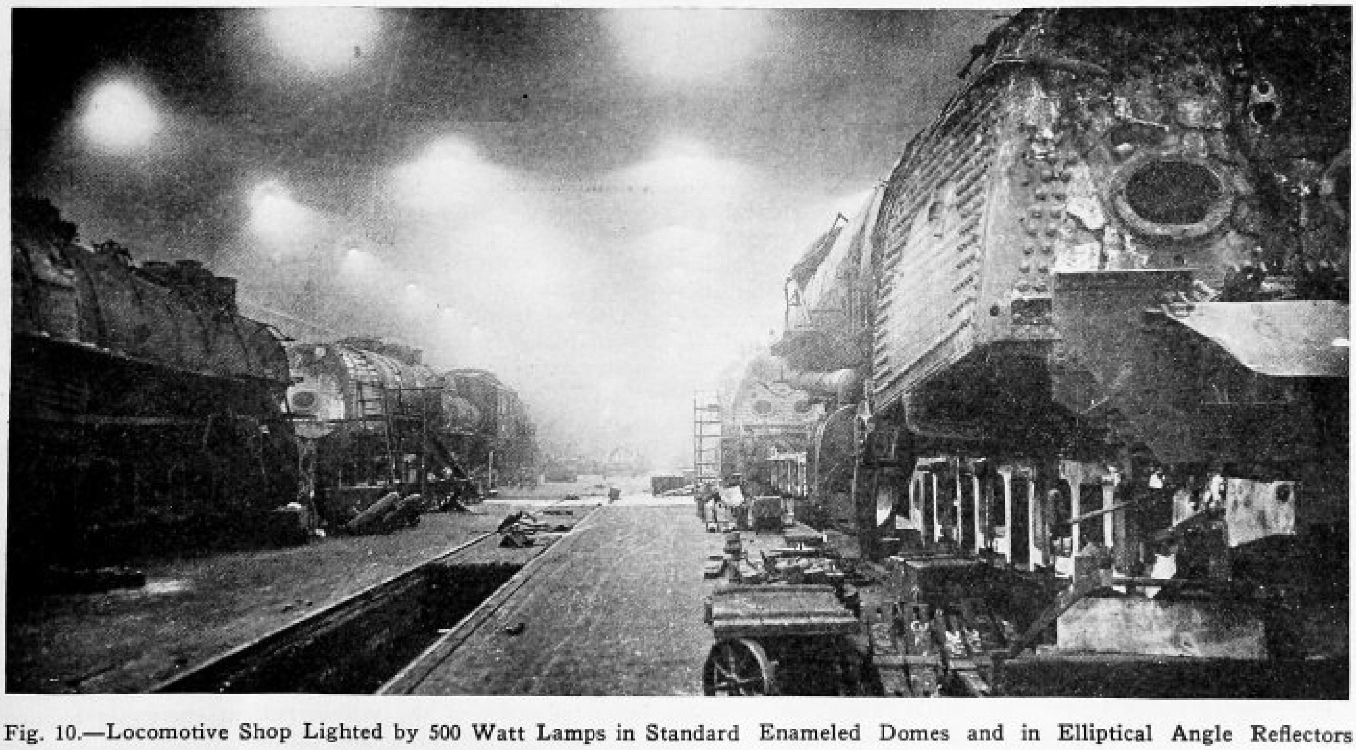


Fig. 10.—Locomotive Shop Lighted by 500 Watt Lamps in Standard Enameled Domes and in Elliptical Angle Reflectors

of the boiler, a local or portable lamp is indispensable. A fairly high intensity is desirable in order to speed up work.

When considering the type of installation for this class of structure, it will be easily seen that there are two general methods applicable, one makes use of high wattage overhead units in either deep bowl or dome enameled steel reflectors; the other makes use of special industrial lighting units. The use of the latter type is required only in places having exceedingly high ceilings or where the atmospheric conditions are such as to absorb a large percentage of the light from overhead units. The average shop, however, can be lighted by two rows of either 500, 750, or 1,000-watt units in dome enameled reflectors running down the center of the shop and one row of elliptical angle reflectors containing 500-watt lamps mounted on each side wall in order to give good illumination on vertical surfaces. Fig. 1 shows a railroad erecting shop lighted by such an installation.

For small shops with ceilings approximating those of the average factory room, a method which gives good results is to run a line of 200 or 300-watt lamps in standard dome reflectors down each aisle of the shop. Convenient outlets should be provided at frequent intervals.

The machine work performed in these shops, such as punching, pressing, forming, dishing, welding, general assembling, etc., does not require a great deal of light for its performance. General lighting should provide a medium intensity over the entire floor surface, preferably from high wattage mazda lamps in deep bowl metal reflectors, supplemented by smaller lamps in angle reflectors, mounted on the sidewalls.

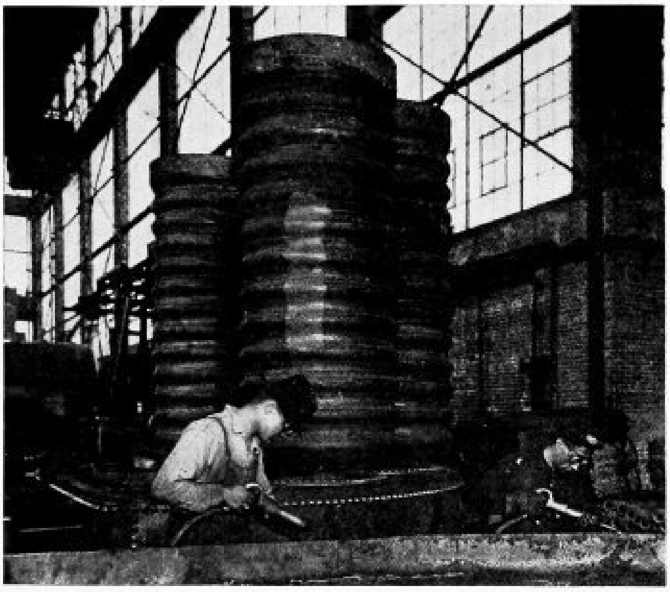


**Fig. 11.—Goggles are Necessary Equipment for Such Operations in the Boiler Shop**

### Machine and Forge Shops

The shops grouped under this heading are contained in rooms approximating those of the average factory. The lighting of them, therefore, becomes a problem similar to that of the ordinary industrial plant. There are few, if any, cases where a straight general system cannot be employed to good advantage. There may be times, however, when local lighting will be necessary, as, for example, over certain machines found in the plate shops.

The shops in general should have an even spacing of overhead units on centers, such as 12 by 12, 15 by 15, etc. The hanging height in any case should range from between 10 and 18 feet. The greater height is preferable if it can be obtained. Machine operators are slowly being weaned away from the idea that local lights are indispensable to their work. There are several instances to be sure, where such a light must be used, but a great majority of the operations do not require one.

### Protective Devices

Another phase of eye accident prevention might well be considered in addition to the eyesight conservation measures resulting from better shop lighting.

All industrial processes involving eye hazards demand protective measures, the protector either being applied to the machines or tools or worn by the worker. Definite codes have been formulated by some industries stipulating all occupations in which goggles must be worn and specifying the type of goggle required for a particular protection. Such codes have now been published by several of the states (including Pennsylvania) and by the Bureau of Standards at Washington. The codes are very explicit as to the best-known designs and as to the manner of testing any protector in question. All concerns are thus given an adequate means of judging what protection is necessary.

### Dangerous Operations

Under the national code the processes or operations in which protection to the eyes is necessary are divided into nine groups as follows: No attempt is made, however, to indicate their order of importance.

1. *Objects.*—Processes in which protection from relatively large flying objects is required, such as chipping, calking and riveting, Fig. 11.

In this group the danger of severe damage is relatively great as the penetrating wound, particularly when the foreign body remains or carries with it infectious material, generally destroys or greatly impairs the eye.

2. *Dust and Small Particles.*—Processes where protection from dust and small flying particles is required.

The use of abrasion wheels gives rise to a large number of relatively less severe injuries. Lighter goggles are required, but their constant use is most necessary.

3. *Dust and Wind.*—Operations where protection from dust and wind is required, e.g., locomotive driving.

Locomotive engineers and firemen find great need for shielding their eyes and very definite discomfort and difficulty in wearing goggles.

4. *Splashing Metal.*—Processes where protection from splashing metal is required, e.g., casting.

The goggles advised for this use have been found to resist breakage or penetration to a remarkable degree, saving many eyes in moisture explosions incident to "pouring" and similar work.

5. *Gases, Fumes and Liquid.*—Processes where protection from gases, fumes and liquids are required, e.g., handling of acids and caustics, galvanizing tanks, and japanning.

6. *Excessive Dust and Small Particles.*—Processes where protection from an excessive amount of dust and small flying particles is required, e.g., sand-blasting. Very complete protective apparatus has been developed and is obtainable.

7. *Reflected Light or Glare.*—Operations where protection is required from reflected light or glare, e.g., sunlight from roofs, roadbeds, water, snow. Lighter tints in lenses, but of a color that will filter out ultra-violet heat and excessive visible rays.

8. *Radiant Energy—Moderate Reduction Required.*—Processes where protection from injurious radiant energy with a moderate reduction in intensity of the visible radiation is required, e.g., oxy-acetylene welding and cutting, open-hearth, Bessemer furnace work.

9. *Radiant Energy—Large Reduction Required.*—Processes where protection from injurious radiant energy with a large reduction of the visible radiant energy is required, e.g., electric arc welding and cutting.

(*Continued on page* 108)

# Defective Staybolts Cause Locomotive Disaster

## Explosion on Pennsylvania Locomotive Partly Due to Heavy Grooving of Back Head at Mud Ring

**By A. G. Pack***

THE accompanying report of the details of the failure to Pennsylvania Railroad locomotive 2599 was submitted to the Interstate Commerce Commission in accordance with the requirements of the Government regulations. The locomotive in question on the day of the explosion had been traveling light from Shire, Pa., to Peters Creek Branch. After this, several heavy drags were made.

At about 4:10 p. m., while the locomotive was moving backward, at Gould Mine, Pa., the back head tore on the right side along the top of the mud ring, just below and slightly to the left of the engineer's position, causing an aperture approximately 24 inches long and 1⅝ inches wide, permitting the water and steam to leave the boiler with terrific force, filling the cab and enveloping the entire locomotive. The engineer was found dead in the cab. His scalded body was found lying across the apron with a large hole in his shoulder, caused by the terrific force of the steam and water issuing from the opening in the sheet under the boiler pressure which existed at the time.

### Fireman Escapes from Cab

The fireman was sitting on his seat box and was forced into the left back corner of the cab by what he described as "a terrific whirlwind," so strong that he could not immediately get away from it. With extreme effort he managed to get his head, shoulders, and upper portion of his body out of the side window, but was unable to control his legs on account of the action of the previously mentioned "whirlwind" effect holding him to the side of the cab. He stated that during this period he realized that to breathe the steam would result in his death if it reached his lungs, so while hanging out of the window with head down he took a deep breath and believes this saved his life. He managed to pull himself up and, like a flash, was again forced into the corner, but kept his eyes closed tight and held his breath. Again he made an effort to get away and this time was quickly forced past the window and made his way through the left front door of the cab to safety. He described the roar as terrible and his escape as miraculous. He stated that he noticed no leak at the mud ring prior to the failure, which came without warning; that so far as he knew the locomotive was in good condition, and the only leak was a slight blow at one of the injector steam globe valve packing nuts, aside from which there was nothing out of the ordinary and that he believed the engine to be in fairly good condition.

The fire was drawn from the firebox by other members of the train crew, about 20 minutes after the accident. The entire firebox was overheated, but owing to the fact that all water and pressure had left the boiler no damage of a serious nature was done to the firebox sheets.

### Details of Boiler

The locomotive was of the Consolidation type, known as Pennsylvania H-6-A, saturated, hand fired, carrying a Belpaire boiler with wide firebox, equipped with three 3-inch arch tubes carrying a brick arch. The firebox was of five-piece construction with riveted seams. The door sheet and back head, the only sheets to be considered in this case, were of 5/16-inch and ⅜-inch steel, respectively. These two sheets were stayed by 15/16-inch rigid and 1-inch flexible bolts spaced 4 inches horizontally by 4¾ inches vertically.

The failure occurred on account of a part of the back head, which had been patched, tearing along the top of the mud ring, beginning at about 6 inches to the right of the center line, and continuing toward the right back corner for a distance of 24 inches, opening up a gap about 1⅝ inches wide. Directly above the rupture and running parallel with it were six broken staybolts, one of which had broken at the outer sheet, the telltale hole having been plugged with a nail; the other five had broken off at the inner sheet and evidenced old breaks.

Eight other broken staybolts were found in the second horizontal row immediately above the six broken staybolts

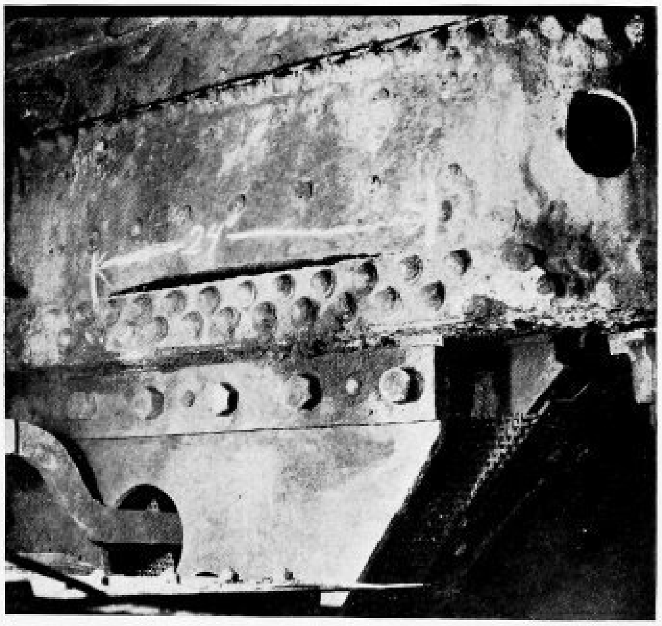



**Fig. 1.—Opening in Door Sheet Caused by Failure of Staybolts**

mentioned, which evidently broke at the time of the failure; because the broken ends at the inside sheet indicated that a portion of the cross sectional area was a new break. Each of these bolts, together with all other bolts in the first and second horizontal rows above the mud ring in the back head were fractured at the inner end, some slightly, but most of them were holding by only about one-third of the cross sectional area. Many of the bolts were also found to be fractured at the outer end, but in no instance deep enough to permit the telltale hole to give warning.

Either at the time or prior to the application of the last new firebox, which was, according to the carrier's records, during May, 1916, at Altoona, Pa., a patch ⅜-inch thick was applied across the bottom of the back head, being riveted to the back head sheet and mud ring. It was this patch that failed and into which all of the previously mentioned staybolts were applied. At the line of rupture the sheet had grooved on the water side along the edge of the mud ring its entire length to approximately two-thirds through the sheet, leaving only about ⅛ inch of metal to resist the stress to

*Chief Inspector, Bureau of Locomotive Inspection, Interstate Commerce Commission.

which it was naturally subjected and the added stress thrown upon it due to the six broken staybolts.

### Appearance of Firebox

The interior of the firebox indicated that all the sheets had been overheated, due to the fact that the fire was not drawn until 15 or 20 minutes after the boiler had emptied itself. The door sheet and flue sheet seams were slightly sprung, due to the intense heat; but no damage of a serious

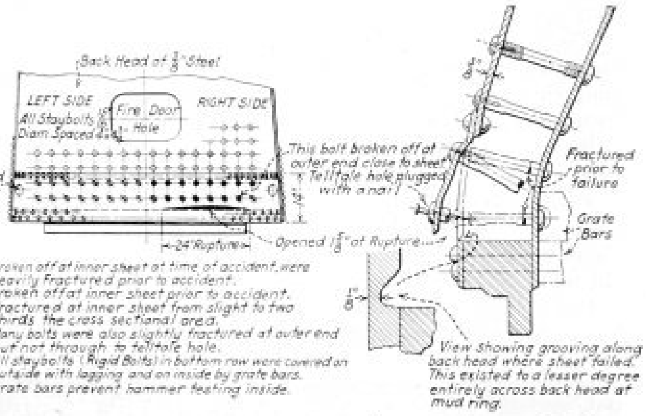



**Fig. 2.—Diagram Showing the Location and Causes of Failure**

nature was caused by the overheating. The general condition of the firebox, including flues and arch tubes, was good.

Unless removed, the grate bars completely prevented the hammer testing of the entire bottom row of staybolts from the inside of the firebox and the lagging and jacket covered the outer end of the bottom row of bolts in the back head.

After observing the failed portion of the sheet it was cut out in such a manner as to reveal the true condition of the staybolts and so as to determine the extent of the corrosion across the back head close to the mud ring. This disclosed the dangerous condition previously described as regards the defective staybolts and the same destructive grooving all the way across the back head close to the mud ring.

To ascertain if the steam pressure carried was in excess of the allowed working pressure at the time of the accident, the steam gage, after being tested on a deadweight tester and being found approximately correct, together with the safety valves from the defective locomotive, were applied to Pennsylvania Railroad locomotive 2250 of the same class and the pressure raised until the safety valves opened at 205 and 209 pounds, respectively, according to the tested gage, which removes all question as to overpressure.

The company's records indicate that the locomotive was built by the Baldwin company during March, 1905. A firebox was applied at Altoona, Pa., in May, 1916, and class 3 repairs given on September 5, 1918, and class 5 on May 16, 1920. There was no record obtainable covering application of the back head patch. The last annual inspection was made on April 20, 1921; the last monthly inspection was made at Shire Oaks, Pa., on November 7, 1921, at which time the staybolts were shown as "good" and none applied.

### Daily Inspections Made

Daily locomotive inspection reports were carefully examined at Shire Oaks and Monongahela City, Pa., for a period of 15 days prior to the accident and nothing was found bearing on the accident except—

On December 4, engineer F. G. Jarrett reported at Monongahela City, Pa., at 4 p. m.:

"Mud seam leaking bad."

The locomotive was afterwards run to the shop at Shire Oaks, a few miles from Monongahela City, for repairs. Upon arrival there, it was found that the bad leak reported came from a telltale hole in a staybolt located in the bottom row on back head near the right back corner, and that the mud seam or ring was not leaking. The foreman in charge ordered the staybolt plugged. This plugging was done sometime between 7 p. m. and midnight of December 4 and the locomotive returned to service at 2:15 a. m. on December 5 with the staybolt plugged.

Engineer Jarrett made the next report, but no mention was made of the leak, which indicates that the leak reported the previous trip was from the telltale hole in the broken staybolt under the jacket instead of the mud ring. Engineer Jarrett verified this during the investigation.

Had it not been for the broken staybolts referred to, the worst that would have resulted from the grooved sheet would have been a leak, even if the grooving had extended entirely through.

The condition of these staybolts should have been disclosed and this fatal accident averted had they been tested and repairs made as required by the rules.

To have properly complied with the rules it would have been necessary at each inspection to have removed the grate bars which covered the inner end of the first row of staybolts

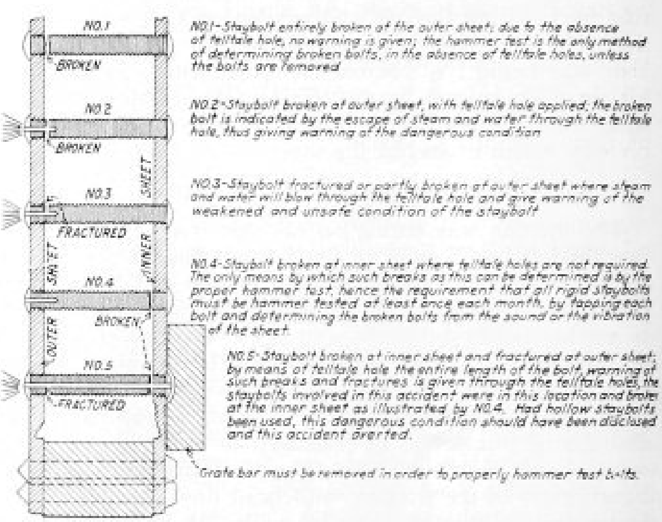



**Fig. 3.—Types of Staybolt Fractures with Telltale Holes as Indicators of Breaks**

above the mud ring, or to have complied with the rules in the most technical sense, it would have been necessary to have removed the jacket and lagging from the back head which covered the outer end of the bolts. Evidence indicates that it has not been the practice of this carrier to make a proper hammer test of staybolts located behind grate bars nor to apply staybolts with telltale holes their entire length.

### Request for Staybolts with Telltale Holes

At the urgent request of a number of railroads for permission to apply staybolts with telltale holes their entire length behind brickwork or oil-burning locomotives, to avoid the necessity for removing the brickwork each time the staybolts are tested, the chief inspector of this bureau issued, on November 11, 1913, Circular 118, as follows:

> If staybolts which are behind brickwork on oil-burning locomotives or behind grate bearers have a telltale hole three-sixteenths inch in diameter their entire length which is kept open at all times, the removal of the brickwork or grate bearers each month for the purpose of hammer testing such bolts will not be required. This will not, however, relieve from making a thorough inspection each time the brickwork is removed nor will it relieve from removing the brickwork for an inspection when necessary.

So far as it has been brought to our knowledge the railroads have taken advantage of this circular and applied staybolts with telltale holes their entire length behind the grate bars and brickwork and other obstructions which prevented a proper hammer test, or lowered the grate bars so that the staybolts could be properly tested.

If advantage had been taken of this circular and staybolts applied with telltale holes their entire length in the rows covered by the grate bars where the six broken bolts were located, this defective condition should have been discovered before failure occurred, and the loss of life averted.

It is well established that in practically all locomotive boilers grooving or corrosion of this nature takes place, the extent of which depends upon the length of time the sheets have been in service and the quality of the feed water used.

The fact that such grooving or corrosion does occur to the extent of materially weakening the sheets in this location, it is imperative that staybolts adjacent to the mud ring should be carefully inspected and maintained, otherwise, as in this case, serious accidents are likely to follow.

The same condition that causes the sheets to groove and corrode also has its effect on the staybolts. It is not uncommon to find staybolts fractured and broken at the inner sheet, in which instance the telltale hole in the outer end is of no value, hence the requirement that "the inspector must tap each bolt and determine the broken bolts from the sound or the vibration of the sheet," except where obstructions prevent a proper hammer test of staybolts which have telltale holes their entire length with such holes kept open at all times.

Figs. 1 and 2 show the ruptured sheet and the staybolts in the two rows above the mud ring that were fractured or broken at the inner sheet, with one that was broken and many that were fractured at the outer sheet yet not of sufficient depth to give warning at the telltale hole. The warning that was given by the one telltale hole was disregarded and the hole plugged by driving a nail in it to stop the warning leak and the locomotive is placed in active service again.

Fig. 3 illustrates the usual manner in which firebox sheets corrode and rigid staybolts fracture and break and the necessity for hammer tests, with the relative value of telltale holes and hollow staybolts.

## Export Service Available to American Manufacturers

With the object of fostering our foreign trade in machinery and equipment of all kinds, the Department of Commerce a few months ago organized the Industrial Machinery Division of the Bureau of Foreign and Domestic Commerce.

The necessity of some such government aid to those industries interested in developing a foreign trade may be realized when it is understood that there are more than 4,000 factories in the United States producing industrial machinery, according to the 1919 census. The value of the products of these factories exceeds $2,200,000,000 per year, of which huge total about 17 percent, or nearly $400,000,000, is exported. Obviously this is a very large business, and it is also a very important business, because these 4,000 plants carry on their pay rolls more than 400,000 employees, whose total income represents the livelihood of, say, 1,500,000 of our people, and the export business is of such volume as to represent the difference between profit and loss in the operation of most of these plants. It represents the difference between good times and depression, between a job and unemployment.

### Purpose of Machinery Division

The Industrial Machinery Division was organized in the Bureau of Foreign and Domestic Commerce in order to defend and promote this trade and there is every reason to believe that the volume of these foreign orders, this imported prosperity, can easily be increased to a much larger total, because the Bureau can do considerably more than has been done to assist the individual manufacturer to develop his foreign business.

It will be noted that the figures before given indicate an export business equal to about $1,000 per employee. This figure ought to be doubled, and with the application of American salesmanship and good business methods this should be accomplished.

### Aims of the Division

This division gives attention to industrial machinery. The kinds of equipment coming within this classification include every kind of machinery used in any kind of factory, power plant, or mine, or that runs on a railway, or is used in the construction of engineering enterprises.

In order that the division may be thoroughly practical in its work, men who are qualified engineers and who have sold a great variety of machinery in South America and Asia for a number of years and are personally familiar with conditions existing in many of the cities of those countries, have been placed in charge. These men are experienced exporters of American machinery and have faced world-wide competition in those foreign markets.

### Close Contact With American Manufacturers

The division aims to be of the greatest possible service to American manufacturers and exporters of machinery and feels that the best way to accomplish this is to establish close contact with these interests, hoping thereby to learn as much as possible about their particular export problems and the information that manufacturers actually need regarding the various foreign markets. Having developed these problems it will be possible to secure help in their solution from the large number of representatives the Government maintains in foreign countries; or, should circumstances justify, arrangements could be made to send special investigators into those fields, and such tasks would be assigned to experts peculiarly qualified for the work.

### Services the Division Offers

In the various markets of the world different sales methods are employed in marketing machinery and experts of the division are familiar with these methods. Where it is wisest to sell through agents or dealers, reasonably complete lists of all available candidates in each of the important cities abroad are obtainable, and these lists may be passed on to interested manufacturers when desired.

### Research Work

The division is also constantly making studies of the various foreign markets and export problems, and these are published in commerce reports, the newspapers, or technical papers, as circumstances justify. A number of these reports have been published recently giving important information regarding the export of railway cars, locomotives, machine tools, German and British competition, etc. The division is also preparing a report on the machinery markets of Asia, which is the result of a special investigation that has involved a personal visit to every important city between Yokohama and Bombay requiring about 30 months.

In cases where problems arise in connection with tariffs, foreign patents, trade-marks, copyrights, agency agreements, or other legal matters assistance can be furnished through the cooperation of the Commercial Laws Division and the Foreign Tariff Division.

(*Continued on page* 108)

# 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, C. W. Obert, 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.

Below are given the interpretations of the Committee in cases Nos. 355, 375 (reopened), 377 and 383 inclusive, as formulated at the meeting of January 19, 1922, and approved by the Council. In accordance with the Committee's practice, the names of inquirers have been omitted.

CASE NO. 355. *Inquiry:* An interpretation is requested of the application of the formulas in the Boiler Code for crown bars to a form of reinforcement for crown sheets where the top sheet of the firebox is a half of a true circle and is braced with arch bars extending over the top and down below the top row of staybolts at the sides, these arch bars being riveted to the water side of the crown sheet through thimbles. Recommendations of the Boiler Code Committee are requested covering low pressure steam heating boilers, as well as high pressure boilers.

*Reply:* This construction is not covered by the Code, but when the unstayed portion of the crown sheet does not exceed 120 degrees in arc, it is recommended that the maximum allowable working pressure should be determined by adding to the maximum allowable working pressure for a plain circular furnace of the same thickness, diameter and length by the formula in paragraph 239, the pressure $P_1$ determined from the following formula, which is a modification of that in paragraph 241, section *a:*

$$P_1 = 10{,}000{,}000 \frac{b \times d^3}{p \times D^3}$$

where;

$b$ = width of crown bar, inches
$d$ = depth of crown bar, inches
$p$ = longitudinal pitch of crown bar, inches
$D$ = outside diameter of furnace, inches

providing that the maximum allowable working pressure must not exceed that determined by the formula for furnaces of the Adamson type, in paragraph 242 when $L$ is made equal to $p$, and also providing that the diameter of the holes for the staybolts in the crown bars does not exceed $\frac{1}{3}$ $b$, and the cross-sectional area of the crown bars is not less than 4 square inches. Paragraph 199 would govern the spacing of the staybolts, rivets or bolts attaching the sheet to the bars.

CASE NO. 375 (REOPENED). *Inquiry:* Is it permissible, under the requirements of the Boiler Code, to weld a seam in a vertical firebox not over 38 inches in diameter and in length ranging from 20 inches up, by the autogenous or fusion process where the firebox has no support other than the tube sheet, mud ring and fire door?

*Reply:* It is the opinion of the Committee that, under the requirements of the Code, autogenous or fusion welding is not permissible for the seam in the firebox of a vertical-tubular boiler, unless the sheet containing the seam is properly supported by staybolting or other form of construction.

CASE NO. 377. *Inquiry:* An opinion is requested from the Boiler Code Committee concerning the applicability of paragraph 428 of the Code relative to the composition of the tin filling for fusible plugs, if used, where the boiler is to be operated under a working pressure of from 350 to 500 pounds per square foot, so that the temperature of the steam under working conditions will be far above that specified for the melting point of tin.

*Reply:* There is nothing in the Code pertaining to the use of fusible plugs on boilers operated at pressures involving temperatures near or above the melting point of tin. It is accordingly proposed to revise paragraph 428 by the addition of the following:

> Where the boilers are to be operated at working pressures in excess of 225 pounds per square inch gage, the use of fusible plugs is not advisable.

CASE NO. 378. *Inquiry:* If an internal boiler feed pipe enters at full size into a steam and water drum and then into a closed vessel within the drum, wherein the end of said feed pipe is open and the said closed vessel has a series of openings, accessible for inspection and the combined areas of which openings are largely in excess of the open end of the pipe and means are provided for blowing down the interior closed vessel, does the construction meet the requirements of paragraph 314 of the Code?

*Reply:* If the closed vessel within the drum, into which the open end of the feed pipe projects, has openings largely in excess of the area of the open end of the pipe so that there may be no possibility for them to become clogged by incrustation and providing the vessel has means for blowing down in cleaning, it is the opinion of the Committee that the construction described will meet the requirements of paragraph 314.

CASE NO. 379. *Inquiry:* Would it meet the requirements of the A.S.M.E. Boiler Code for an authorized inspector to stamp a boiler as a 200 pound pressure boiler if the same meets all the requirements regarding the boiler proper but the cross connection between the drums is composed of extra-heavy pipe and extra heavy flanged cast iron fittings?

*Reply:* It is the opinion of the Committee that a boiler so fitted with the cross connection using extra-heavy cast-iron fittings would not meet the requirements of Paragraph 9 of the Code.

CASE NO. 380. *Inquiry:* Is it necessary under the requirement of Paragraph 336*b* of the Boiler Code, that a boiler head must be stamped by the manufacturer in two places when it is less than 12 inches in diameter and, due to the tube spacing, it is impossible to find room for more than one stamping?

*Reply:* It is the opinion of the Committee that as long as there is one stamp legible on a miniature boiler, the intent of the Code is met, where the parts are so small that it is impossible to apply two stamps.

CASE NO. 381. *Inquiry:* An interpretation is requested of the requirement in the last sentence of Paragraph 257 that calking shall be done with a round-nosed tool, where a form of flat-faced tool of the full width of the plate is being successfully used so as to thicken out or upset the end of the plate with pressure, instead of hammering. It is pointed out that with this method there is no danger of scoring or damaging the plate underneath the calking edge and the result is a very firm and effective result in calking

*Reply:* It was the intent of the Committee in imposing this requirement that calking should be done so that the plate at or beneath the calking edge will not be scored or damaged. If the tool is of such shape as to upset or compress the edge of the plate without splitting it and will not score or damage the adjacent plate, the requirements of this paragraph may be considered as fully met.

CASE No. 382. *Inquiry:* Is it not permissible, under the requirements of paragraph 180 of the Code, to use plate thicknesses for the shells and tube sheets of horizontal return tubular boilers thinner than those specified in paragraphs 18 and 20, provided the maximum allowable working pressure formula gives the desired pressure with a factor of safety of 5?

*Reply:* It is the opinion of the Committee that it is not permissible under the rules of the Code, to use plate thicknesses in any case for shells or tube sheets less than the minimum thicknesses specified in paragraphs 18 and 20 of the Code.

CASE No. 383. *Inquiry:* Paragraph L-18 states in the first sentence that the gage thickness of the tubes shall not be less than a certain amount. In the second sentence it states that the gage thickness shall be measured by the B. W. gage and the thickness at any section must not vary more than one gage below or one gage above that specified. Does this require using one gage heavier than the nominal gage in order to meet the requirements?

*Reply:* The intent of the Committee in formulating this rule was that the gage thickness referred to in the first paragraph of L-18 of the Locomotive Code, described a nominal gage to be used. The gage thickness referred to in the second paragraph specifies that whichever gage is used, the limitations are minus one gage and plus one gage. Therefore, if a particular gage is specified for the boiler tube, the limits are one gage less and one more than that specified.

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## Supply Exhibits to be Featured at Master Boiler Makers' Convention

AT the forthcoming convention of the Master Boiler Makers' Association, to be held at the Hotel Sherman, Chicago, Ill., May 23-26, the Supply Men's Association will present a very complete exhibition of new and standard tools and equipment. Considerable disappointment was expressed by the members of the Association at the 1920 convention in Minneapolis that this feature of the convention was omitted, since to many of them it was the only opportunity of the year to become familiar with developments in the supply field.

The plans for this year have been developed on an extensive scale and, up to the present time, about forty companies have engaged space in the exhibition room at the hotel for displays of their products.

However, quite a number of supply companies have not made arrangements as yet for exhibiting and, as space is being assigned in the order of application, it will be necessary for them to apply immediately to George B. Boyce, secretary of the association (care of the A. M. Castle Company, 715 North Morgan street, Chicago, Ill.) if they wish to be represented in the exhibition at the convention.

The diagram of the exhibition hall as given below will be of assistance to supply companies in applying for space.

The following companies have already signified their intention of exhibiting at the convention:

Air Reduction Sales Company, 342 Madison Ave., New York.
The Prime Mfg. Company, 653 Clinton St., Milwaukee, Wis.
The Superheater Company, 17 E. 42nd St., New York.
The W. S. Tyler Company, 3615 Superior Ave., Cleveland, O.
Torchweld Equipment Company, 224 N. Carpenter St., Chicago, Ill.
Scully Steel & Iron Company, 24th & Ashland Ave., Chicago, Ill.
Dearborn Chemical Company, 332 S. Michigan Ave., Chicago, Ill.
Monongahela Tube Company, 321 3rd Ave., Pittsburgh, Pa.
Chicago Pneumatic Tool Company, 6 East 44th St., New York.
National Tube Company, 208 S. La Salle St., Chicago, Ill.
American Arch Company, 30 Church St., New York.
Midvale Steel & Ordnance Company, Widener Bldg., Philadelphia, Pa.
The Boiler Maker, Woolworth Building, New York.
Parkesburg Iron Company, Parkesburg, Pa.
The Bird Archer Company, 33 Rector St., New York.
The Talmadge Mfg. Company, 1279 West 3rd St., Cleveland, O.
American Locomotive Company, 30 Church St., New York.
Ingersoll-Rand Company, 11 Broadway, New York.
Railway Journal, 327 S. La Salle St., Chicago, Ill.

(*Continued on page* 106)

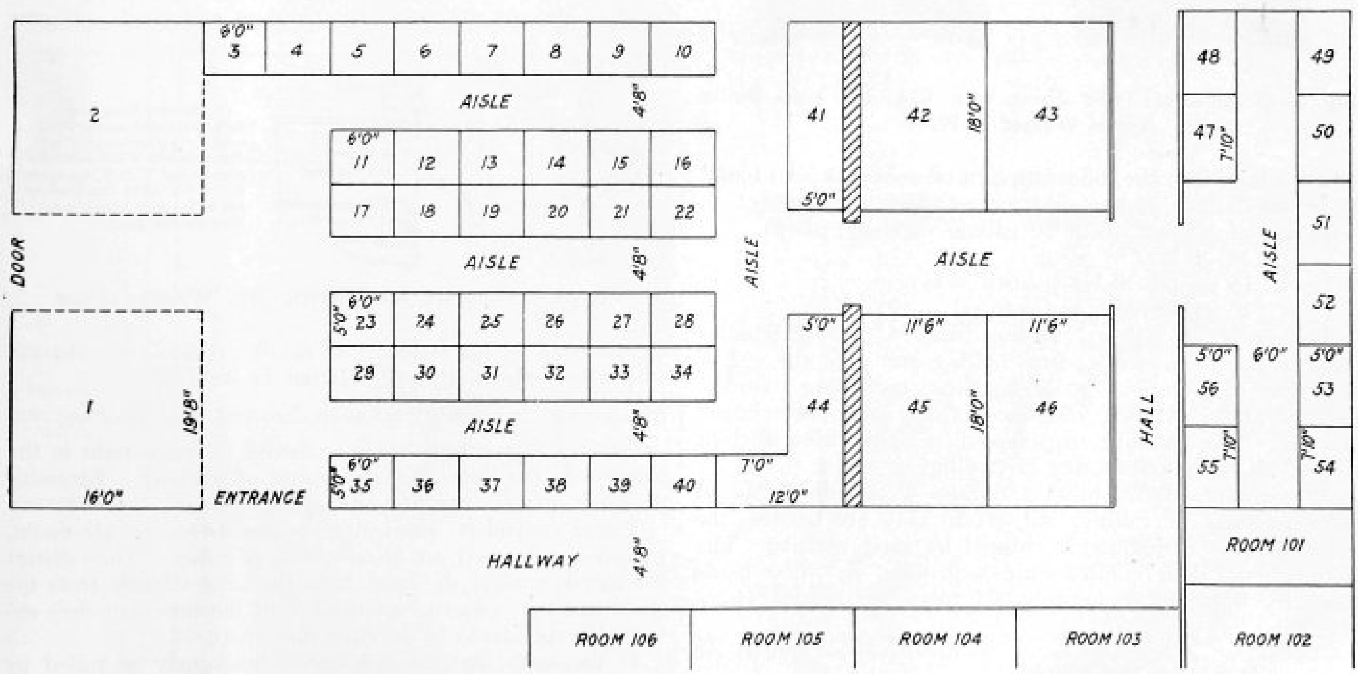


**Diagram of Supply Mens' Association Exhibition Hall at Master Boiler Makers' Convention**

# Installing and Maintaining Charcoal Iron Locomotive Boiler Tubes

By G. H. Woodroffe* and C. E. Lester**

*The following article is a continuation of the suggested standard tube practice appearing in the March issue of THE BOILER MAKER. This division of the subject deals with the use of welding in tube work and the proper methods to be followed in maintenance and repair.*

THE growing practice of electrically welding tubes and flues to back tube sheets saves a great deal of boiler trouble and maintenance work. However, welding alone will not hold carelessly set tubes and flues. Each operation should be carried out as carefully and thoroughly as though no welding were to be done.

The metal of the weld is somewhat brittle and may be porous on account of tiny blow holes that form as the metal solidifies from the molten state. The welding metal alone therefore cannot be depended upon to hold the tube in place or prevent leakage.

By uniting the bead to the sheet, however, the weld furnishes the strength and stiffness necessary to hold the shoulder of the tube against the ferrule, just as it was left by the expanding tool and may also be dense enough to prevent a loosened tube from leaking in an emergency.

### Electrically Welding Firebox Ends of Tubes

*Setting Tubes and Flues for Welding.*—Expand, roll and bead as described previously (first installment, March issue), using no lubricant on the setting tools. If it is felt necessary to use a lubricant, the following corn oil soap has been found to be satisfactory and is said not to affect the welding:

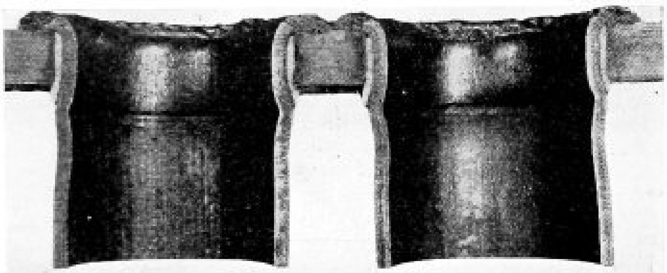

Fig. 1.—Section of Tube Sheet with Charcoal Iron Boiler Tubes Welded in Place

In a steel tank of about 60 gallons capacity, place:

- 20 gallons of water
- 15 pounds of lye (caustic soda)
- 10 gallons of pure corn oil

Boil from 6 to 8 hours, adding from 15 to 20 gallons of water to keep the mixture from boiling over. At the end of this time the solution should be clear, indicating complete saponification. If not, continue boiling until the mixture is clear. The resulting soap should be light amber in color and of about the consistency of vaseline.

*Preparation.*—After tubes and flues have been tightened by expanding or rolling, but before they are beaded, the sheet should be thoroughly cleaned by sand blasting. The boiler should then be filled with warm water and tubes made perfectly tight before beading. If tubes are beaded (locomotives taken out of service to have tubes welded), they should be made perfectly tight before welding.

The welding operation should be performed with warm water in the boiler and after the tubes or flues have been properly beaded.

*Welding.*—Begin with the top row and work downward, welding superheater flues first. Each tube and flue should be welded by starting near the bottom, welding first up one side, then up the other, completing the weld near the top center, Fig. 3.

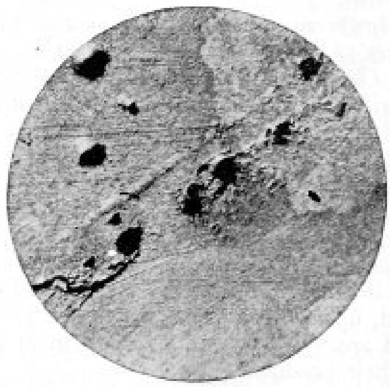

Fig. 2.—Section of One of the Welds in Fig. 1, Showing Blow Holes in Welding

*Removing Welding Deposit.*—During the welding operation, a deposit will form on the sheet and beads adjacent to the bead being welded. Carefully remove this deposit with a wire brush before starting to weld.

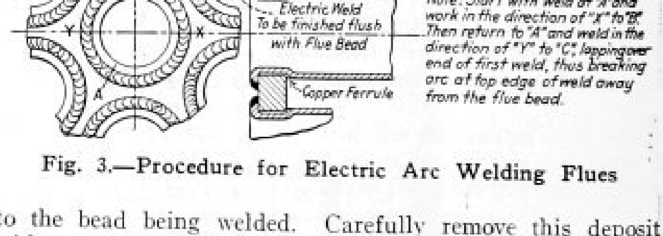


Fig. 3.—Procedure for Electric Arc Welding Flues

### Maintenance—Recommended Engine House Practice

*General Suggestions.*—Tubes should be made tight in the sheets with the least possible amount of working. Excessive working shortens the life of tubes and flues.

Roller expanders, particularly when driven by air motor, should not be used on firebox ends of tubes. They distort the metal, weaken the tube, raise the bead slightly from the sheet and not only shorten the life of the tube, but they enlarge the tube holes in the back tube sheet.

If necessary, new or safe-ended tubes may be rolled by hand, lightly, after beading.

*Removing Tubes.*—Tubes should be taken out at the front

Note:—This is the second instalment of an article on suggested tube practice which has been copyrighted by the Parkesburg Iron Company and which will be published later in book form.

*Mechanical Engineer, The Parkesburg Iron Company.

**Formerly General Superintendent, 19th Division, Transportation Corps, A. E. F., and Superintendent of Nievre Locomotive and Car Shops.

end, through their respective holes. If their condition is such that this is impossible, remove them through the large holes near the bottom of the front tube sheet.

The dangerous practice of enlarging holes in the back tube sheet for the removal of tubes should not be permitted.

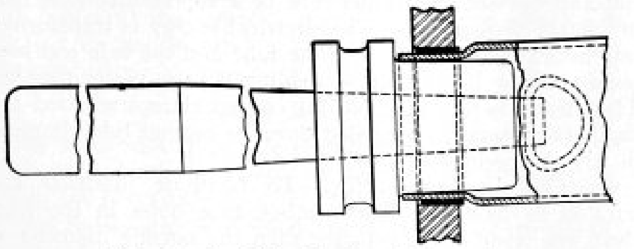

**Fig. 4.—Straight Sectional Expander**

*Tubes leaking slightly.*—With a standard beading tool, lightly set the beads down to the sheet. Trim off the burrs with a chisel. If necessary to expand a tube, use a straight sectional expander, with a light pneumatic or a four pound hand hammer. The tube should then be beaded lightly.

The use of the lipped sectional expander while a boiler is under pressure is a dangerous practice that should not be permitted.

*Tubes Leaking Seriously.*—When a locomotive arrives at the engine house with tubes that are leaking badly, draw the fire and drain the boiler. Reset the tubes with a standard lipped sectional expander, Fig. 5. Reset the beads with a standard beading tool. Remove any burrs that may be raised with a small chisel and hand hammer.

*Washout Period.*—At the washout period, reset the tubes with a standard lipped sectional expander. Set down beads with a standard beading tool, using a light pneumatic hammer. Trim off all burrs, using a small chisel.

### Electrically Welded Tubes

*Running Repairs.*—Electrically welded tubes, leaking through "pin holes" in the weld, may be calked with a fuller and hand hammer. The pein of a hammer or a beading tool must not be used.

If the leak is under the weld, cut off the defective portion of the weld, reset the tube with a lipped sectional expander, bead down, clean and reweld. If welding facilities are not available, expand the tube with a straight sectional expander. Rewelding should be done at the first opportunity.

At the washout period and before steam is blown, carefully inspect all tubes and flues. Proceed with necessary work when the boiler has cooled.

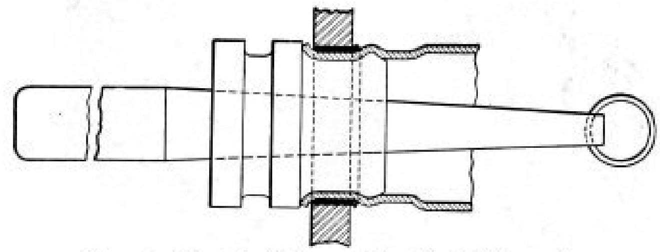

**Fig. 5.—Standard Lipped Sectional Expander**

### Flue Shop Practice

By flue shop is meant that part of the plant in which tubes, removed from boilers after a period of service, are cleaned, cut off, safe ended and stocked for future use and where new or reclaimed tubes are swaged and expanded for application.

### Flue Shop Equipment and Lay Out

Flue shop equipment and lay out are seldom given the consideration which they merit. Too often, flue shop machinery is obsolete or inadequate and poorly arranged. A careful study of almost any shop layout will open up new ways of saving time and money. Modern economical flue shop equipment, which can be purchased and installed at a moderate outlay, will save its initial cost in a short time and speed up the reconditioning.

The railroad flue shop shown in Fig. 6, handles five hundred boiler tubes and superheater flues a day at an exceedingly low cost. The work progresses in one direction only, forward. Specially designed cradle trucks are used. Machines have been so arranged as to make it unnecessary to turn tubes end for end. The use of an overhead crane though not essential will further reduce the handling cost.

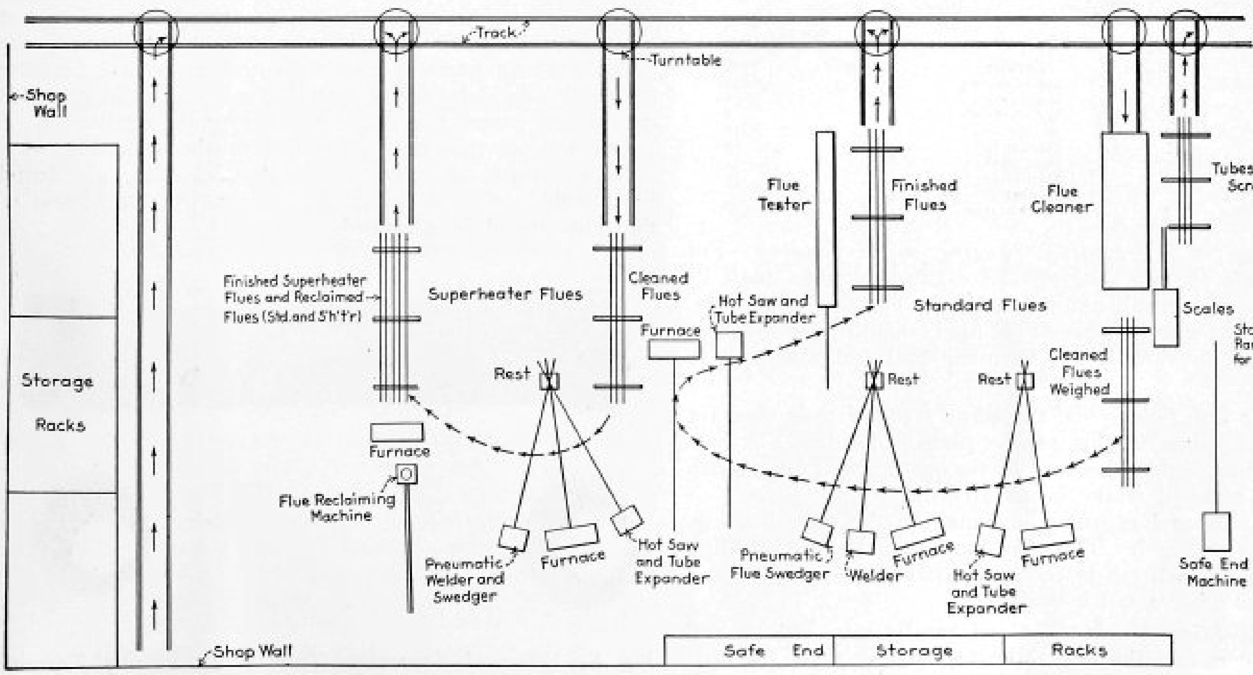


**Fig. 6.—Typical Flue Shop Designed to Handle 500 Tubes and Flues a Day**

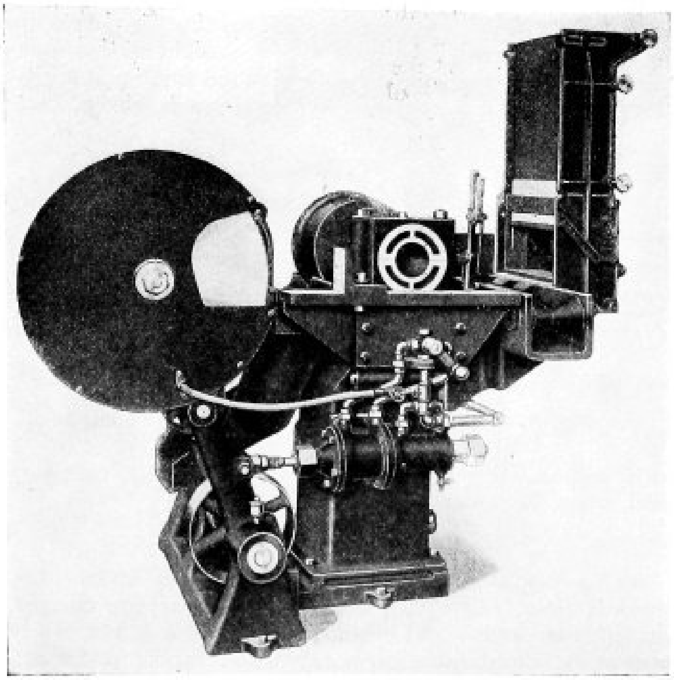

Fig. 7.—Combination Hot Saw and Expander for Use in the Flue Shop

This layout, varied slightly to meet individual conditions, is followed in a number of shops throughout the country.

*Cleaning Tubes.*—There are three general types of tube cleaners: rotary single tube cleaner; dry rattler; wet rattler.

The small shop, handling comparatively few tubes a day, may find the rotary single tube cleaner sufficient for its needs. Where a considerable number of tubes have to be handled dry rattlers and wet rattlers are used.

*Weighing Cleaned Tubes.*—After cleaning, tubes should be weighed and those below definite limiting weights should be scrapped. This practice has two advantages; it saves good material that might otherwise be discarded and it goes far toward eliminating tube failures on the road by weeding out worn, under-gage tubes.

TABLE I.—MINIMUM WEIGHTS OF TUBES

| Diameter of Tube, inches | Gage of New Tube | Service | Weight | |
|---|---|---|---|---|
| | | | Pounds | Ounces |
| 2 | 11 | Locomotive | 1 | 11 |
| 2¼ | 11 | Locomotive | 1 | 15 |
| 2½ | 11 | Locomotive | 2 | 3 |
| 3 | 12 | Stationary | 2 | 11 |
| 3½ | 11 | Stationary | 3 | 14 |
| 4 | 10 | Stationary | 4 | 12 |
| 5⅜ | 9 | Locomotive Superheater | 6 | 11 |
| 5½ | 9 | Superheater | 7 | 00 |

*Heating for Safe Ending, Swaging and Expanding.*—For proper safe ending, swaging and expanding, tubes must be heated quickly, evenly and thoroughly. The heating furnace, whether coke-burning, gas or oil fired, should have sufficient brick work to absorb heat from the fuel and radiate it to the work.

*Cutting Off Tubes.*—Of the many types of tools used for cutting off tubes, the hot saw is perhaps the best. It cuts quickly, uses little power and leaves only a small burr which is easily removed while the metal is hot.

A hot saw and expander, mounted on the same housing, are shown in Fig 7. This machine eliminates one handling of the tube, which can be cut, and expanded at one heat and safe-ended after a quick wash heat.

*Flue Welding Machine.*—Good results may be obtained with welders of either the roller or hammer type. A little care and the right kind of mandrel will minimize or entirely eliminate the ridge that is often left inside the tube.

*Electric Safe-ending.*—Where cheap electrical power is available, the matter of safe end welding electrically should be studied carefully. The operation is quick and the welds excellent.

A heavy, low voltage current is passed through the safe end and the end of a boiler tube or a superheater flue, held in contact by pressure. The electrical energy is transformed into heat and the junction of the tube and the safe end soon becomes white hot, fusing or welding the two pieces together. The current is then shut off, the contact clamps released and the joint smoothed and rolled down to normal tube diameter in a roller welder.

*Swaging and Expanding.*—To facilitate insertion and removal of locomotive boiler tubes, tube holes in the front sheet are made slightly larger than the outside diameter of the tube. The front ends of the tubes, therefore, have to be expanded for a tight fit.

Tube holes in the back tube sheet are the same size or slightly smaller than the outside diameter of the tube. With a copper ferrule in the tube hole, it is necessary to swage the firebox end of the tube, reducing its diameter.

Swaging is always done hot. Tubes are usually heated for expanding.

With the use of the equipment and the arrangement suggested, safe end welding can be finished quickly enough to permit swaging (or expanding) at this heat. A slower process, however, may necessitate a quick "wash heat" after welding and before swaging or expanding.

The charcoal iron tube has a critical range, 1,550 to 1,750 degrees, F., during which mechanical work like swaging and expanding should not be done. Temperature determination by color is misleading and unsatisfactory, but in this particular case, if the work is kept above an orange color (in the shadow), failures will be avoided.

In Fig. 8, one end of the short piece of charcoal iron tube was expanded while the tube was passing through the critical or "red short" range. The other end was given even more expansion at a temperature above this range. The perfect test on the one end would have been duplicated on the other had the tube been expanded at a temperature above or below the critical range.

*Tube Testing.*—The removal of tubes that leak under the hydrostatic test of the boiler causes delay and is expensive, therefore, we believe it to be good practice to test all safe ended tubes before putting them into the boiler. The test pressure should be twenty-five percent in excess of the boiler working pressure and while under the test pressure the tubes should be struck near the safe end weld or welds with a two pound steel hand hammer or the equivalent.

One type of tube testing machine is shown in Fig. 9.

Tubes which on examination after cleaning are found to be pitted or worn one-third of the original thickness of the tube should be scrapped.

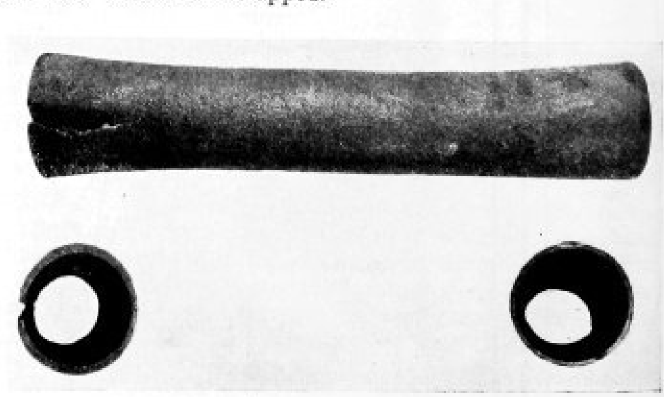

Fig. 8.—Effect of Expanding Tube When Passing Through the "Red Short" Temperature Range. Right End of Tube Expanded Correctly at Proper Temperature

If the pitted or worn surface is not too great, it may be cut off and the good portion of the tube used in boilers having shorter tubes.

When tubes, otherwise good, have been reduced in weight below the limits given in Table 1, they should be discarded.

Tubes that are slightly pitted or otherwise weakened, but which are still serviceable, should be kept together and reapplied in sets of tubes which are in approximately the same condition.

### Safe Ending

Good tubes should be safe ended as follows:

Safe ends should be scarfed on one end for half an inch, see Fig. 10, being tapered to 1/32 inch at end of scarfing.

Tubes to be safe ended should be expanded for the scarfed end of safe end so that they will fit snugly.

Place the safe end in end of the tube. Heat both to a welding heat. Draw out and quickly weld on the flue welding machine, taking care to see that the weld is smoothly made.

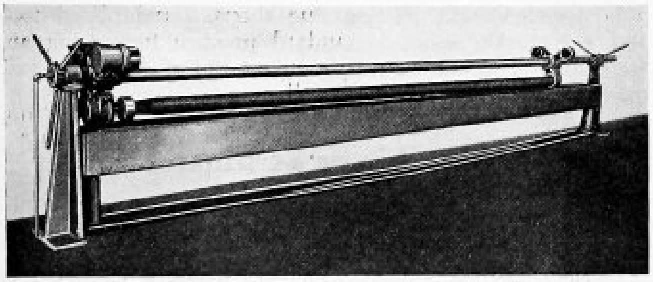

**Fig. 9.—One Type of Tube Testing Machine**

### Successive Safe Ending

It is recommended that body tubes contain not more than three welds at one time, with a total length of welded ends not to exceed 21 inches. If the total lengths of welds exceed 21 inches, all welds should be cut off and one piece of the tube welded on to bring the length up to the requirement. To this a new 5-inch safe end should be added at the firebox end at the first safe ending. Thereafter Table 2 should govern.

Superheater flues should not contain more than two welds.

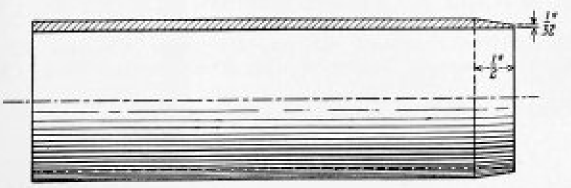

**Fig. 10.—Correct Method of Preparing Safe Ends for Use**

The use of a safe end shorter than five inches is not recommended, Fig. 11.

*First Application.*—New flue.

*Second Application.*—Cut swaged end to 3½ inches and apply 5 inches safe end, cutting to length after welding.

*Third Application.*—Cut swaged end to 3½ inches and apply safe end just long enough to give required length.

*Fourth Application.*—Cut off previous weld and reswage end of original dimensions. Apply safe end of full diameter at smokebox end, just long enough to give required length. Expand to standard requirements.

*Fifth Application.*—Same as second.

*Sixth Application.*—Same as third.

*Seventh Application.*—Same as fourth, except that old safe end at smokebox end of the flue must be cut off and a longer safe end used.

### Suggestions in Connection With the Ordering, Unloading and Storing of the Tubes

*Ordering.*—Requisitions or orders for boiler tubes, arch tubes, superheater flues and safe ends, for new work or replacements, should clearly state:

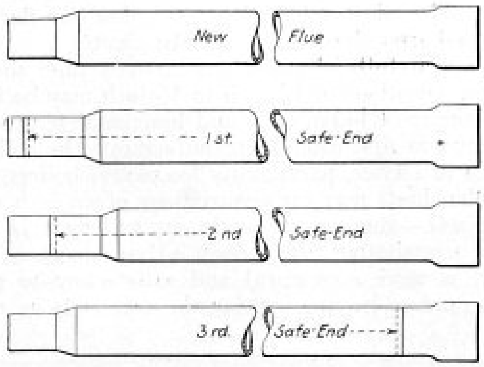


**Fig. 11.—Successive Applications of Safe Ends**

Length ............................ in feet or inches.
Outside diameter ............................ in inches
Thickness ................ in B. W. G. number, or in decimals of an inch.

The thickness of heavy wall arch tubes, water bars and marine stay tubes is often expressed in fractions of an inch: 3/16 inch, ¼ inch, etc.

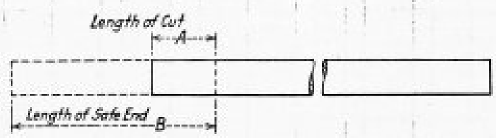


**Fig. 12.—Lengths of Safe Ends**

Table 2.—Application of Safe Ends

| Application | Length of Cut A Inches | Length of End B Inches | Remarks |
|---|---|---|---|
| First | ... | .. | new flue |
| Second | 1½ | 5 | one weld |
| Third | 5½ | 8 | one weld |
| Fourth | 8½ | 11 | one weld |
| Fifth | 11½ | 14 | one weld |
| Sixth | 1½ | 5 | two welds |
| Seventh | 5½ | 8 | two welds |
| Eighth | 8½ | 11 | two welds |
| Ninth | 27½ | 30 | two welds |
| Tenth | 1½ | 5 | three welds |

Table 3.—Decimal Equivalents of Birmingham Wire Gage (B.W.G.) Numbers Used in Boiler Tube Practice

| Thickness Birmingham Wire Gage Number | Inches |
|---|---|
| 13 | 0.095 |
| 12 | 0.109 |
| 11 | 0.120 |
| 10 | 0.134 |
| 9 | 0.148 |
| 8 | 0.165 |
| 7 | 0.180 |
| 6 | 0.203 |
| 5 | 0.220 |

If tubes or flues are to be swaged or expanded, the fact should be stated on the order, and a blueprint or sketch furnished to the tube manufacturer. Heavy tubes for special purposes may have the ends upset and enlarged within certain limits. When such work is to be done by the manufacturer, a blueprint or sketch should accompany the order.

*Length.*—Tubes for locomotive type boilers should be ordered 1 inch longer and flues for locomotive superheater service 1½ inches longer than the actual distance between the outer sides of the tube sheets to allow for flaring and beading and irregularities in the tube sheets.

Measure carefully the distance between tube sheets. In new work, variations of ¼ inch to ½ inch may be found in the tube sheets of locomotives and horizontal return tubular boilers, due to distortion in manufacture. On boilers that have been in service, particularly locomotive boilers, bulging of the tube sheets may cause variations of an inch or more.

*Safe Ends.*—Buying safe ends cut to length is a costly practice, necessitating, as it does, a large stock of various sizes. It is more economical and satisfactory to purchase tubes in random lengths, cutting the safe ends as required.

| RECORD OF FLUES | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BODY FLUES | | | | | | | SERVICE | | SAFE ENDS | | | SERVICE | | |
| SHOP | APPLIED TO LOCOMO. | REMOVED FROM LOCOMO. | APP. NO. | NAME | MTL. | NUMBER | DATE APPLIED | MILES | MONTH | NAME | MTL. | DATE APPLIED | MILES | MONTH | REMARKS |
| | | | | | | | | | | | | | | | |

Fig. 13.—Service Record for Set of Locomotive Tubes

A good safe ending machine will handle 120 safe ends per hour at a very small labor cost.

*Scarfing of Safe Ends.*—Opinion differs as to the amount of scarf required to give the best results. Our suggestion is that safe ends be scarfed for a distance of ½ inch, the metal tapering to a thickness of 1/32 inch.

*Unloading and Storing.*—Tubes should be unloaded with care and placed under cover at once, the various sizes in separate racks. The ends of the tubes, if exposed to the weather, should be sprayed or coated with oil. Refuse lubricating oil answers the purpose, at very little cost.

#### Remedying Conditions Responsible for Tube Maintenance Work

A great deal of tube and flue repairs are due to:

Faulty application of tubes and flues.

Lack of standardization of tube setting tools, or tools of poor design.

Too many safe ends on tubes or flues at one time.

Poor workmanship in safe ending.

Continuance of tubes in service after they have become thin and worn out.

Tubes stopped up.

Abuse by careless or unskilled hot workers.

Cooling boiler too rapidly by injector and improper use of blower.

Cooling too rapidly by blowing down for washout.

Washing out hot boilers with cold water.

Lack of proper attention at washout period.

Delayed washout in bad water districts.

Firing up rapidly and raising steam too quickly in engine house.

Allowing fire to die next to tube sheet while locomotive is standing in engine house or yard.

Most of these conditions can be improved, if not corrected entirely, by the mechanical department. Defective or inferior material, bad fuel, impure feed water, poor boiler design and conditions beyond the control of the mechanical department may frequently be bettered as a result of constructive suggestions to the responsible departments.

#### Importance of Recording Boiler Tube Service

Recording the service life of tubes in locomotives running hundreds of miles every day and handled by two or more shops admittedly presents difficulties. But an accurate and systematic record of tube service is absolutely essential, if tube costs are to be reduced.

A suggested form for recording the service of a set of tubes is shown in Fig. 12.

Careful study of conditions disclosed by worthwhile records, together with modern flue shops, standardized tools and a generally adopted standard practice for setting and maintenance, would reduce the tube costs of American railroads by many thousands of dollars.

## Supply Exhibitors at Master Boiler Makers' Convention

(*Continued from page* 101)

Simmons-Boardman Publishing Company, 608 S. Dearborn St., Chicago, Ill:

The Welding Engineer, 608 S. Dearborn St., Chicago, Ill.

Independent Pneumatic Tool Company, 600 W. Jackson Blvd., Chicago, Ill.

W. L. Brubaker & Bros. Company, Millersburg, Pa.

The Champion Rivet Company, Cleveland, Ohio.

McCabe Manufacturing Company, 9 Water St., Lawrence, Mass.

Pittsburgh Forge & Iron Company, Chamber of Commerce Bldg., Pittsburgh, Pa.

The Oxweld Railroad Service Company, Railway Exchange, 80 E. Jackson Blvd., Chicago, Ill.

J. Faessler Mfg. Company, Moberly, Missouri.

Rome Iron Mills, Inc., 30 Church St., New York.

Joseph T. Ryerson & Son, 2558 W. 16th St., Chicago, Ill.

Globe Seamless Steel Tubes Company, 122 S. Michigan Ave., Chicago, Ill.

Pittsburgh Steel Products Company., 332 S. Michigan Ave., Chicago, Ill.

Flannery Bolt Company, Vanadium Bldg., Pittsburgh, Pa.

A. M. Castle & Company, 1300-1600 N. Branch St., Chicago, Ill.

Ewald Iron Company, Railway Exchange, Chicago, Ill.

Keller Pneumatic Tool Company, 20 E. Jackson Blvd., Chicago, Ill.

Penn Iron & Steel Company, Creighton, Pa.

## Making Washers from Old Flues

One railroad shop has developed an interesting method of utilizing scrap boiler flues in the manufacture of washers at a relatively low cost. Dies have been made for punching ½-inch, ⅝-inch, ¾-inch and ⅞-inch washers of which many hundred pounds are used in railroad shops annually. The old flues are flattened out under a steam hammer and punched, two washers being secured with each revolution of the punch. The cost of producing washers by this method is as follows:

| | |
|---|---|
| Labor to handle and flatten flues | $0.30 per 100 lb. |
| Labor of cutting and handling flues | .31 per 100 lb. |
| Labor or punching washers | .55 per 100 lb. |
| Scrap value of flues | .50 per 100 lb. |
| Total cost | $1.66 per 100 lb. |
| 25 per cent overhead | .415 |
| Grand total | $2.075 per 100 lb. |

# Designing Locomotive Boilers for Maximum Efficiency

## Air and Gas Areas and Ratio of Tube Length to Diameter Important Factors to Be Considered

**By J. T. Anthony***

IN my opinion too much stress is laid on the mere subject of heating surface and too little attention is paid to the location and distribution of the heating surfaces. Some of the most important factors in design are the ratio of the tube length to the inside diameter; the ratio of the firebox heating surface to the total heating surface; the ratio of the superheating surface to the total heating surface; and particularly the relation between the net gas area through the tubes and the power to be developed.

In Table 1 are shown some of the most important data on four designs of Mikado (2-8-2 type) locomotives, together with the ratios, which, to my mind, are important. The last two—the ratio of the air inlet through the ash pan and through the grates to the grate area—are never shown and are probably considered a matter of no importance; but I am satisfied that the lack of attention paid to these ratios is costing our railroads a lot of money.

In designing the locomotive boiler the method usually followed is to determine the cylinder, horsepower output at a piston speed of 1,000 feet per minute for superheated locomotives, and from this figure determine the grate area on the supposition that one horsepower hour requires 3¼ pounds of coal, the maximum allowable rate of combustion being 120 pounds of coal per square foot of grate per hour. The total steam required per hour is obtained by multiplying the cylinder horsepower by 20.8 for superheated locomotives, and the amount of heating surface required to give this evaporation is based on the Coatesville test which showed 55 pounds evaporation per square foot of firebox heating surface, and about 10 pounds for tube heating surface.

I am satisfied that these evaporation figures can be, and often are, greatly exceeded in locomotive practice, and that the main problem is to design a firebox that will liberate the heat; then provide sufficient gas area to enable the firebox to free itself of the gases of combustion, without unduly high drafts; and last, to determine the correct proportion between the diameter and length of the tubes. A logical method for the design of a locomotive boiler would be about as follows:

Cylinder horsepower, according to the American Locomotive Company method = .0229 x P x A where

P is equal to boiler pressure and

A is equal to the area of one cylinder in square inches.

$$\text{Grate Area} = \frac{\text{Cyl. h.p.} \times 3.2}{120} \text{ for coal of 14,000 B.t.u.}$$

If coal of inferior quality is to be burned it is necessary to burn more of it in order to get the same heat output, and if the poorer coal is to be burned with the same degree of efficiency it is necessary to keep the rate of combustion down to 120 pounds which requires a larger grate. Therefore the

$$\text{grate area should be equal to } \frac{\text{Cyl. h.p.} \times .37}{\text{1000 B.t.u. in coal}}$$

With poor Western coal running 11,000 B.t.u., this gives a rather large grate area, but as most heavy engines are now being stoker-fired there is no logical reason why the larger grates should not be used. Of course, the argument against the larger grate is that it increases the standby losses. If a locomotive is designed to adorn the terminal tracks and sidings the argument is effective; but if it is designed to haul heavy trains at fair speeds and at the same time to burn a poor quality of coal efficiently, the larger grate will prove more economical than the smaller one, regardless of the standby losses.

Having determined the grate area the question of net gas area through the flues should next be considered.

According to the best information available when firing a high grade Pennsylvania coal at the rate of combustion of 120 pounds of coal, there is formed about 10.35 pounds of gas for each pound of coal fired, which equalled, in the particular locomotive, 9,660 pounds of gas per hour per square foot of flue opening. At higher rates of combustion there is a decrease in weight of gas per pound of coal and but a

*Vice-president, American Arch Company.

TABLE 1

DIMENSIONS AND FACTORS OF TYPICAL MIKADO LOCOMOTIVES

| Road | G. T. | I. C. | S. A. L. | Penn. |
|---|---|---|---|---|
| Tractive effort | 51,600 lb. | 51,700 lb. | 50,200 lb. | 57,850 lb. |
| Cylinders, diameter and stroke | 27 in. by 30 in. | 27 in. by 30 in. | 27 in. by 30 in. | 27 in. by 30 in. |
| Weight on drivers | 204,700 lb. | 218,300 lb. | 208,000 lb. | 235,800 lb. |
| Total weight of engine | 272,100 lb. | 82,700 lb. | 282,000 lb. | 315,000 lb. |
| Cylinder horsepower | 2,296 | 2,296 | 2,230 | 2,690 |
| Boiler pressure | 175 lb. | 175 lb. | 170 lb. | 205 lb. |
| Boiler type | W. T. | Straight | Ext. W. T. | Belpaire |
| Boiler, outside diameter, front end | 74 in. | 82 in. | 74 in. | 80½ in. |
| Tubes, number and diameter | 240-2-in. | 262-2 in. | 230-2 in. | 237-2¼ in. |
| Flues, number and diameter | 32-5⅜ in. | 36-5⅜ in. | 32-5⅜ in. | 40-5½ in. |
| Tubes and flues, length | 20 ft. 0 in. | 20 ft. 6 in. | 20 ft. 0 in. | 19 ft. 0 in. |
| Heating surface, firebox | 249.8 sq. ft. | 272.2 sq. ft. | 247 sq ft. | 302 sq. ft. |
| Heating surface, tubes and flues | 3,400 sq. ft. | 3,834 sq. ft. | 3,295sq. ft. | 3,716 sq. ft. |
| Heating surface, superheater | 769 sq. ft. | 887 sq. ft. | 760 sq. ft. | 1,172 sq. ft. |
| Heating surface, total (including superheater) | 4,418.8 sq. ft. | 4,993.2 sq. ft. | 4,302 sq. ft. | 5,190 sq. ft. |
| Net gas area through tubes and flues | 6.39 sq. ft | 7.06 sq. ft. | 6.23 sq. ft. | 8.44 sq ft. |
| Grate area | 56.5 sq. ft. | 70.4 sq. ft. | 63.2 sq. ft. | 70.0 sq. ft. |
| Firebox volume | .......... | .......... | .......... | 427 cu. ft. |
| Air inlets through ashpan | .......... | .......... | .......... | 8.44 sq. ft. |
| Air inlets through grates | .......... | .......... | .......... | 19.43 sq. ft. |
| Weight on drivers ÷ total weight | 0.752 | 0.772 | 0.737 | 0.749 |
| Weight on drivers ÷ tractive effort | 3.97 | 4.22 | 4.14 | 4.11 |
| Total weight ÷ tractive effort | 5.27 | 5.47 | 5.62 | 5.45 |
| Total weight ÷ cylinder horsepower | 119 | 123 | 127 | 117 |
| Cylinder horsepower ÷ grate area | 40.6 | 32.6 | 35.3 | 38.4 |
| Cylinder horsepower ÷ gas area | 359 | 325 | 358 | 319 |
| Tube length ÷ inside diameter of tube | 137 | 140 | 137 | 114 |
| Total heating surface ÷ cylinder horsepower | 1.92 | 2.17 | 1.93 | 1.93 |
| Superheater surface ÷ total heating surface | 17.4 | 17.7 | 17.6 | 22.58 |
| Firebox heating surface ÷ total heating surface | 5.65 | 5.45 | 5.74 | 5.81 |
| Firebox volume ÷ grate area | .......... | .......... | .......... | 6.10 |
| Air inlet through grate ÷ grate area | .......... | .......... | .......... | 28.8 |
| Air inlet through ash pan ÷ grate area | .......... | .......... | .......... | 11.1 |

slight increase in the total weight of gas formed. Thus at the rate of 170 pounds of coal per square foot of grate per hour only 10,800 pounds of gas pass through each square foot of tube and flue opening. It is possible that even a greater weight of gas could be put through each square foot of opening without unduly increasing the draft; but I have no accurate data as to this. Using 10,800 pounds as a base figure, however, the net gas area required is

$$\frac{\text{Cyl. hp.} \times 3.2 \times 10.35}{10{,}800} = \frac{\text{Cyl. hp.}}{330}$$

Having determined the gas area required this would be apportioned between the superheater and the smaller tubes as follows, using 40 percent of the area for superheater flues:

$$\text{No. units } 5\tfrac{1}{2} \text{ inch flues} = \frac{\text{Gas area in sq. in.} \times 0.4}{11.78}$$

$$\text{No. units } 5\tfrac{3}{8} \text{ inch flues} = \frac{\text{Gas area in sq. in.} \times 0.4}{10.78}$$

The remaining 60 percent of gas area goes to be used for the 2 inch or 2¼ inch tubes.

$$\text{No. Tubes} = \frac{\text{Remaining gas area in square inches}}{\text{Area of one 2 inch or } 2\tfrac{1}{4} \text{ inch tube}}$$

The length of the tubes should not be in excess of 120 times the inside diameter. While, personally, I think that 110 is a better ratio, I have used the larger figure to be conservative. A 2-inch tube with 1¾ inches inside diameter would, therefore, be 17 feet 6 inches long, and a 2¼ inch tube with 2 inch inside diameter and would be 20 feet long. The use of the shorter tubes in long wheel base engines of the Mikado, Pacific and Santa Fe types would, of course, necessitate longer combustion chambers, and this, to my mind, is an advantage. I would make the combustion chamber as long as necessary to connect the tubes with the firebox.

In Table 2 are shown the same locomotives as in Table 1, with the boilers figured according to the method above outlined and some of the resulting ratios. Different grades of fuel have been used for the four roads in order to illustrate their effect on the grate area. The ratios between the grate area and heating surface have not been shown, as with the above method of boiler design differences in such ratios would only indicate a difference in the B.t.u. content of the fuel.

It will be noted that no mention has been made of cylinder volume, nor have any ratios been shown containing this item, as it is of no importance and should be replaced by the cylinder horsepower.

The ratio of firebox volume to grate area should be at least six and as much greater as is possible to obtain.

I have not made any calculations as to the increase or decrease in weight of boilers which would be brought about by the suggested methods of designing, but this should differ but little from the results when following present practice.

TABLE 3

LOCOMOTIVES AS REDESIGNED BY SUGGESTED RATIOS

| Road | G. T. | I. C. | S. A. L. | Penn. |
|---|---|---|---|---|
| Tractive effort | 51,600 lb. | 51,700 lb. | 50,200 lb. | 57,850 lb. |
| Cylinders, diameter and stroke | 27 in. by 30 in. | 27 in. by 30 in. | 27 in. by 30 in. | 27 in. by 30 in. |
| Boiler pressure | 175 lb. | 175 lb. | 170 lb. | 205 lb. |
| Cylinder horsepower | 2,296 | 2,296 | 2,230 | 2,690 |
| B. t. u. per lb. of fuel used | 12,500 | 12,000 | 13,500 | 14,250 |
| Grate area | 68 sq. ft. | 70.8 sq. ft. | 61.1 sq. ft. | 70 sq. ft. |
| Net gas area, sq. ft. = cylinder horsepower ÷ 330 | 6.96 | 6.96 | 6.76 | 8.15 |
| Tubes, number and diameter | 256-2 in. | 256-2 in. | 246-2 in. | 290-2 in. |
| Flues, number and diameter | 36-5⅜ in. | 36-5⅜ in. | 36-5⅜ in. | 44-5⅜ in. |
| Tubes and flues, length | 17 ft. 6 in. | 17 ft. 6 in. | 17 ft. 6 in. | 17 ft. 6 in. |
| Firebox heating surface, approx. | 290 sq. ft. | 320 sq. ft. | 287 sq. ft. | 330 sq. ft. |
| Tube and flue heating surface, approx. | 3,230 sq. ft. | 3,230 sq. ft. | 3,140 sq. ft. | 3,740 sq. ft. |
| Superheating surface, approx. | 720 sq. ft. | 720 sq. ft. | 720 sq. ft. | 1,188 sq. ft. |
| Heating surface, total (including superheater) | 4,240 sq. ft. | 4,270 sq. ft. | 4,147 sq. ft. | 5,258 sq. ft. |
| Firebox volume | *50 cu. ft. | *60 cu. ft. | *50 cu. ft. | 457 cu. ft. |
| Total heating surface ÷ cylinder horsepower | 1.85 | 1.86 | 1.86 | 1.95 |
| Superheater surface ÷ total heating surface | 17.00 | 17.00 | 17.3 | 22.6 |
| Firebox heating surface ÷ total heating surface | 6.84 | 7.49 | 6.92 | 6.27 |

*The firebox volumes under the first three locomotives could not be shown, due to lack of data: but shortening the tubes to 17 ft. 6 in. length increases the present firebox volume by the amount shown.

## Export Service Available to American Manufacturers

(*Continued from page 99*)

The Industrial Machinery Division has just begun to collect the laws and regulations of all foreign countries covering the inspection, construction, and operation of steam boilers, air receivers, and similar containers. These will be available for the use of American manufacturers and exporters of machinery as circumstances show this to be necessary. A general survey of the railway mileage and rolling stock of the world is in preparation, and an effort will be made to have the report indicate extensions in prospect during 1922 and, if possible, 1923. A like survey of the steam, waterpower, and other electric stations of the world is being prepared in cooperation with the Electrical Division.

The Industrial Machinery Division is new and a great amount of important work is to be done. In making plans for this work the division wishes to have the benefit of advice from manufacturers, in order to profit by their contact with specific problems in the various foreign markets. The methods that have been established for collecting and distributing this information should prove of definite value to each of the 4,000 machinery manufacturers of America. The division wishes to handle these facilities in such a way that manufacturers may secure actual sales in many widely distributed markets.

## How Good Shop Lighting Aids Production

(*Continued from page 96*)

The matter of objections to wearing goggles has been gone into many times. These have been largely overcome through educational campaigns and many firms have developed additional measures for enforcing protection. There is, however, much opportunity to improve the goggles now in use and the manufacturers are most active to this end. For example, the range of vision, with a glass sufficiently small to give the needed strength for severe hazards, is such as to make them objectionable in certain structural work. Also, up to the present time there has been a reduction in the strength incident to the surfacing of the glass to correct for visual defects. The careful, exact fitting of the frames to facial contour, on which depend comfort and much of the value, is frequently difficult and certainly not universal.

# Rules for Constructing Miniature Boilers

## Material Specifications, Regulation of the Use of Welding and Data Reports for Small Pressure Boilers

FOR over two years a sub-committee of the Boiler Code Committee has been engaged in formulating rules for the construction of the so-called miniature boilers, which is to form Section 5, Part 1 of the A. S. M. E. Boiler Code. There has been considerable demand for such a Code embodying special rules for boilers of small size that come within this classification in which the requirements for power boilers of average size are scarcely necessary or justified. Several preliminary reports upon this Code have been considered by the Boiler Code Committee and two revisions thereof have been submitted to the steam boiler industry for purposes of discussion. In connection with the 1921 annual meeting of the Society, a public hearing on the proposed rules was held and the manufacturers were there invited to discuss the proposed regulations. The report is here published for the information of the membership. Anyone desiring to discuss the report is requested to address the Secretary of the Boiler Code Committee, 29 West 39th street, N. Y.

## A.S.M.E. Boiler Code

### Part I—Section 5

RULES FOR THE CONSTRUCTION OF MINIATURE BOILERS

M-1.—*Definition.*—Boilers to which the classification "miniature" applies, embrace fired pressure vessels which do not exceed the following limits:

16 inches inside diameter of shell.
42 inches in length of shell.
20 square feet total heating surface.
100 pounds per square inch working pressure.

Where any one of the above limits is exceeded the rules for power boilers shall apply.

M-2.—Specifications are given in these rules, paragraphs 23-178 of Part I, Section 1 of the Code, for the important materials used in the construction of boilers, and the materials for miniature boilers, for which specifications exist, shall conform thereto, except that in lieu of definite specifications for boiler plate material, there may be used for the shells or drums of miniature boilers, seamless drawn shells with integral heads, or seamless or extra-heavy lapwelded steel or iron pipe or tubing, provided it is of open-hearth material and the weld is formed by the forging process. Owing to the small size of the parts of miniature boilers, stamping as required by paragraph 36 of the rules for power boilers, need not be visible after completing the boiler providing the manufacturer certifies on the data slip accompanying the boiler that the material is in accordance with the requirements of the A. S. M. E. Code for Miniature Boilers. Provisions shall be made by the manufacturer whereby he shall be able to supply complete information regarding the material and details of construction of any boiler built under the Miniature Boiler Code.

M-3.—Steel plate when used for any part of a miniature boiler where under pressure, shall be of the firebox or flange grades, but in no case shall steel of less than 1/4 inch thickness be used for riveted shells or less than 3/16 inch thickness for seamless shells. The heads, if used as tube sheets with tubes rolled in, shall be at least 5/16 inch thick.

M-4.—The construction of miniature boilers, except where otherwise specified, shall conform to that required for power boilers. The factor of safety and method of computing the maximum allowable working pressure shall be the same as for power boilers.

M-5.—Heads or parts of miniature boilers when not exposed to the direct action of the fire may be made of cast iron or malleable iron provided it complies with the requirements in Part I, Section 1 of the Boiler Code for the headers of watertube boilers.

M-6.—Steam generator elements of not over 600 cubic inches in volume may be made of cast copper or bronze having a copper content of not less than 90 percent and wall thickness of not less than 1/4 inch. Such generators shall be equipped with at least two brass washout plugs of not less than 1 inch iron pipe size and shall be tested to a hydrostatic pressure of 600 pounds per square inch.

M-7.—Circumferential riveted joints, where used, shall conform to the requirements in paragraph 184 of Part I, Section 1 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.

M-8.—Tubes may be made of wrought iron, steel, drawn copper or drawn brass. Fire tubes 1½ inches and over shall have both ends substantially expanded into the tube sheet by rolling and beading. Fire tubes less than 1½ inches shall be expanded and beaded, or expanded and welded. The gage of the tubes shall not be less than those specified for watertube boilers and firetube boilers as specified in paragraphs 21 and 22 of Part I, Section 1 of the Code.

M-9.—All rivet holes shall be drilled full size or they may be punched not to exceed 1/8 inch less than full diameter and then drilled or reamed to full diameter.

M-10.—The calking edges of plates, butt straps and heads shall be beveled to an angle not sharper than 70 degrees t the plane of the plate, and as near thereto as practicabl Every portion of the sheared surfaces of the calking edg shall be planed, milled or chipped to a depth of not less th 1/8 inch. Calking shall be so done that there is no danger scoring or damaging the plate underneath the calking ed or splitting the edge of the sheet.

M-11.—Every miniature boiler shall be fitted with not than three brass washout plugs of 1 inch iron pipe which shall be screwed into openings in the shell near bottom, reinforced to give four full threads. All thre openings in the boiler shell shall be provided with a ri or welded reinforcement if necessary, to give four full th

M-12.—Every miniature boiler shall be provided w least one feed pump or other feeding device, except w is connected to a water main carrying sufficient pres feed the boiler.

M-13.—Each miniature boiler shall be fitted w water and blow-off connections, which shall not be ½ inch iron pipe size. The feed pipe shall be provi a check valve and a stop valve. The feed water delivered to the boiler through the blow-off conn desired. The blow-off shall be fitted with a valve direct connection with the lowest water space pra

M-14.—Each miniature boiler for operation wit water level shall be equipped with a glass wate determining the water level. The lowest, permis level shall be at a point one-third of the height c except where boiler is equipped with internal fur it shall be not less than one-third of the length o above the top of the furnace.

M-15.—Each miniature boiler shall be equipp steam gage, having a dial graduated to not less and one-half times the maximum allowable working pressure. The gage shall be connected to the steam space or to the steam connection to the water column, by a syphon tube or equivalent device that will keep the gage tube filled with water.

M-16.—Each miniature boiler shall be equipped with a sealed spring-loaded pop safety valve, not less than ½ inch diameter, connected direct to the boiler, independent of any other connection. The safety valve shall be plainly marked by the manufacturer with a name or an identifying trademark, the nominal diameter, the steam pressure at which it is set to blow, and A. S. M. E. Std. The minimum relieving capacity shall be determined on the basis of 3 pounds of steam per hour per square foot of boiler heating surface.

M-17.—Each steam line from a miniature boiler shall be provided with a stop valve located as close to the boiler shell or drum as is practical.

M-18.—Where miniature boilers are gas-fired, the burners used shall conform to the requirements of the American Gas Association, as given in the Appendix. The burners shall in such cases be equipped with a fuel-regulating governor, which shall be automatic and regulated by the steam pressure. This governor shall be so constructed that in the event of its failure, there can be no possibility of steam from the boiler entering the gas chamber or supply pipe.

M-19.—All boilers referred to in this section shall be plainly marked with the manufacturer's name and maximum allowable working pressure which shall be indicated in arabic numerals, followed by the letters "lb." All boilers built according to these rules shall be marked A. S. M. E. Min. Std. Individual shop inspection is not required for miniature boilers.

A data sheet shall be filled out for each boiler and signed by the manufacturer, this data sheet to include the most important items and to be numbered. In addition to this, the complete data sheet required for power boilers shall be filled out and preserved by the manufacturer for each lot of steel and each lot of boilers manufactured therefrom. The complete data sheet shall be marked to indicate to which boilers it applies and the manufacturer shall furnish copies of this complete data sheet when requested to do so by the owner of any one of the boilers. In requesting the complete data sheet the owner should forward the number of the boiler which would be stamped thereon in order that the manufacturer may readily identify the complete data sheet applying to the boiler.

(Name of manufacture)
. . . . . . . . . . . . . . . . .
60 lb.
A. S. M. E. Min. Std.

SAMPLE OF MARKING

...CTURERS' DATA REPORT FOR MINIATURE BOILERS

...ed by the Provisions of the A. S. M. E. Code Rules

...ufactured by..............................
(Name and address of the manufacturer)

...factured for..............................
(Name and address of the purchaser)

.....Boiler No.(....) (....) (....) Yr. built
Manufrs. Serial No. State and State No. (A.S.M.E. No.)

...er of: Length of
...r Drums......Drums....overall....ft....in.
(... of outside course)

...l for Shell, Straps
...and Furnace Sheets made by...............
(If more than one make, give names of manufacturers in same order as parts referred to.)

...aterial used in boiler been checked with mill test
...s ......................................

6. Built for maximum allowable working pressure....lb.
7. Hydrostatic pressure applied...................lb.

Note: The mill test reports of tests of material used in this boiler are preserved by the manufacturer as well as all data applying to the boiler called for in the data sheet for Power Boilers. This data will be supplied by the manufacturer at the request of the owner of the boiler.

8. Openings: No..Size..in., No..Size..in., No..Size..in.
(Main steam connections) (Safety valve) (Blow-off)

## Appendix

GAS BURNER SPECIFICATIONS—AMERICAN GAS ASSOCIATION

Each burner shall be equipped as follows:

1. With a separate one-quarter turn gas cock.
2. With either an adjustable gas orifice or a removable brass orifice of a fixed drilling to meet the local condition.
3. With an adjustable air shutter capable of giving complete shut off; a lock washer or screw should hold the shutter so securely that accidental shifting of the shutter is impossible.
4. The mixing tube should be at least six times as long as its minimum diameter.
5. When the air mixer, mixing tube and burner are made in separate parts, they shall assemble so that there is no reduction in internal area at the point of their connection in the direction of the gas flow.

The burner proper shall preferably be of a one-piece cored casting.

The port openings shall be drilled, or if assembled, shall be of uniform size.

The burner shall be capable of operating satisfactorily without a wire gauze.

For satisfactory operation a burner should have sufficient flexibility to burn with a blue flame at full load and not flash back when shut down to the gas flow required to just maintain radiation losses.

A positive pilot-lighting burner shall be provided.

# Repairing Tube Sheet Cracks in Locomotive Boilers*

THE firebox tube-plates of locomotive boilers sometimes develop cracks between the tubes, and the question of repairing these cracks is a matter of interest. Frequently the work of repairing tube plates falls to the locomotive handling staff, as at the time the cracks develop, the locomotive may not have run the necessary miles to warrant a shopping for general repairs. Often it is found advisable when a locomotive is sent into the shops to repair a cracked tube plate rather than renew it.

The method of repair depends upon whether or not the boiler is empty of tubes. If only a few tubes in the vicinity of the cracks are removed, a good repair can be made by threading the tube holes which have their bridges cracked and inserting tapered brass plugs. Heads are formed on the plugs which meet one another and entirely cover the cracks. The centers of the plugs are then drilled to receive the tubes, the tubes in this case being smaller than the original to allow of a substantial thickness of metal in the bushing. This method makes a fairly good repair, as the tubes have an unbroken contact surface and the cracks are covered and protected by the heads of the plugs.

Another method often employed is to insert plugs as in the previous case and then bore a tube hole into every alternate plug, leaving the remainder solid and plugging up the corresponding holes in the smokebox tube plate. The tube plate is thereby strengthened in the parts which are cracked, but the heating surface is reduced and additional stress thrown on stays which may be in the vicinity.

*Abstract of an article in the August 12, 1921, *Engineering*, describing a method of repairing cracks in locomotive copper tube-sheets, but which should be equally applicable with steel tube-sheets.

# The Boiler Maker

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Four million boiler tubes a year to be removed and reconditioned or discarded is one of the items of expense involved in maintaining the 68,000 locomotives in the United States. The care of the 16,000,000 tubes and flues, which is approximately the total number installed, comes within the charge of the boiler maker. How many railroads in the country have considered the importance of tube maintenance in its shops in relation to the whole problem and have formulated standard methods for carrying on the work?

The large systems have done this and as a result effect real economies in handling tubes, but the majority of roads trust to the experience and knowledge of their boiler makers. Fortunately, most of the men responsible obtain excellent results, but to do this they must depend entirely on themselves and spend long hours developing methods that the shop across the town has worked out satisfactorily.

With the idea of suggesting acceptable standards of tube installation and maintenance for such shops, the article on tube and flue work concluded in this issue of The Boiler Maker was prepared. The data resulted from the study and comparison of the best features of tube care on more than thirty large railroads and the final instructions were checked by an engineering committee of another prominent system. The practice, therefore, is reliable and may be depended upon.

In shops where the practice is not so good the types of equipment designated may well be adopted and a system which will give good results put into effect to help increase the operating efficiency of our railroads.

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In these days of health conservation and promotion of industrial production economies, more than half the states of the country have given absolutely no attention to the matter of shop lighting; this, in spite of the fact that the industrial blind in the United States constitute a large percentage of the total blind population. The protection afforded by proper lighting facilities and accident prevention devices, and a slight amount of consideration given to the matter by the states, would have made impossible the loss of these individuals as valuable productive units of our industrial system. It is unfortunate that this condition exists for the most interested and skilled workers are generally the ones to suffer from lack of adequate facilities and protection for carrying on their work.

The majority of the remaining states have left this important matter to the mercy of state or city industrial commissions and safety councils who may have excellent intentions of supervising the lighting of industrial plants coming within their jurisdiction, but through lack of necessary legislation are unable to enforce their suggestions.

Fortunately there are a few states which are always active in promoting measures designed to better working conditions and increase safety within their borders. These states have not only adopted the American Standards Code for Factory Lighting formulated by the Illuminating engineering Society, but are rigidly enforcing it. In the States of Pennsylvania, New Jersey, New York, Wisconsin, Oregon, California and Ohio, where the Code is in force, manufacturers have found that it works no hardship on them since it entails a minimum change in the existing lighting facilities. In fact it actually increases their production to a very appreciable extent with a slight increase in cost for lighting.

This brings up the matter of light in the boiler shop, where with the exception of a few modern plants, up to date in every respect, the matter of adequate illumination has never been thought of. Because a plant is small and old and employs but few men is no legitimate reason why it should be kept in darkness. If it otherwise has a good record of production this record will be bettered by the use of whitewash and the addition of a few well placed lights in modern reflectors. The walls pierced for a number of additional windows will make an old plant take on a new lease of life.

Consideration of this subject when it leads to the improvement of lighting facilities will pay dividends now and all time.

# Engineering Specialties for Boiler Making

**New Tools, Machinery, Appliances and Supplies for the Boiler Shop and Improved Fittings for Boilers**

## High Speed Wire Brush for Cleaning Metal Surfaces

The increasing use of air-driven wire brushes for cleaning metal surfaces has demonstrated the need of high rotative speed. Especially has this been true on such cleaning work as the removing of paint, rust, dirt and scale

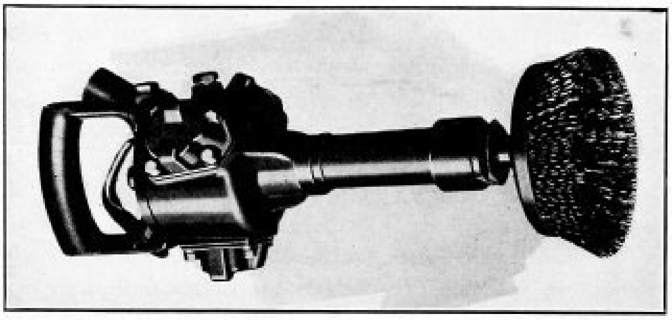


Fig. 1.—No. 601 Little David Wire Brush

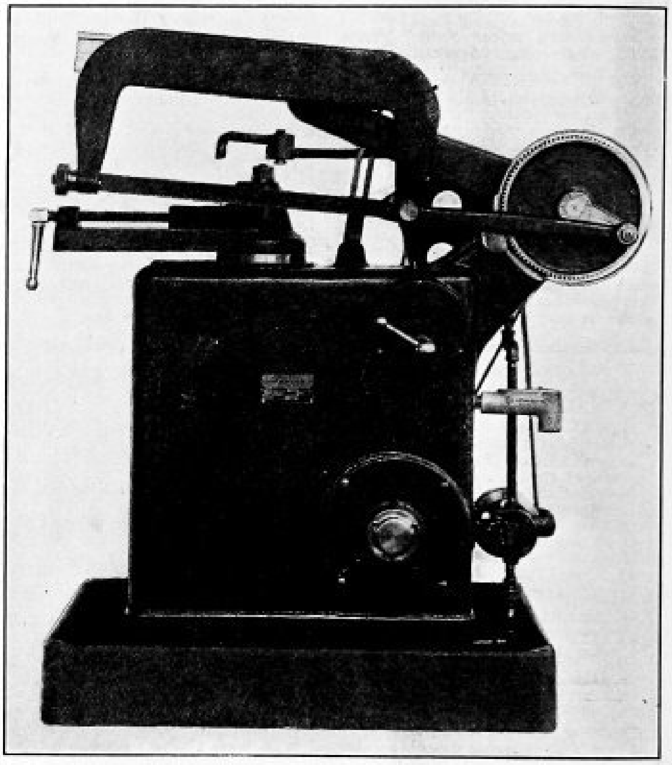
from tanks, steel cars, structural steel forms, etc., where the area to be cleaned is large and a fast rate of work is required. It has been found that a wire brush turning at high speed cleans faster and also stands up to the severe service much better than if only revolving at 2,000 or 3,000 revolutions per minute.

The Ingersoll-Rand Company, New York, has recently brought out a high speed cleaner (Fig. 1) known as the No. 601 Little David wire brush, which has a maximum speed of 4,200 revolutions per minute. This machine is said to be unusually successful in operation, effectively cleaning surfaces such as mentioned above and also iron and steel castings. It is designed to do a first-class cleaning job and effect a considerable saving of time and labor as well.

The air motor is of the three-cylinder type such as used in the Little David portable grinder which has been thoroughly tested out in the severe service to which pneumatic grinders are subjected. The machine is designed to be simple in construction, well balanced and operate without vibration. Light weight has been attained by using an aluminum casing reinforced with cast-in steel bushings. The weight of the complete machine is 14 pounds; the average free speed at 90 pound air pressure, 4,200 revolutions per minute; the length overall, 17½ inches and the diameter of the wire brush, 6 inches.

## Self-Contained Power Hack Saw

The electrically driven hack saw outfit shown in the illustration is unique in that the motor is housed in the base, thus making a compact self-contained unit which can be mounted on wheels if desired and used as a portable machine. The motor and its control switches are built into the machine in such a manner as to be out of the way and at the same time protected from injury. The ½ horsepower ball bearing motor used with the equipment may be had for any commercial voltage desired. The length of the saw used is 16 inches and the length of the stroke is adjustable between 5 and 7 inches. The saw can be operated at either 45 or 90 strokes per minute so that hard or free cutting stock can be cut with best results. The saw can be raised and held in any position. The feed is by gravity and an automatic stop is arranged to stop the motor when the work is cut off. The saw slide is above the blade where cutting and grit will not fall on the sliding surfaces. An oil pump may be used if desired. The vise swivels are graduated for cutting angles.



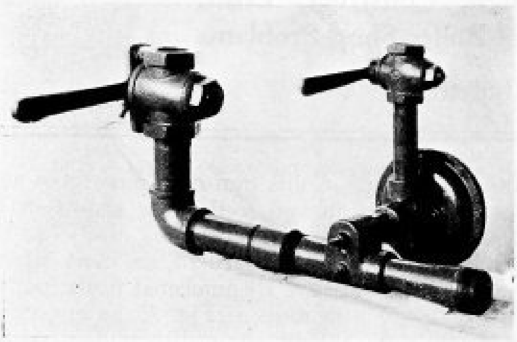
Portable Self-Contained Power Hack Saw

The machine has a height of 36 inches, occupies a floor space of 18 inches by 39 inches and weighs 450 pounds. This hack saw outfit is being marketed by the Louisville Electric Mfg. Co., Louisville, Ky.

## Air-Gas Inspirator for Gas Furnaces

The surface combustion, low pressure air-gas inspirator hitherto used exclusively on the furnaces of the Surface Combustion Company, New York, has been re-designed for use with any make of gas furnace. It is stated that this type of automatic inspirator is essentially a gas furnace carburetor utilizing many of the same principles as the automobile carburetor. The inspirators operate with any fuel system which has air available at a pressure greater than one quarter pound per square inch and gas at pressures above one inch of water.

The complete equipment consists of the inspirator casting, a governor, an air cock, a gas cock and a water gage. The entire operation of the furnace is controlled through the air cock. An increase or decrease of the air supply automatically increases or decreases the gas so that the mixture proportions remain in a constant fixed ratio. The water gage indicates the rate of consumption and enables the operator to accurately reproduce each day the most advantageous rate of operation. The gas cock is used only when starting or



Surface Combustion Air-Gas Inspirator

stopping and is either full on or full off; no adjustment of it being required.

The general principle of operation is based on the venturi. The operating energy is furnished by the pressure of air which in turn is controlled by the air cock. The tapered approach, restricted throat and expansion cone of the venturi cause the air to change from static to velocity and back to static head again respectively. The high velocity of the air passing through the narrow section in the tube sets up a suction which is utilized to draw in the gas.

In the expansion cone the gas is mixed thoroughly with the air and the homogeneous mixture is converted to a pressure head suitable for delivery to the burners. The governor provides the automatic feature which regulates the gas to a constant zero pressure.

The advantages claimed for the inspirator are the automatic supply of the exact proportions of air and gas to the furnace under all conditions of operation, thorough and homogeneous mixing just prior to entering the furnace and instantaneous combustion.

## Safety Washout and Arch Tube Plug

The special safety washout plug illustrated in Fig 1 is being produced by Frank Crist & Company, Lima, Ohio. This plug is made to fit washout holes 2½ inches and larger and is especially adaptable to arch tube holes.

The split construction of the plug is evident from the illustration and when installed with the cap screwed in place the plug becomes a solid closure for the washout hole. It is stated that the feature of this plug is that a large hole through which to wash the boiler may be used without the danger of wearing down the edges, thus making patching of the mud-ring corners unnecessary. The tapping of holes is eliminated and the cost of re-application is carried out by simply cleaning off the ground seat for the nut. Graphite

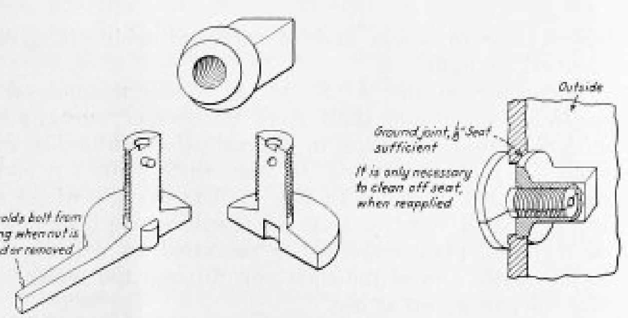



Fig. 1.—Split Type Safety Washout Plug

is used on the seat and nut when applying it. The plug cannot blow out because of the fact that the pressure in the boiler holds the head tight against the sheet.

The inventor states that these plugs have so far been applied on two roads and are giving entire satisfaction after six months service. No complaints have been made of leakage caused by the caps working loose from the vibration of the engine nor have the seats been ground since the plugs were installed. The plugs are located on the front corner of the mud-ring where the service requirements are most rigid.

These plugs are made up in stock sizes and are intended to fit all holes anywhere in a locomotive boiler below the

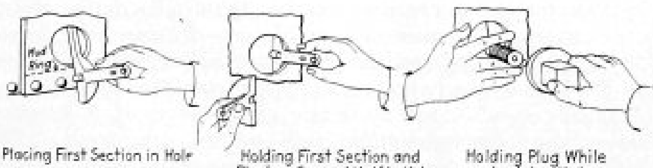



Fig. 2.—Method of Installing Plug

running board. They have also been found useful in stationary watertube boilers because in this service it is unnecessary to roll thimbles into the sheet. They also tend to eliminate warping and leaking of the sheet.

## Thimble for Protecting Boiler Tubes

The American Boiler Tube Thimble Company, Providence, R. I., recently began the commercial production of boiler tube protection thimbles invented by John F. McKenna, foreman boiler maker of the New York, New Haven and Hartford Railroad of Providence. This device was described in detail on page 223 of the July, 1919, issue of *The Boiler Maker*.

Thimbles are being manufactured for standard size tubes from 1½ inches to 4⅝ inches diameter although no additional charge is made for special sizes. The thimble is intended to protect the tube end from burning where it comes in contact with the flame and also to reinforce the tube sheet.

## Air Reduction Sales Company Consolidates with Davis-Bournonville Company

The Air Reduction Sales Company, New York, recently acquired all the assets, including the patents, trade marks and trade names of the Davis-Bournonville Company of Jersey City, N. J. The consolidation brings together two large companies, whose histories have, to a great extent, been the history of the development of the oxy-acetylene welding and cutting industry.

The Air Reduction Sales Company is a pioneer in the extraction of gases from the air for industrial use. Its principal product is oxygen, which is used to the greatest extent, in conjunction with acetylene, in producing the high-temperature oxy-acetylene flame. The Air Reduction Company further produces nitrogen and argon for incandescent lamp manufacture, and neon for electrical devices.

The Davis-Bournonville Company was organized in 1907 by Augustine Davis, Eugene Bournonville and C. B. Wortham and at once took up the manufacture of oxy-acetylene torches. As success was attained in connection with the welding torch, the company's activities were directed to the development of oxy-acetylene cutting torches, acetylene generators, and finally to machines for welding and cutting. It is the intention of the Air Reduction Sales Company to continue the manufacture of D-B torches, acetylene generators, special machines, etc., under the supervision of the men who developed them. The equipment will be marketed under the trade name of Airco-Davis-Bournonville.

# Questions and Answers for Boiler Makers

## Information for Those Who Design, Construct, Erect, Inspect and Repair Boilers—Practical Boiler Shop Problems

**Conducted by C. B. Lindstrom**

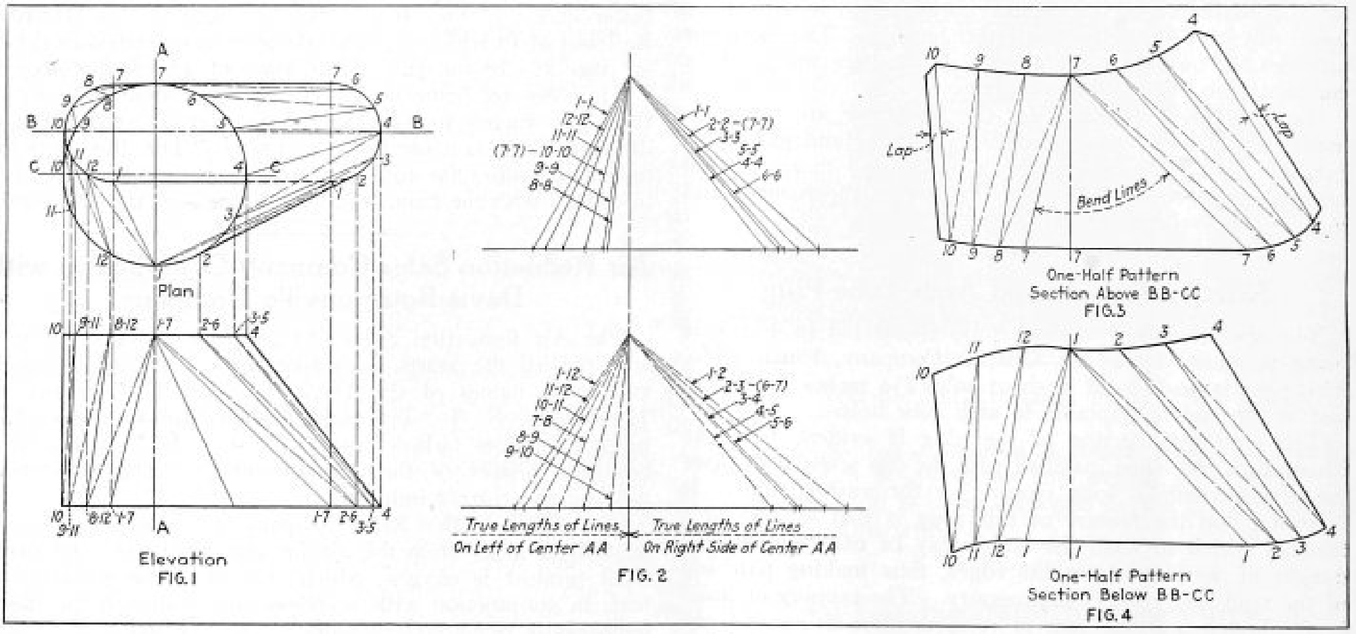
*This department is open to subscribers of* THE BOILER MAKER *for the purpose of helping those who desire assistance on practical boiler shop problems. All questions should be definitely stated and clearly written in ink, or typewritten, on one side of the paper, and sketches furnished if necessary. 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 permission to do so.*

### Development of an Irregular Uptake

Q.—I wish to ask you for the correct method to use to lay out an uptake cut of center, round at one end and oblong on the other.—C. W. E.

A.—A complete layout of your problem is given in the accompanying illustrations, Figs. 1 to 4. The first requirement is to lay off a plan and elevation according to the dimensions given. As the object is of an irregular form, it is necessary to divide the plan and elevation into a number of triangular sections, as shown. This is done by dividing the circle into a number of equal parts; also the semi-circular ends of the wash-boiler shaped base. The construction lines, *1-1*, *2-2*, *3-3* to *12-12*, etc. are then drawn connecting the respective points of division on the upper and lower bases.

From these data, the true lengths of the construction lines are obtained, as shown in Fig. 2. Each line is numbered, thus making the development work easy to follow. Bear in mind that the base distances of the triangles are equal to those of corresponding length, plan view. The height of all the triangles equals the vertical distance between the two bases, measured as shown at *x* of the elevation.




**Complete Layout of Uptake, Square at One End and Round at the Other**

Owing to the shape of this transition piece, it is advisable to make the pattern in two sections as shown in Figs. 3 and 4. The patterns are laid off in this case so as to bring the seam lines on lines *4-4* and *10-10*, the outer extremity of the object. As the lines are all numbered in the pattern sections to correspond with those of Fig. 2, the respective steps in the layout work should be readily understood and no difficulty found in completing the construction.

### Reinforcing a Manhole Opening

Q.—How should an A. S. M. E. boiler code standard manhole plate having the following dimensions be designed: 10½ inches by 15 inches; 15/16-inch holes and ⅝-inch plate?—A. K.

A.—On account of the removal of the solid plate section to form a manhole opening in a boiler, the boiler plate is weakened. To compensate for this loss of strength, reinforcing liners or rings must be applied around the opening. The thickness of the plate liner should not be less than the boiler plate thickness and of sufficient width to give the required strength.

According to the A. S. M. E. Code, manhole frames on shells or drums shall have the proper curvature and on boilers over 48 inches in diameter the reinforcing frames shall be double riveted to the shell, with 2 rows of rivets pitched as shown in Fig. 1. The strength of the rivets in shear shall equal at least the tensile strength of that part of the shell plate removed, as measured on a line parallel to the center line of the shell and through the center of the manhole, as shown at *a-a*.

The width of the reinforcing ring when the ring is attached to the shell with 2 rows of rivets may be determined by the formula:

$$W = \frac{l \times t_1}{2 \times t} + 2d$$

in which:

$W$ = least width of reinforcing ring, inches.
$l$ = length of opening in shell in direction parallel to axis of shell, inches.
$t_1$ = thickness of shell plate, inches.
$d$ = diameter of rivet when driven, inches.
$t$ = thickness of reinforcing ring—not less than thickness of the shell plate, inches.

Substituting the values of the problem in the formula, the width equals:

$$\frac{10\tfrac{1}{2} \times \tfrac{1}{2}}{2 \times \tfrac{5}{8}} + 2 \times \tfrac{15}{16} = 6.075 \text{ inches.}$$

To find the number of rivets for a single or double reinforcing ring the A. S. M. E. Code gives the formula,

$$N = \frac{5.1 \times T \times a}{S \times d^2}$$

in which:

$N$ = number of rivets.
$T$ = tensile strength of the ring, pounds per square inch of section.
$a$ = net section of one side of the ring or rings, square inches.
$S$ = shearing strength of rivet, pounds per square inch of section.

Assuming the value of 55,000 pounds for $T$ and 44,000

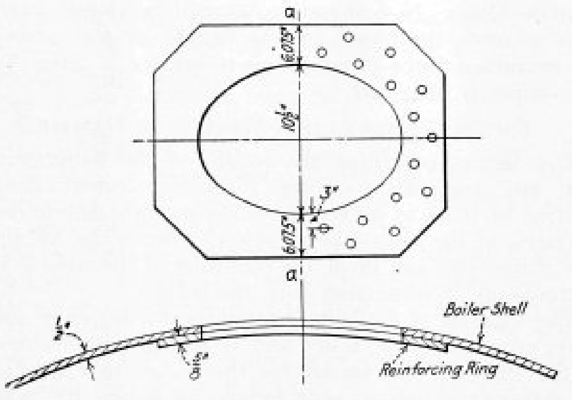



**Fig. 1.—Reinforcing Frames Riveted to Boiler Shell Around Manhole Opening**

pounds for $S$ and substituting the values in the formula, the required number of rivets equals:

$$\frac{5.1 \times 55{,}000 \times 6.075 \times \tfrac{5}{8}}{44{,}000 \times \tfrac{15}{16}^2} = 28 \text{ rivets, nearly.}$$

Strength of rivets on each side of center line $a$—$a$ equals $0.9375^2 \times 0.7854 \times 14 \times 44{,}000 = 425{,}040$ pounds.

Strength of solid plate removed on line $a$—$a$ equals $10\tfrac{1}{2} \times \tfrac{1}{2} \times 55{,}000 = 288{,}750$ pounds.

Strength of liner on $a$—$a$ equals $6.075 \times 2 \times \tfrac{5}{8} \times 55{,}000 = 418{,}000$ pounds. Thus showing that the liner and rivets are amply strong to support the weakened section.

## Determining Strength of Boiler Plate

Q.—In general what are the requirements in determining the strength of steel plate for boilers and pressure vessels?—A. C.

A.—According to the American Society of Mechanical Engineers' code, the tensile strength of flange steel shall range between 55,000 pounds and 65,000 pounds per square inch and firebox steel between 55,000 pounds and 63,000 pounds per square inch. A lower tensile strength is permissible, in which the code specifies a minimum range of 10,000 pounds per square inch less than that given for the minimum value for flange steel and 8,000 pounds per square inch for firebox steel, providing the steel conforms with the requirements specified by the code. The minimum tensile strength within the specified range must be stamped on the steel plate.

For existing installations, when the strength of the plate is not known, the tensile strength of steel plate shall be taken at 55,000 pounds per square inch, and for wrought iron at 45,000 pounds per square inch.

To determine the strength of boiler steel, several strips of the steel plate are tested for toughness and ductility. A standard form of test pieces for tensile strength is shown in Fig. 1, which gives the respective dimensions of the strip. The American Society of Mechanical Engineers' boiler code requires that the tension and bend pieces shall be taken from the finished rolled material of the same thickness of material as rolled and machined to the shape shown in Fig. 1. For bend tests, the test pieces may be machined with both edges parallel.

Three tests are required for each rolled plate; one for tension, one cold-bend and one quench-bend.

The tension test is made on a geared pulling machine by placing the shaped ends of the test pieces in the jaws of the machine. When the machine is in operation, the jaws are pulled away from each other, thus the boiler strip stretches until it reaches the yield point of the material, as measured by the beam of the testing machine. When boiler steel undergoes this test, attention is paid to its elongation, or the percentage of its length that the test strip stretches before it reaches the breaking point. On the stretching quality of the material depends its ability to withstand the bending, rolling and flanging operations.

The bend tests for material one inch and under in thickness shall bend cold through 180 degrees, without cracking

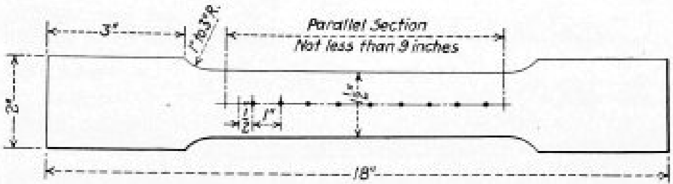



**Fig. 1.—Test Piece to Determine Strength of Plate**

on the outside of the plate at the bend, or, in other words, the strip must be bent flat on itself without breaking or cracking.

In the quench bend test, the test piece is heated to a light cherry red heat (approximately 1,200 degrees F.) and then it is quenched in water having a temperature range from 80 to 90 degrees F. The piece should then bend through 180 degrees, without cracking, if the test piece is one inch in thickness and under. For plate over one inch in thickness it should bend around a pin equal in diameter to the plate thickness.

Firebox steel plate must be homogeneous so as to withstand the intense heat it is subjected to in furnaces and fireboxes. Homogeneous steel plate is material without laminations, cavities or foreign matter interposed in the structure. Visual inspection of broken plate will show the cross-sectional state of the metal and the use of a magnifying lens will bring its condition out more clearly.

The crushing strength of steel plate is taken at 95,000 pounds per square inch of cross-sectional area of the material.

The Combustion Engineering Corporation, New York, has opened its own office in the First National Bank building, Pittsburgh, Pa., and will soon open an office in Cleveland, Ohio, both of which will be in charge of W. C. Stripe, former manager of the Philadelphia office.

The Diamond Power Specialty Corporation, a new company, announces the purchase as of March 1st, 1922 of the soot blower business of the Diamond Power Specialty Company. Norman L. Snow resigns his position as vice-president and general manager of the Terry Steam Turbine Company of Hartford, Connecticut, to take up the presidency and management of the new corporation.

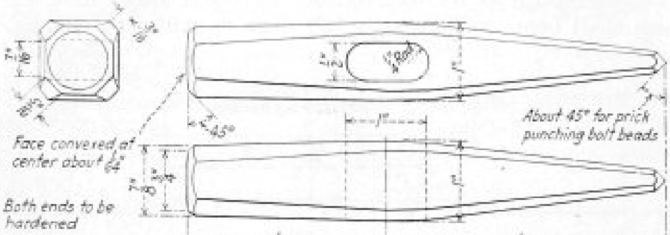
# Letters from Practical Boiler Makers

**This Department Is Open to All Readers of the Magazine —All Letters Published Are Paid for at Regular Rates**

## The Proper Type Hammer for Testing Staybolts

Since 1905 I have been a continuous subscriber to The Boiler Maker and during all this time I have kept a complete file of the magazine, so that now, when I look at the stack they make, I wonder if I have not even more copies than the folks that published them.

It occurred to me, after looking over the editorial page of the February, 1922, number, that perhaps the editors are right in assuming that the real value of the magazine depends in a large measure on the willingness of the subscribers to share their particular experiences and special knowledge acquired in their work with other subscribers through the medium of its pages.




**Best Type Hammer to be Used for Testing Staybolts**

In common with the fellows to whom the third paragraph of the editorial on page 51 seemed to refer, I have more confidence in my ability as a boiler maker than as a writer. However, since the invitation was evidently sincere and the editors promised to "blue pencil" all contributions into printable shape, I am taking this opportunity to express myself in regard to hammer testing staybolts, feeling that perhaps I can add something in detail to the answer given to the query by C. B. (page 54) as to the weight and design of hammer best suited to that work.

The statement that *any* type of hammer weighing one or two pounds is suitable for bolt testing is rather too general to be of much help to the fellow who does not know and, assuming the information is asked in good faith and the inquirer is not fully informed, is also unintentionally misleading.

### Weight of Hammer to Be Used

In my experience, embracing acquaintance with a good many men engaged in that work, I have found that, with one exception only, they all favored a hammer weighing very close to one pound, the variation from that weight seldom exceeding one ounce either way and designed as shown in the attached sketch.

It had often caused me to wonder, before trying a hammer of this shape on bolt testing, why an experienced section hand or track walker, when given his choice of an ordinary broad faced, straight or cross peined sledge hammer and a long, slender, narrow faced spike maul for use at his work, would invariably choose the spike maul. The reason seems to be that although the maul, due to its small face, must be thrown with more accuracy in order to strike a smaller spike head than would be necessary with an ordinary sledge, it is, weights being equal, much more effective due to the fact that its entire weight and the force of the blow, when delivered, is centered close to the longitudinal axis of the hammer. No part of this force is wasted in an offside movement, as is the case when a broad faced hammer is used and the blow not accurately struck. In other words, when using a long bodied, evenly balanced, small faced maul the blows are all fair, or very nearly so, or else are clean misses and this principle, if it can be so called, when applied to the design of a testing hammer serves to help the user to strike nearly accurate blows. In bolt testing, as will be shown later, the more accurate the blows are the better. At the same time, the maximum force or vibrating power for a given weight of hammer is delivered.

### Factors Determining Weight of Hammer

The factors governing the weight of the hammer to be used are, generally speaking, three in number; first, the location of bolts to be tested, which in turn determines the thickness of the sheets they connect; second, the length and size of the bolts and third, the condition of the outside sheets at the point of connection with the bolts.

The location of the bolts determines the degree of solidity to be expected by the tester and is reflected in the rebound of the hammer, the reason for this being that due to the requirements of design, as in locomotive boilers for example, a flue sheet of ½ inch or 9/16 inch thickness will be joined by staybolts to a throat sheet ⅝ inch or ¾ inch thick. The result apparently is that these two sheets, each of them relatively solid of itself, are given an increased degree of solidity through being connected.

Now suppose, for the sake of comparison, that we move over to one of the side sheets, we find that a 5/16 inch inside or firebox sheet has been joined to a ½ inch outside, or properly termed, wrapper sheet.

We find upon comparing these two locations that the combined thickness of the flue and throat sheets is 1⅛ inches or 1 5/16 inches and the combined thickness of the other two is 13/16 inch, a difference of ½ inch, or the equivalent of a third sheet of that thickness.

### Connection of Crown Sheet and Wagon Top

Again, at the connection of the crown sheet to the wagon top, we have a condition similar to the flue and throat sheet connection in the matter of weights, but dissimilar in that the space is wider between them, making a longer connecting bolt necessary which will absorb the shock of an ordinary blow with a light hammer without indicating anything clearly. Another difference is that all the bolts radiating from approximately the transverse center of the boiler and so spaced in the top sheet as to distribute the support equally, are often entered obliquely in the top sheet for that reason. Here again is a condition that produces a rebound in a too light hammer that will confuse even an experienced inspector.

Because of these conditions it is evident that a properly designed hammer must be heavy enough to vibrate the heaviest inside box sheet and connecting bolt to such a degree as to enable the tester to feel the outside and more solid sheet, where the connecting bolt is good; the absence of such feel, location and surrounding connections considered, indicating a defective bolt. On the other hand, a too heavy hammer capable of vibrating both sheets will give so nearly an equal rebound in all cases (except, perhaps, in the case of a bolt broken and standing away from the outside sheet), as to make it extremely difficult to detect any difference between the feel of a fractured bolt and that of a solid one, especially where the solid bolt has been installed only a short time before the test or is the least bit loose outside.

### Proficiency in Using a Hammer

We have shown how accuracy of blow and vibration transmission peculiar to that shape governs the contour of the hammer and why its weight must conform to the weights of the sheets in which the bolts are located as well as the angular connections, which add to local solidity, and corroded or weakened spots at the point of outside connection, which subtract from it. If, after establishing the mean between them the hammer weight is set at that point, only a certain amount of practice is necessary to bring the user to the point where he can detect a fracture, if it be 1/3 or more of the sectional area of the bolt, as readily as a clean break. Both will lack the degree of solidity of a good bolt of course, but the fractured bolt will give a part of the rebound felt when a good bolt is struck, at the same time giving off a high pitched rattle, which is due to the fact that the hammer raises only a short distance from the bolt head and immediately returns, each succeeding return being shorter and more rapid. Whereas, when a clean break is found, the hammer feels as if it were going to stick to the bolt head and gives off a dead, hollow sound easily distinguishable from the fracture rattle.

Experience seems to prove also that, since hammer testing is in a sense a comparison of rebounds, as between bolts in the same boiler, a better gaging is possible if the tester will tap all the bolts in the same horizontal row in any one sheet before moving to the next, rather than skip about from bolt to bolt without regard to row or location. This permits a fair comparison because the set or angle of connection, as previously described, is likely to be the same the whole length of the same horizontal row and, of course, the sheets are of equal respective thickness.

### Sound Not the Most Important Factor

It is well to guard against the tendency to rely too much upon sound since bolts adjacent to washout and fitting connection holes in outside sheets and behind frame bars between pad flanges, where no fillers are used, very often sound bad. The holes subtracting from the stiffness of the sheets necessarily reduces rebound. A careful retapping, however, and some familiarity with the construction of the boiler should serve to reassure where the doubt at first seems justified.

Another reason for relying upon touch rather than sound is found in the fact that most locomotive hammer testing is done in the engine house and it sometimes happens that, while this work is going on, there are several engines being blown down and perhaps two or three having their fires forced with their front end or the roundhouse blowers. This added to the partial deafness usually found among boiler makers who have been years in the service and you haven't much sound left to go on.

Quite a good deal more might be said regarding the shape and surface conditions of bolts and sheets, particularly the necessary preparation of rough, burned or honeycombed button headed crown bolts, from which the squares have not been removed, all of which is important and makes for efficiency, to the end that the bad ones shall be detected and removed, and the good ones allowed to remain.

I hope that the foregoing will provoke some discussion from the readers of The Boiler Maker that will be helpful to all of us.

Nashville, Tenn. Edwin H. McHugh.

## Chart to Determine Length of Radial Stays

The accompanying illustration of a boiler radial stay chart is used by the writer to eliminate some difficulties formerly experienced in having radial stays of proper length applied or, rather, in not having a boiler charted to conform to the radial bolts ordered for it.

Prior to the use of this chart, the practice was as follows: the drawing room made the layout of the radial stay section of the boiler to determine the proper length of bolts required. From this layout the order department was given a list of the bolts to be placed on the bill of material to be ordered or taken from stock, as determined by the stock department. The boiler department ordered these bolts from the stock department as specified on the bill of boiler materials and, after delivery to the boiler department, the various holes in the boiler were measured up. Due to 1/4-inch variation in lengths of the holes, or rather in the distance between sheets,

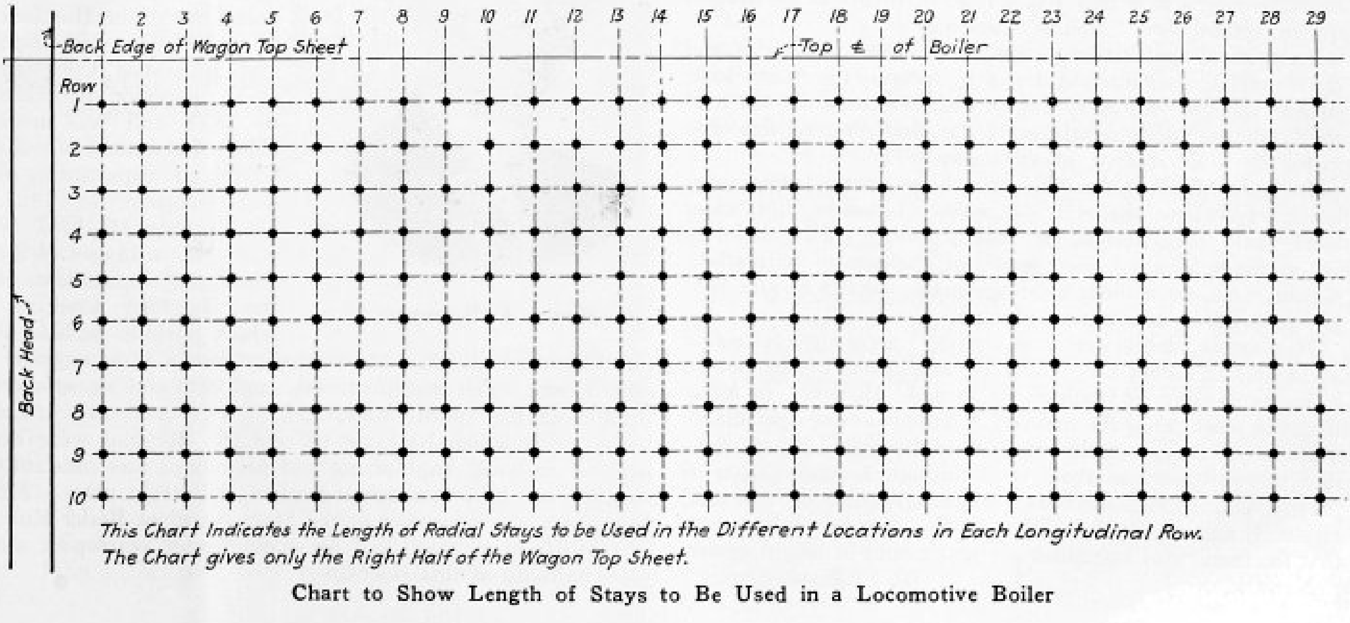



Chart to Show Length of Stays to Be Used in a Locomotive Boiler particularly on boilers with sloping wagon tops, it was frequently found that before all the bolts were entered that there were several bolts of one or two sizes (the bolts run in variations of one inch in length) left over and as many short of other lengths.

The use of this chart adds but little to the labor of the draftsman, as, after determining the various lengths of bolts for the order department, he simply enters the various lengths on the chart and it is issued to the boiler shop where the lengths are chalked off on the new boiler and each bolt is easily selected for its proper location.

Aspinwall, Pa. C. E. Lester

## Trouble With Front End Appliances

The following request for information on the cause for a locomotive not steaming due to front end troubles has been received from one of our readers. The subject is an interesting one and well worth bringing up for discussion. We will be glad to have all of our readers think over their experiences in this connection and send an account of them to us for publication:

"I am at present engaged in roundhouse work and have had considerable trouble with front end draft appliances. I would like to see a treatise on this subject in your magazine. I suppose the front end arrangements are constructed from calculations and experiment.

"We often find an engine that has been giving satisfactory service suddenly being booked 'not steaming.' The foreman consults the boiler maker, who examines the front end and finds the exhaust pipe bridge and diaphragm the same as when the engine was steaming properly. It seems that the trouble is generally found in leaking superheaters, valves, piston rings and, in a few cases, a poor fireman or a poor tank of coal.

"March first inaugurated a season of misery for the roundhouse boiler maker in this country (Canada), as Government inspection of front ends for fire protection began and continues until the snow flies, and the geese hit south next fall. This inspection is very strict—an opening of 1/16 inch in width by 1 inch in length is not allowed in deflector or dead plates."

Edmonton, Alberta, Canada. Clifford Young.

## Accidents

It has of late been forcefully brought to the writer's attention that most accidents are "common" accidents. When the annual number of accidents and their nature are compiled by statisticians it is found that most of them can be covered under certain very "common" headings.

In spite of the warning signs to be seen in factories and on streets all over the world and in spite of the "stop, look, listen" signs we see every day at railroad crossings, we read the "common" news nearly every day that someone has been killed by a locomotive, or an automobile.

In spite of all the articles that have been written about boiler explosions, the evils of grease in boilers, low water level, scale, poor design, etc., engineers are still inclined to ignore the warnings. They permit oil deposits to accumulate, permit scale, do without good automatic regulators and subject themselves to continual danger.

If most accidents were "uncommon" accidents, excusable accidents, accidents not caused by negligence of the person killed or injured, it wouldn't be so bad. However, in many if not in most cases, the maimed or killed person is blamable himself. It is regrettable that this is the truth, but it seems that the only way to avoid it is through a continuation of present educational methods. Warnings must be repeated, repeated, and repeated. Without such warnings it is certain that the number of casualties per year would be much greater.

Newark, N. J. W. F. Schaphorst

## PERSONAL

E. S. Fitzsimmons has been appointed manager of sales of the Flannery Bolt Company, Pittsburgh, Pa. He was born on April 12, 1876, at Columbus, Ohio. He served his apprenticeship with the Chicago, Rock Island & Pacific at Horton, Kan., leaving that company in 1899 to become foreman boiler maker with the Delaware, Lackawanna & Western at Scranton, Pa. In 1904 he served as general boiler inspector of the New York, New Haven & Hartford and from 1905 to 1907 as general foreman boiler maker of the Erie. He was then promoted to master mechanic at Galion, Ohio, and in 1908 was transferred as master mechanic to Hornell, N. Y., which position he held until 1912, when he was promoted to mechanical superintendent Erie, Lines West. In 1914 he was transferred to New York as mechanical superintendent of the Erie, Lines East, resigning in 1918 to become works manager for the McCord Manufacturing Company, Detroit, Mich. Mr. Fitzsimmons entered the service of the Flannery Bolt Company at Pittsburgh as salesman in December, 1920, and now becomes manager of sales of the same company.

E. S. Fitzsimmons

## OBITUARY

Henry A. Baumhart, manager of the Cleveland department of the Hartford Steam Boiler Inspection and Insurance Company, died at his home in Vermilion, Ohio, on the morning of March 17 after an illness of three weeks. Mr. Baumhart was born April 25, 1862 and early in life was a chief engineer on the Great Lakes. He became connected with The Hartford Steam Boiler Inspection and Insurance Company as an inspector of boilers in 1891 and was made chief inspector of the Cleveland department of that company in 1902. On October 31, 1907 he was made manager of the Cleveland department of the Hartford Company, which position he held at the time of his death. Mr. Baumhart had a wide acquaintance among boiler manufacturers, engineers and steam users throughout the middle west, and he was universally liked by all with whom he came in contact. He had wide experience in boiler engineering and his advice was constantly sought, both by boiler manufacturers and steam users. Mr. Baumhart was a member of the State Board of Boiler Rules of Ohio from its start, and for a number of years past was vice-chairman of this Board.

Henry A. Baumhart

# ASSOCIATIONS

### Bureau of Locomotive Inspection of the Interstate Commerce Commission

Chief Inspector—A. G. Pack, Washington, D. C.
Assistant Chief Inspector—J. M. Hall, Washington, D. C.

### Steamboat Inspection Service of the Department of Commerce

Supervising Inspector General—George Uhler, Washington, D. C.
Deputy 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—John A. Stevens, Lowell, Mass.
Vice-Chairman—D. S. Jacobus, New York.
Secretary—C. W. Obert, 29 West 39th Street, New York.

### National Board of Boiler and Pressure Vessel Inspectors

Chairman—J. F. Scott, Trenton, N. J.
Secretary-Treasurer—C. O. Myers, State House, Columbus, Ohio.
Vice-Chairman—R. L. Hemingway, San Francisco, Cal.
Statistician—W. E. Murray, Seattle, Wash.

### American Boiler Manufacturers' Association

President—A. G. Pratt, Babcock & Wilcox Company, New York.
Vice-President—G. S. Barnum, The Bigelow Company, New Haven, Conn.
Secretary and Treasurer—H. N. Covell, Lidgerwood Manufacturing Company, Brooklyn, N. Y.
Executive Committee—F. C. Burton, Erie City Iron Works, Erie, Pa.; E. C. Fisher, Wickes Boiler Company, Saginaw, Mich.; C. V. Kellogg, Kellogg-McKay Company, Chicago, Ill.; W. S. Cameron, Frost Manufacturing Company, Galesburg, Ill.; W. A. Drake, The Brownell Company, Dayton, Ohio; Alex. R. Goldie, Goldie & McCullock Company, Galt, Ont., Can.; F. G. Cox, Edge Moor Iron Company, Edge Moor, Del.; J. C. McKeown, John O'Brien Boiler Works Company, St. Louis, Mo.

### International Brotherhood of Boiler Makers, Iron Ship Builders and Helpers of America

Louis Weyand, Acting International President, suite 315 Wyandotte building, Kansas City, Kans.
Frank Reinemeyer, International Secretary-Treasurer, suite 315 Wyandotte building, Kansas City, Kans.
James B. Casey, Editor-Manager of Journal, suite 312-314 Wyandotte building, Kansas City, Kans.
William Atkinson, Acting Assistant President, suite 315 Wyandotte building, Kansas City, Kans.
International Vice-Presidents—Joe Reed, 1123 East Madison street, Portland, Ore.; Thomas Nolan, 700 Court street, Portsmouth, Va.; Joseph Flynn, 111 South Park avenue, Little Rock, Ark.; M. A. Maher, 2114 Eighteenth street, Portsmouth, Ohio; E. J. Sheehan, 7826 South Shore Drive, Chicago, Ill.; John J. Dowd, 953 Avenue C, Bayonne, N. J.; R. C. McCutcheon, suite 15, La Salle Block, Winnipeg, Man., Can.; Joseph P. Ryan, 7533 Vernon avenue, Chicago, Ill.; John F. Schmitt, 1489 North Fourth street, Columbus, Ohio.

### Boiler Makers' Supply Men's Association

President—Frank J. O'Brien, Globe Seamless Steel Tubes Company, Milwaukee, Wis.
Vice-President—William B. Wilson, Flannery Bolt Company, Pittsburgh, Pa.
Secretary—George B. Boyce, A. M. Castle & Company, 715 N. Morgan street, Chicago, Ill.
Treasurer—Stephen F. Sullivan, Ewald Iron Company, Chicago, Ill.

### Master Boiler Makers' Association

President—Charles P. Patrick, Mgr., Chicago, Wilson Welding Repair Company, Chicago, Ill.
First Vice-President—Thomas Lewis, general B. I., L. V. System, Sayre, Pa.
Second Vice-President—T. P. Madden, general B. I., M. P. R. R., 6947 Clayton avenue, St. Louis, Mo.
Third Vice-President—E. W. Young, general B. I., C. M. & St. P. R. R., 81 Caledonia Pl., Dubuque, Iowa.
Fourth Vice-President—Frank Gray, G. F. B. M., C. & A. R. R., 705 West Mulberry street, Bloomington, Ill.
Fifth Vice-President—Thomas F. Powers, System G. F., Boiler Dept., C. & N. W. R. R., 1129 Clarence avenue, Oak Park, Ill.
Secretary—Harry D. Vought, 26 Cortlandt street, New York City.
Treasurer—W. H. Laughridge, G. F. B. M., Hocking Valley Railroad, 537 Linwood avenue, Columbus, Ohio.
Executive Board—John F. Raps, general B. I., C. R. R., 4041 Ellis avenue, Chicago, Ill., chairman.

# TRADE PUBLICATIONS

Boiler Tube Thimbles.—A folder describing the method of installing boiler tube protection thimbles has recently been sent out by the American Boiler Tube Thimble Company, Providence, R. I. The folder outlines the advantages of protecting the ends of boiler tubes by this means and includes a price list for the different size thimbles.

Copper and Brass.—The April bulletin of the Research Association of the Copper and Brass Industry, New York, contains information on the relative merits of copper and aluminium electric conductors. The subject of brass hardware and the use of brass pipe are taken up in detail.

London Steam Turbine.—For driving boiler feed pumps and standard types of centrifugal machinery, the London steam turbine has been developed in two bearing units. The application and advantages of this system of drive have been described in a preliminary folder distributed by the London Steam Turbine Company, Troy, N. Y. Complete details of the equipment will be given in a new catalogue which will be published within a short time.

Evaporators for Boiler Feed Water.—The application of evaporators to the purification of boiler feed water by distillation is covered in a general and non-technical manner in bulletin No. 360 now being distributed by the Griscom-Russell Company, New York. This booklet is so written that the application of Reilly self-scaling evaporators to the power plant may be readily understood by executives.

Export Helps.—The Department of Commerce, Bureau of Foreign and Domestic Commerce, has issued a booklet outlining the organization and purpose of the new industrial machinery division of the bureau. Every manufacturer who has surplus products which can be exported is recommended to use the service of the new division in extending his foreign business. The research work of the division is extensive and as time goes on will be the source of practically any information that may be required on foreign markets.

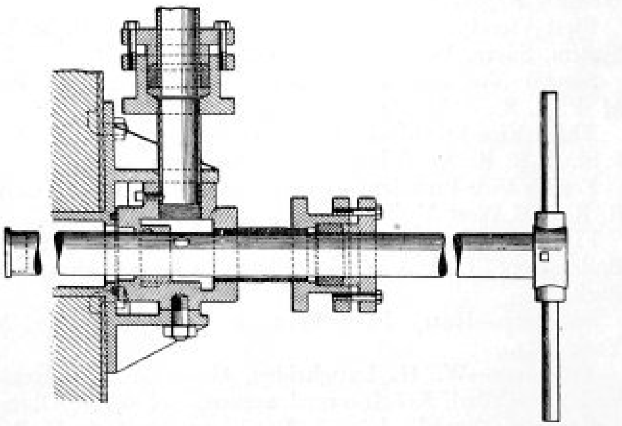
# SELECTED BOILER PATENTS

Compiled by
GEORGE A. HUTCHINSON, Patent Attorney,
Washington Loan and Trust Building,
Washington, D. C.

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

1,408,369. TUBE CLEANER. FREDERICK W. LINAKER AND THEODORE M. BRUBACK, OF DUBOIS, PENNSYLVANIA.

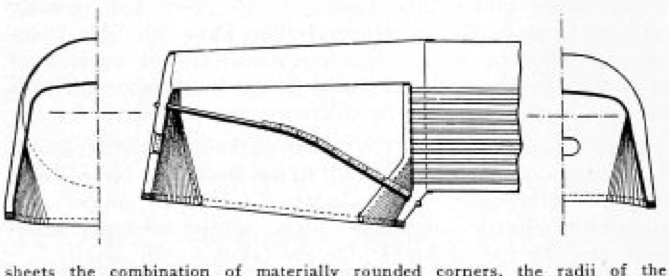
*Claim* 1.—A tube cleaner, or the like, comprising a cleaner tube, and a pivotal support therefor, mounted outside the wall of the boiler furnace, said



cleaner tube having a cleaning fluid passage, and jet forming orifices therein, said tube being slidable in said support, and adapted, when slid out, to swing on the axis of said support into a position alongside the wall of the structure.

1,402,132. LOCOMOTIVE FIREBOX. JAMES T. ANTHONY, OF EAST ORANGE, NEW JERSEY, ASSIGNOR TO AMERICAN ARCH COMPANY, OF NEW YORK, N. Y., A CORPORATION OF DELAWARE.

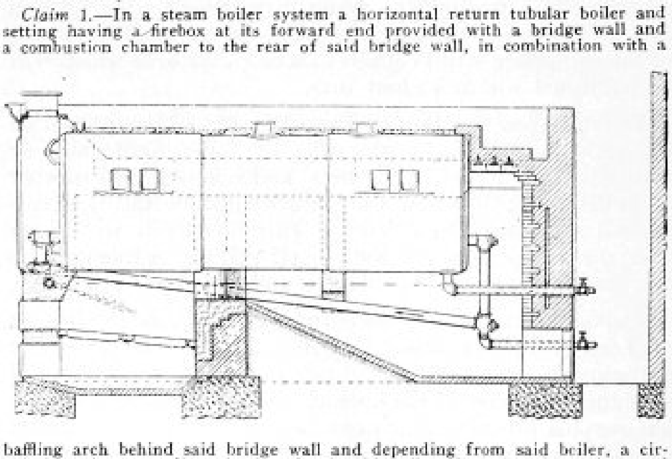
*Claim* 1.—In a locomotive firebox structure having a mud ring and evaporating surfaces comprising a crown sheet and front, rear and side



sheets the combination of materially rounded corners, the radii of the lower portions of which are of substantial dimensions whereby to eliminate dead spaces in the fire bed and the radii of the upper portions of which are of comparatively small dimensions whereby to retain substantially the full effective evaporating surface of the crown sheet. Four claims.

1,402,430. STEAM BOILER SYSTEM. JAMES J. MILDON, OF BROOKLYN, N. Y.

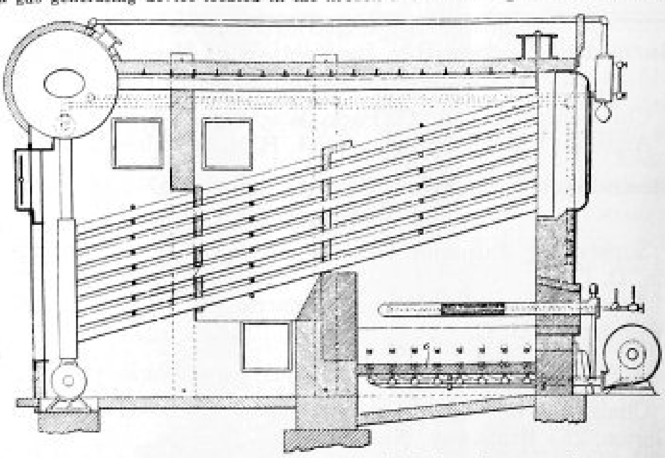
*Claim* 1.—In a steam boiler system a horizontal return tubular boiler and setting having a firebox at its forward end provided with a bridge wall and a combustion chamber to the rear of said bridge wall, in combination with a



baffling arch behind said bridge wall and depending from said boiler, a circulating pipe extending the length of said boiler through said firebox and combustion chamber and inclined downwardly toward the rear and connected to the heads of the boiler below the water line, the rear portion of said circulating pipe being exposed to the gases downwardly deflected by the baffling arch, and rearwardly discharging blast nozzles at the front of said firebox.

1,408,052. STEAM BOILER. WILLIAM F. WEGNER, OF NEW YORK, N. Y., ASSIGNOR OF ONE-HALF TO MORLAND A. BROWER, OF NEW YORK, N. Y.

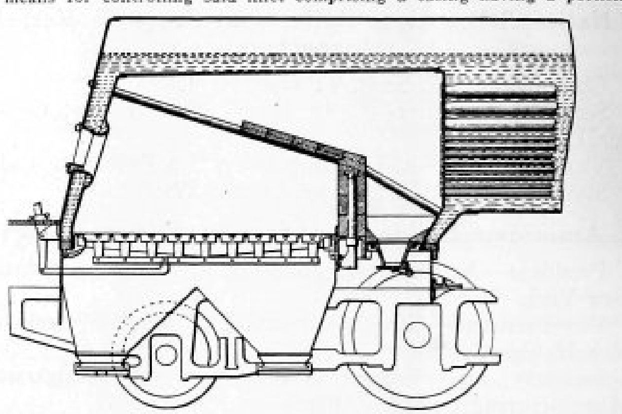
*Claim* 1.—In a steam boiler, a firebox, a source of illuminating gas supply, a gas generating device located in the firebox and containing difficultly fusible



material, means for feeding steam and liquid hydrocarbon to said gas generating device, and means for leading gas from both said source of gas supply and said gas generating device into the firebox for combination therein of their products of combustion.

1,402,161. LOCOMOTIVE FIREBOX. RALEIGH J. HIMMELRIGHT, OF NEW YORK, N. Y., ASSIGNOR TO AMERICAN ARCH COMPANY.

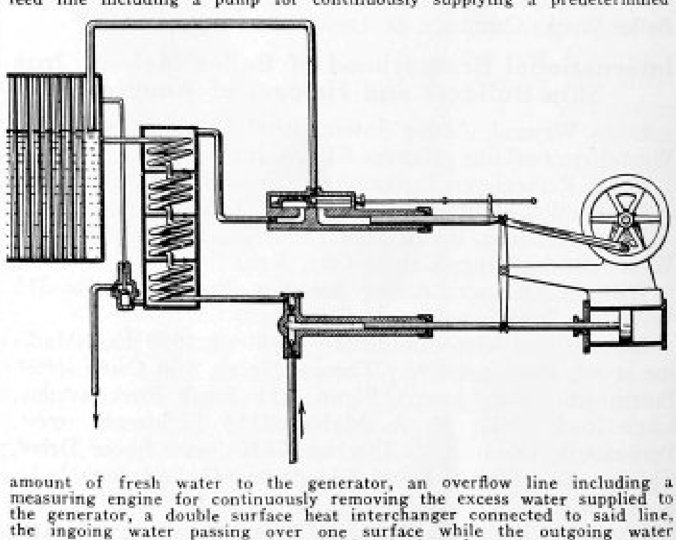
*Claim* 1.—A locomotive firebox construction operating under variable forced draft conditions comprising in combination, a supplemental air inlet and means for controlling said inlet comprising a casing having a portion



of its interior passage in line with said inlet and an enlarged portion offset with respect to said inlet, a damper, and means for pivoting said damper at a point removed from an edge so as to provide unequal areas at each side of the pivot line, the greater area being opposite the offset portion and the lesser area being opposite the inlet, said damper being adapted to increase the effective opening through the inlet as the locomotive is worked harder. Two claims.

1,401,893. MEANS FOR PREVENTING THE FORMATION OF SCALE IN STEAM BOILERS. FRANCIS I. DU PONT, OF WILMINGTON, DELAWARE.

*Claim* 1.—In a feed water supply system for steam generators, a water feed line including a pump for continuously supplying a predetermined



amount of fresh water to the generator, an overflow line including a measuring engine for continuously removing the excess water supplied to the generator, a double surface heat interchanger connected to said line, the ingoing water passing over one surface while the outgoing water passes over the other surface, to transfer the heat from the outgoing water to the ingoing water, and means for controlling the discharge of water from the heat interchanger. Three claims.

# The Boiler Maker

MAY, 1922

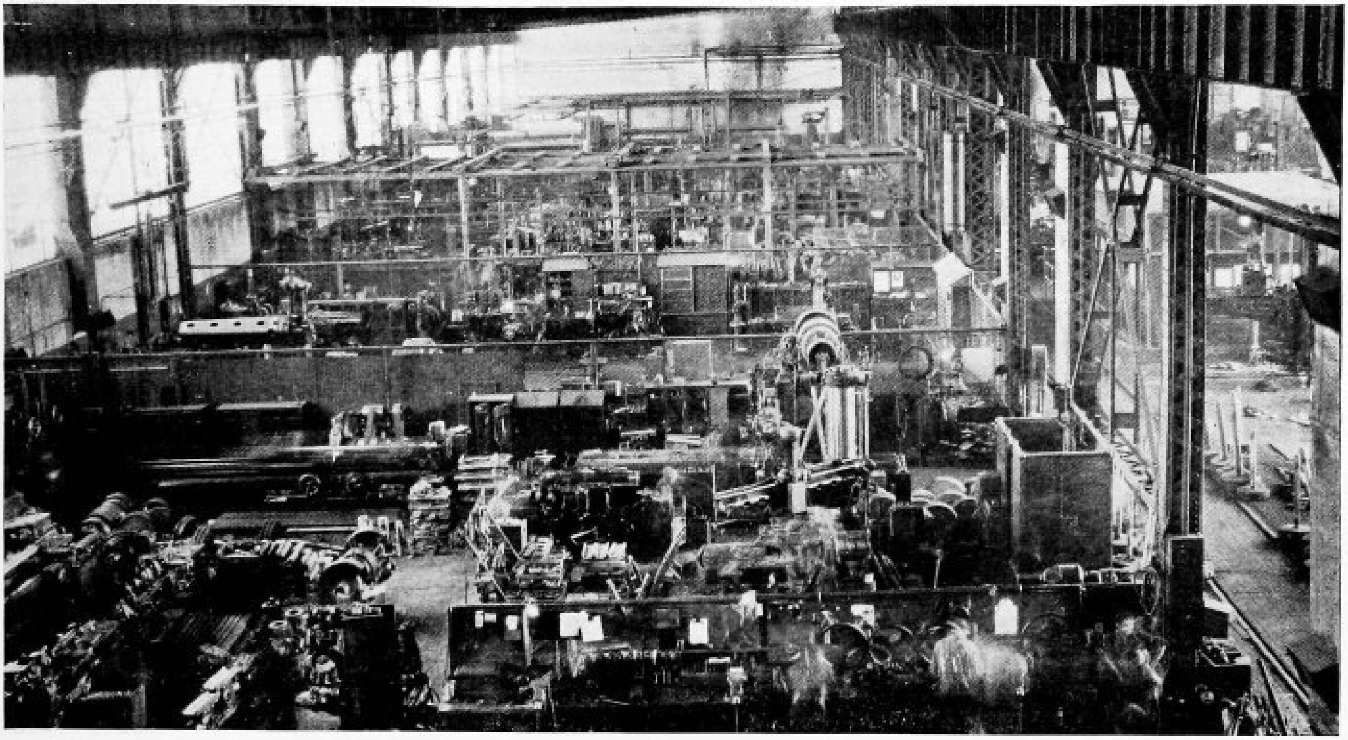



Fig. 1.—Machine Shop at the West Albany Shops of the New York Central Lines in Which the Scheduling Supervisor's Office Is Located

# Scheduling Operations in a Locomotive Repair Shop

*Planning and routing repair operations and material, checking work as completed according to the department schedules and eliminating delays by means of foremen check sheets constitute the fundamental duties of a well organized locomotive repair shop schedule system.*

The methods of developing the repair schedule system of a railroad and its application to the work of the boiler shop are outlined in the accompanying article. One of the most representative systems in the country—that of the New York Central Shops at West Albany, which handles three to four locomotives a day and which functions equally well under day or piece work, is used as the basis of the description. The system is not complicated, yet by means of it the actual condition of a locomotive and of its repair parts is known from the moment it goes on the pit until it leaves the shop.

### Shop Systems in General Use

Two distinct courses are open in a locomotive shop to obtain efficiency in moving engines through the repair processes. The piece work system and the scheduling or routing system. The latter has found its widest application during the past three years when it has been used in many shops to replace the piece work system which was made inoperative during the control of the United States Railroad Administration. Under an efficient scheduling system, production in a given shop can be increased 30 to 40 percent over the former records.

The entire aim of this system, is to create a competitive spirit between departments to turn out the work on time in order that the repair parts from all divisions may be assembled at a specified time and fitted to a locomotive on the erecting floor. The efficiency of this system depends largely on the interest and cooperation of the foremen and men themselves. The system works well in practically every shop in which it has been installed.

Piece work, on the other hand, carries its own incentive—a direct return for the amount of work performed.

By combining the two, the tendency of the men to work at maximum efficiency under piece work and the order and assistance to the departments under the scheduling system, a shop should be able to develop a greater repair production record than is possible under either system alone.

### Scheduling System at West Albany

In the New York Central Shops at West Albany under the schedule system, a supervisor of schedules and an assistant whose office is located at a vantage point in the machine shop within easy reach of the offices of the superintendent of shops and the general foreman maintain direct supervision over the progress of the work.

When an engine is to be repaired it is brought to the shop and given a careful boiler and machinery inspection by company inspectors. Their report in addition to the reports from the engine house foreman and the road service records, as well as the record of the last flue removal and the government inspector's reports are filed with the superintendent of shops. So far as possible from these data a complete outline of the repairs necessary is sent to the scheduling office with the class repair indicated.

### Classification System

Classification at this shop is designated in six divisions as follows:

A Class 1 repair requires a new boiler and general machine work.

A class 2 repair calls for a new firebox and heavy machine repairs.

Class 3 repair calls for a back and front flue sheet, new flues, etc., or any one of these items and machine repairs.

Class 4 work requires the replacement of flues in which case at least 50 percent must be removed to classify under this division. Light repairs to machinery are also included here.

Class 5 repairs call for general boiler work without flue replacements such as the removal of staybolts, etc., and machine work.

The sixth section is unclassified and includes all kinds of machine work, but without the tires turned.

To be designated under one of the five classes tires must be turned and the boiler work specified above performed.

Once an engine has been placed on the pit while it is being stripped the boiler is carefully inspected for cracks and fractures and if the flue and staybolt reports indicate that they have not been removed within the maximum period of service allowed by the Interstate Commerce Commission rules their replacement must be included in the work performed.

### Function of the Master Schedule

When the work to be done on an engine has been determined, the scheduling department by means of master schedules assigns the required number of days to each repair operation that will be necessary to move the locomotive through the shop in the specified time. Master schedules have been developed for repairs requiring from four to eighteen days which include all work that may be required on a locomotive and tender except the construction of a new firebox or a new boiler.

**THE NEW YORK CENTRAL RAILROAD COMPANY**
M. P. DEPT.
SCHEDULE OFFICE
**ERECTING SHOP REPAIR CARD**
**OPERATIONS**
ISSUED TO ........................FOREMAN

Schedule No. ..................
Engine No. ....................
Class of Repairs...............
Date Taken In............192..
Date to Leave............192..
Time Allowed.............Days

| Class of Work | Date Wanted | Date Finished | Remarks—Cause of Delay, etc. |
|---|---|---|---|
| Engine in Shop Unwheeled | | | |
| Smoke Box Stripped | | | |
| Engine Stripped Material Delivered | | | |
| Boiler in Shop and Mounted | | | |
| Cylinders Bolted to Frame and Boiler | | | |
| Valve Bushings Out Sizes in M. S. | | | |
| Valve Bushings in and Bored | | | |
| Boiler Fittings Applied | | | |
| Cab and Runs Up | | | |
| Jaws and Binders O. K. Shoes and Wedges Lined | | | |
| Crossheads Up and Guides Lined | | | |
| Reverse Gear and Cylinder O. K. | | | |
| Valves in | | | |
| Links and Motion Work Up | | | |
| Spring Rigging Up Engine Truck O. K. | | | |
| Engine Wheeled | | | |
| Flues Set | | | |
| Dry Pipe in Boiler Test (Water) | | | |
| Boiler Work O. K. | | | |
| Steam Pipes and Units in | | | |
| Generator and Bracket Up | | | |
| Boiler Lagged | | | |
| Boiler Jacket O. K. | | | |
| Main Rods Up Valves Set | | | |
| Brake Rigging O. K. | | | |
| Headlight and Smoke Box Work O. K. | | | |
| Pipe Work O. K. Side Rods Up | | | |
| Engine Out | | | |

..........................................General Foreman

Fig. 2.—Form Used by the Schedule Department to Time Operations in the Erecting Shop

Shop sheets for each department having work to perform on a given locomotive are made out from the master schedules. In transferring the constant time intervals indicated on the master schedules to the shop cards a calendar slide rule is used which makes the assigning of a large number of dates a simple operation with a single setting of the rule.

In order to definitely arrange the work so there may be no question as to the repairs necessary nor about the time re-

UNITED STATES RAILROAD ADMINISTRATION
Director General of Railroads
NEW YORK CENTRAL RAILROAD
M. P. DEPT.
SCHEDULE OFFICE

**ERECTING SHOP REPAIR CARD**
**MATERIAL**

ISSUED TO ........................... FOREMAN

Schedule No. ....................
Engine No. ....................
Class of Repairs................
Date Taken In.............192..
Date to Leave.............192..
Time Allowed..............Days

| Class of Work | Wanted in Machine Shop | Wanted from Machine Shop | Class of Work | Wanted in Smith Shop | Wanted from Smith Shop | Remarks |
|---|---|---|---|---|---|---|
| Main Rods | | | Frame Binders | | | |
| Side Rods | | | Engine Springs | | | |
| Valve Bushings Machined | | | Guides | | | |
| Steam Chest or Piston Valves | | | Engine Frame | | | |
| Rocker Boxes | | | | | | |
| Links | | | | | | |
| Motion Work Complete | | | Class of Work | Wanted in Boiler Shop | Wanted from Boiler Shop | |
| Driving Wheels and Boxes | | | Ash Pan | | | |
| Trailer Wheels and Boxes | | | New Boiler | | | |
| Engine Truck Boxes | | | New Fire Box | | | |
| Engine Brake Rigging | | | New Flue Sheet | | | |
| Engine Brake Cylinders | | | New Side Sheets | | | |
| Engine Brake Valves | | | Steel Cab and Runs | | | |
| Air Pump | | | Class of Work | Wanted in Cab Shop | Wanted from Cab Shop | |
| Engine Truck Wheels | | | Cab | | | |
| Boiler Fittings | | | Running Boards | | | |
| Engine and Trailer Truck Side Play | | | Pilot | | | |
| Eccentrics and Straps | | | | | | |
| Crossheads and Gibs | | | Class of Work | Wanted in Tin Shop | Wanted from Tin Shop | |
| Pistons and Rods | | | Jacket | | | |
| Piston and Valve Packing | | | Piping | | | |
| Shoes and Wedges | | | | | | |
| Steam Chests and Covers | | | | | | |
| Valve Yokes | | | | | | |
| Spring Rigging | | | | | | |
| Guides | | | | | | |
| Driving Box Sizes | | | | | | |

..........................................General Foreman

Fig. 3.—General Shop Card Including Operations in the Boiler Shop

quired for any operation, the erecting shop repair card of operations shown in Fig. 2 is first prepared from the master schedule. The dates on which each section of the locomotive must be stripped and delivered to the proper shop for repair are indicated as well as the date that each part must be returned in condition to the erecting floor.

As soon as the erecting shop card is prepared, additional schedule sheets are sent to the machine shop, to the smith shop, cab shop, tank shop and boiler shop. The last four shops are listed on a single sheet shown in Fig. 3.

The general scheme of work is now definitely developed and the dates indicated for all the operations are entered on the master schedule boards, Fig. 4; one board being arranged for the current month and a second for the coming month. Here a vertical scale is arranged with the days of the month and a horizontal scale with all of the items listed on the schedule sheets under erecting shop operations, machine shop operations, boiler shop, cab shop, smith shop and tank shop operations. On each square the engine numbers are indicated for each day of the month and each operation.

The next move of the schedule supervision is to prepare individual work cards to be distributed to the foremen and men in each shop who have a given operation to perform. These cards, as indicated in Fig. 5 for the boiler shop, duplicate the items on the erecting shop card. By means of it the boiler shop foreman knows exactly what he is required to do each day on the engines undergoing boiler repairs. In a similar manner every foreman in the entire plant knows exactly for what he is responsible.

## LOCOMOTIVE FIREBOX REPAIR

As an illustration of the time allotment for carrying out boiler operations the following schedule is outlined for a major firebox repair:

The locomotive in question is reported on the stripping pit as requiring firebox repairs, for which the schedule department decides that sixteen days will be necessary for completion.

From the first to the fourth day is permitted for stripping the locomotive and sending the parts to the boiler shop. At the same time the sheets for the repair are requisitioned and cut to shape ready for fabrication.

On the fourth day the flues and old firebox are scheduled for removal. By the seventh day the sheets are ready to be

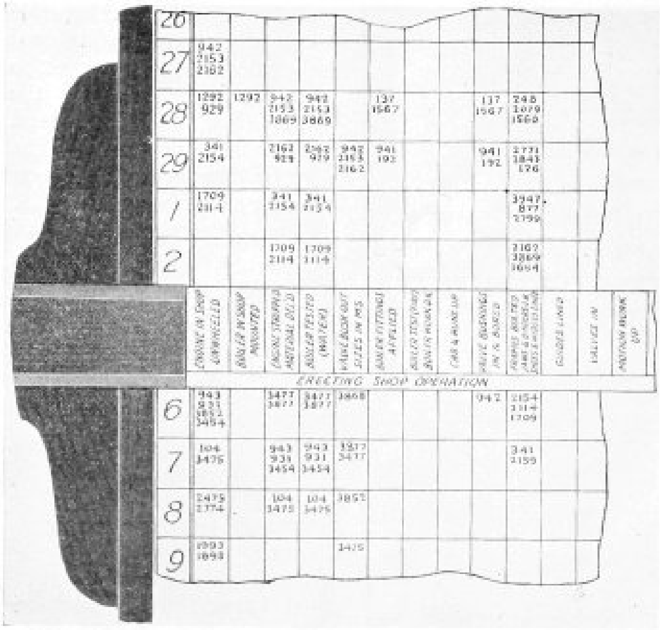


Fig. 4.—Section of Master Schedule Board

laid out, punched, flanged and drilled, which operations require about two days.

On the ninth day the sheets are assembled and riveted, the mud ring riveted and the firebox assembled and applied to the boiler complete.

In the course of the tenth day the bolts, flues and all are completely assembled so that by the eleventh day the boiler is ready to be tested and sent to the erecting floor for mounting on the frames.

The twelfth day is required for mounting the boiler. The fittings are applied on the thirteenth; the boiler work is completed on the fourteenth. On the fifteenth day the boiler jacket is applied and on the seventeenth day after the locomotive goes to the shop it is again ready for the road.

The foregoing procedure outlines the scheduling of repairs to a locomotive and it is found that the foremen and men cooperate to the greatest extent possible in maintaining the dates posted. Work slides through the shops with surprisingly little friction, possibly because when delays do occur the responsibility is absolutely fixed in the department at fault and when work goes through promptly the department is credited with the performance.

THE NEW YORK CENTRAL RAILROAD COMPANY
M. P. DEPT.
SCHEDULE OFFICE
BOILER SHOP REPAIR CARD

ISSUED TO..............................ENGINE No.........

| Class of Work | Wanted in Erecting Shop | Wanted from Erecting Shop | Remarks |
|---|---|---|---|
| Boiler Test First | | | |
| Boiler Test Last | | | |
| Boiler Work O. K. | | | |
| Ash Pan | | | |
| Smoke Box Work O. K. | | | |
| Flues Set | | | |
| Steel Cab and Runs | | | |
| New Flue Sheet | | | |
| New Side Sheets | | | |
| | | | |

.....................................FOREMAN

Fig. 5.—Foreman Job Card for the Boiler Work

| Pit No. | Engine No. | Flues Out | Flues Set | Boiler Test | Ash Pan Applied | Boiler Work O. K. |
|---|---|---|---|---|---|---|
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |
| 7 | | | | | | |
| 8 | | | | | | |
| 9 | | | | | | |
| 10 | | | DATES DUE | | | |
| 11 | | | | | | |
| 12 | | | | | | |
| 13 | | | | | | |
| 14 | | | | | | |
| 15 | | | | | | |
| 16 | | | | | | |
| 17 | | | | | | |
| 18 | | | | | | |
| 19 | | | | | | |
| 20 | | | | | | |
| 21 | | | | | | |

Fig. 6—Erecting Shop Job Board

### CHECKING THE DEPARTMENT OPERATIONS

Following the actual planning of the work for the various departments, it is necessary to follow up each job in order that work completed may be checked, that delays may be recorded, and, wherever possible, the causes eliminated when they do occur. So that the men in the departments may be informed of the progress of jobs in their shop, each section is provided with a job board on which is marked the engine number and the date due out of the shop for each part of the material. As soon as the work is completed a line is drawn through it indicating that this operation should be

| Operation | Locomotive Number | Days Late | Remarks |
|---|---|---|---|
| Flues set | | | |
| Boiler Tested | | | |
| Boiler Work (OK) | | | |
| Ash Pan (OK) | | | |
| Smoke box (OK) | | | |
| New flue sheet (OK) | | | |
| Firebox (OK) | | | |

Fig. 7.—Operation Check Sheet for Boiler Shop Foreman

checked off by the supervisor and reported finished.

In the erecting shop and in the boiler shop, job boards are provided that schedule all boiler and sheet metal operations except new fireboxes and new boilers. At West Albany there are twenty-one pits in each erecting shop so that the boards are numbered to take care of forty-two pits. The board for pit numbers 1 to 21 is arranged with the operations indicated in Fig. 6. This board is duplicated in the second erecting shop for pit numbers 22 to 42.

Coming to the boiler shop, the job schedule boards are divided to cover the 42 pits and on them is listed all sheet metal work that has to be performed, except as previously indicated, the firebox and new boiler work.

### Check Sheets for the General Foreman

The form shown in Fig. 8 for material and operations due on a given day is filled out by the supervisor from his department check sheets and given to the general foreman. From this sheet the head office is able to maintain an accurate record of the work in progress in the shops and the exact condition of each engine. Other forms that are sent each day to the general foreman list the operations and material that have for some reason been delayed in any of the departments. On this form the engine number, shop responsible for the delay, the operation, the number of days late and an explanation of the difficulty are all given. On the material delay form the information required includes the engine number, the material delayed, the point of delay, the number of days late and an explanation

This completes the actual details of the scheduling, but in this shop additional operation delay forms are used for the information of the department foremen and their assistants in order that they may keep track of the progress of work for which they are responsible. The form used for the boiler shop in Fig. 7 is typical of the other shop forms.

**THE NEW YORK CENTRAL RAILROAD COMPANY**

M. P. DEPT.

SCHEDULE OFFICE .............................................................192......

MR..................................................................................
General Foreman

**PLEASE NOTE STATEMENT OF MATERIAL AND OPERATIONS DUE TO-DAY**

| Engine No. | Erecting Shop Operation | Engine | Machine Shop Material | Where Due | Engine No. | Smith, Boiler, Tank and Cab Shop Material | Where Due |
|---|---|---|---|---|---|---|---|
| | Engine in Shop Unwheeled | | Main Rods | | | Valve Yokes | M. S. |
| | Boiler in Shop Mounted | | Side Rods | | | Main and Side Boards | M. S. |
| | Engine Stripped Material Delivered | | Valve Bushings Machined | | | Engine Brake Rigging | M. S. |
| | Boiler Tested (Water) | | Steam Chest or Piston Valves | | | Spring Rigging | M. S. |
| | Valve Bushings Out Sizes in M. S. | | Rocker Boxes | | | Guides | M. S. |
| | Boiler Fittings Applied | | Links | | | Engine Frames | M. S. |
| | Boiler Test (Fire) Boiler Work (O. K.) | | Motion Work Complete | | | Engine Springs | E. S. |
| | Cab and Runs Up | | Driving Wheels And Boxes | | | Frame Binders | E. S. |
| | Valve Bushings in and Bored | | Trailer Wheels and Boxes | | | Tender Brake Rigging | T. S. |
| | Frames Bolted Jaws and Binders (O.K.) Shoes and Wedges Lined | | Engine Truck Boxes | | | Tender Springs | T. S. |
| | Cylinder Bolted to Frames and Boiler | | Engine Brake Rigging | | | Ash Pan | E. S. |
| | Frame Rails Bolted Motion Crosstie Up | | Engine Brake Cylinders | | | Steel Cabs and Steel Running Boards | E. S. |
| | Guides Lined | | Engine Brake Valves | | | New Fire-Box or Boiler | E. S. |
| | Valves in | | Air Pump | | | New Flue Sheet | E. O. |
| | Motion Work Up | | Tender Brake Cylinders and Valves | | | New Side Sheet | E. S. |
| | Spring Rigging Up Engine Truck (O.K.) | | Engine Truck Wheels | | | Tender Tank | T. S. |
| | Engine Wheeled | | Tender Wheels | | | Tender Due for Engine | On Farm |
| | Flues Set | | Boiler Fittings | | | Cab Runs and Pilot | E. S. |
| | Dry Pipe in Boiler Test (Water) | | Eccentrics and Straps | | | | |
| | Boiler Work O. K. | | Crossheads and Gibs | | | | |
| | Steam Pipes in | | Pistons and Rods | | | | |
| | Boiler Lagged | | Piston and Valve Packing | | | | |
| | Boiler Jacket O. K. | | Shoes and Wedges | | | | |
| | Main Rods Up Valves Set | | Steam Chests and Covers | | | | |
| | Brake Rigging Up | | Valve Yokes | | | | |
| | Smoke Box Work O. K. | | Spring Rigging | | | | |
| | Pipe Work O. K. Side Rods Up | | Guides | | | | |
| | Engine Out | | | | | | |

Fig. 8—Form Showing Progress of Work in All Shops, Made Out From Job Check Sheets

From this outline of the system it may be seen that the work is completely laid out for each shop in such a way that every man interested knows exactly what he is supposed to do every day. Operations are arranged on a general plan of shop production to obtain the best efficiency from all departments. By means of the checking system, the supervision knows exactly the condition of the work throughout the shops at all times. Finally, every foreman and

(*Continued on page* 138)

# Calculating the Efficiency of Boiler Seams

## Tables Reduce the Chance for Error and Facilitate Work; Points Where Failure Is Likely to Occur

**By R. J. Finch***

To determine the efficiency of a seam, it is necessary to calculate the breaking strength by the different ways in which it may fail; namely, by shearing the rivets, tearing the plates between rivets, crushing the rivets or plate, or by a combination of two or more of the foregoing causes. The calculation which shows the least result is the actual strength of the seam. Thus, the efficiency of a seam is the ratio of the actual strength of the seam, or the strength of its weakest part, to the strength of the solid plate.

To make these calculations is a tedious task, especially if the calculations are made longhand and no slide rules or calculating machines are available. The purpose of this article is to present two tables with an explanation of their use. These tables when thoroughly understood and then made use of, will shorten the work of finding the efficiency by at least one-half. The short method eliminates the tedious work and consequently, in making the calculations one is not so apt to overlook some vital point of weakness in the seam, which point may be out of the ordinary but still may exist. It is also the purpose of this article to indicate the places where weakness, or the point of lowest efficiency, may occur and yet might be easily overlooked.

To explain the use of the tables, two sketches of parts of longitudinal seams are shown. Fig. 1 shows a section of a sextuple riveted seam and Fig. 2 a section of a decuple riveted seam. While only the two types of seams are here shown, it should be understood that the tables apply equally well to a quadruple, octuple or any other type of riveted seam.

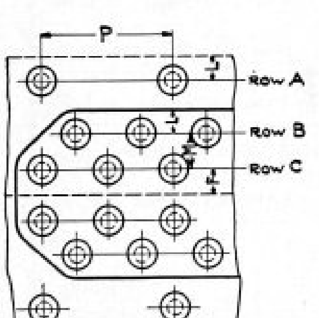



Fig. 1.—Sextuple Riveted Seam

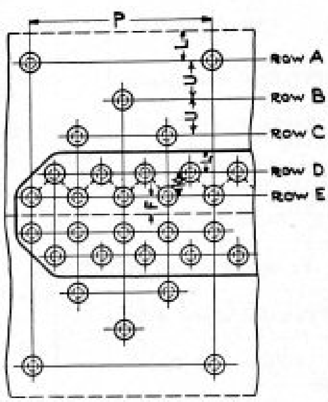



Fig. 2.—Decuple Riveted Seam

Table I shows the "value of rivet holes in plates," or possibly it might be more explicit to say that this table shows the strength removed from the plate for various sizes of holes and thicknesses of plate. The table is based on an ultimate tensile strength of 55,000 lb. per square inch for boiler steel, which figure is almost universally used. The table ranges in thickness of plates from 1/4 in. to 1 5/16 in., and in rivet diameters from 1/2 in. to 1 7/16 in., or a range in rivet hole diameters from 9/16 in. to 1 1/2 in., the diameter of the driven rivet being taken as 1/16 in. larger than the rivet before driving.

Table II gives the shearing value of iron and steel rivets for the different sizes of rivets shown in Table I. This table is based on an ultimate shearing strength of iron rivets of 38,000 lb. per sq. in., and 40,000 and 44,000 lb. per sq. in. for steel rivets, the shearing strengths of 38,000 and 44,000 being those allowed by the Interstate Commerce Commission, while 40,000 lb. for steel rivets is the American Locomotive Company's practice.

*American Locomotive Company, Schenectady, N. Y.

### Calculating the Efficiency of Seams

Referring to sextuple seam (Fig. 1) and assuming the pitch, *P*, is 8 in., diameter of rivet before driving 1 1/8 in., after driving 1 3/16 in., thickness of plate 13/16 in., steel rivets being used, the efficiency through outer row, *A*, is found to be as follows:

$$\frac{8 - 1\ 3/16}{8} = 85.1 \text{ per cent}$$

To find the efficiency through other rows of rivets, proceed as follows:

Strength of solid plate is—

$$8 \times 13/16 \times 55{,}000 = 357{,}500 \text{ lb.}$$

In row *B* two rivet holes have been taken out, but if the plate fails here, it must shear off one rivet (two halves) in the outer row.

From Table I it is found that the strength removed is 2 × 53,066 lb. and the strength added, from Table II, is 48,730 lb. The efficiency through row *B* then is

$$\frac{357{,}500 - (2 \times 53{,}066) + 48{,}730}{357{,}500} = 83.9 \text{ per cent}$$

In row *C* two rivet holes are taken out, but to fail here it would be necessary to shear off five rivets (two rivets in double shear and one in single shear) and it is readily seen that the added strength is considerably more than the removed strength and no calculations are necessary.

The efficiency has been found by breaking through the different rows and the next step is to find the efficiency due to shearing of the rivets as a whole. To fail in this manner it is necessary to shear off nine rivets (four in double shear and one in single shear).

Then,

$$\frac{48{,}730 \times 9}{357{,}500} = 122.7 \text{ per cent, efficiency of rivets}$$

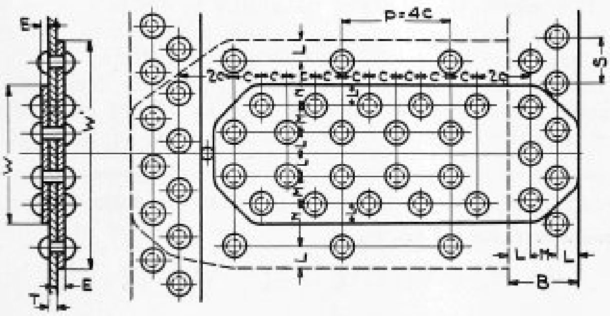
The efficiency of this seam is the value found for row *B*, or 83.9 per cent.

If the thickness of the plate had been assumed 11/16 in. instead of 3/4 in., the strength of the metal removed by one rivet hole would be 44,902 lb. instead of 53,066 lb. It is at once noted that the least efficiency is in the outside row and is 85.1 per cent; in other words, on a seam of this type, when the shear of a rivet is greater than the strength removed by a rivet hole, the least efficiency must be in the outer row of rivets and it is not necessary to make any calculations for the efficiency of other rows. The shear of the rivets as a whole should always be calculated, as it sometimes happens, although seldom, that the least efficiency may be in the rivets.

### Decuple Riveted Seam

The decuple riveted seam, Fig. 2, is taken care of identically the same as the sextuple riveted seam, except that an inspection of values from the two tables will quickly show that the efficiency through rows *B*, *C* and *E* must always be greater than the efficiency through the outer row, and, therefore, these rows in a riveted seam of this type need not be considered. The efficiency of the outer row is found exactly the same as for the sextuple riveted seam and the efficiency through row *D* is found the same as for row *B* of the sextuple seam, except that the tensile value of four rivet holes is deducted and the shearing strength of four rivets added. If the shearing value of a rivet is more than the strength removed by a rivet hole, it is useless to do any figuring for this row as it is at once noted that the efficiency will be more than in the outer row. The efficiency for the shear of the rivets as a whole is also found by the same method as for the sextuple riveted seam, except here the shear of 20 rivets (8 in double shear and 4 in single shear) is compared with the strength of the solid plate.

As for further points to be considered in calculating seam efficiencies, attention is called to the distance from the row of rivets to the edge of the welts (both inner and outer) or the dimension *L* on Figs. 1 and 2. In a well designed seam this distance or dimension *L* should always be great enough to insure that the metal between the rivet and the edge of

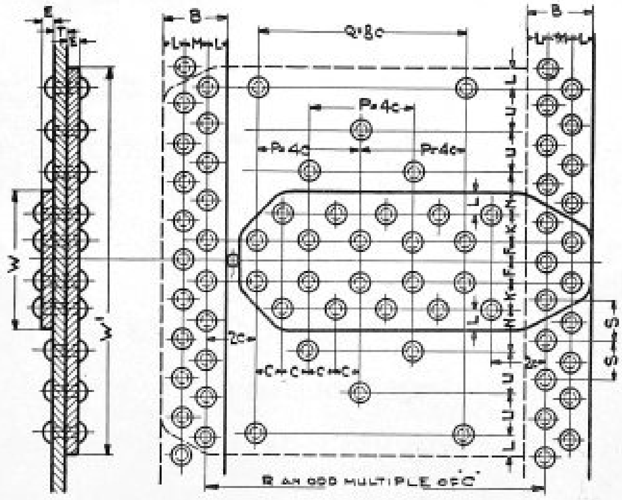



| T | Dia. of Rivets | Dia. of Holes | C | P | L | M | N | E | W | W' | Per cent Eff. | S | L | M | B | Per cent Eff. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3/8 | 3/4 | 13/16 | 1 1/4 | 5 | 1 1/8 | 1 1/2 | 2 3/8 | 5/16 | 7 1/2 | 12 1/2 | 83.7 | 2 3/4 | 1 1/8 | 1 1/2 | 3 3/4 | 70.5 |
| 13/32 | 7/8 | 15/16 | 1 1/2 | 6 | 1 3/8 | 1 3/4 | 2 3/4 | 3/8 | 9 | 14 1/2 | 84.3 | 3 | 1 1/4 | 1 3/4 | 4 1/4 | 68.7 |
| 7/16 | 7/8 | 15/16 | 1 1/2 | 6 | 1 3/8 | 1 3/4 | 2 3/4 | 3/8 | 9 | 14 1/2 | 84.3 | 3 | 1 1/4 | 1 3/4 | 4 1/4 | 68.7 |
| 15/32 | 7/8 | 15/16 | 1 1/2 | 6 | 1 3/8 | 1 3/4 | 2 3/4 | 3/8 | 9 | 14 1/2 | 84.3 | 3 | 1 1/4 | 1 3/4 | 4 1/4 | 68.7 |
| 1/2 | 7/8 | 15/16 | 1 1/2 | 6 | 1 3/8 | 1 3/4 | 2 3/4 | 3/8 | 9 | 14 1/2 | 84.3 | 3 | 1 1/4 | 1 3/4 | 4 1/4 | 66.9 |
| 17/32 | 1 | 1 1/16 | 1 3/4 | 7 | 1 1/2 | 1 7/8 | 3 | 7/16 | 9 1/2 | 15 3/4 | 84.8 | 3 1/4 | 1 1/2 | 1 3/4 | 4 1/2 | 67.4 |
| 9/16 | 1 | 1 1/16 | 1 3/4 | 7 | 1 1/2 | 1 7/8 | 3 | 1/2 | 9 3/4 | 15 1/2 | 84.8 | 3 1/4 | 1 1/2 | 1 3/4 | 4 1/2 | 67.4 |
| 19/32 | 1 | 1 1/16 | 1 3/4 | 7 | 1 1/2 | 1 7/8 | 3 | 1/2 | 9 3/4 | 15 3/4 | 84.8 | 3 1/4 | 1 1/2 | 1 3/4 | 4 1/2 | 66.8 |
| 5/8 | 1 | 1 1/16 | 1 3/4 | 7 | 1 1/2 | 1 7/8 | 3 | 1/2 | 9 3/4 | 15 3/4 | 84.4 | 3 1/4 | 1 1/2 | 1 3/4 | 4 1/2 | 63.6 |
| 21/32 | 1 1/8 | 1 3/16 | 2 | 8 | 1 5/8 | 2 1/8 | 3 1/4 | 9/16 | 10 3/4 | 17 1/2 | 85.1 | 3 1/2 | 1 5/8 | 2 | 5 1/4 | 66.0 |
| 11/16 | 1 1/8 | 1 3/16 | 2 | 8 | 1 5/8 | 2 1/8 | 3 1/4 | 9/16 | 10 3/4 | 17 3/4 | 84.9 | 3 1/2 | 1 5/8 | 2 | 5 1/4 | 66.0 |
| 23/32 | 1 1/8 | 1 3/16 | 2 | 8 | 1 5/8 | 2 1/8 | 3 1/4 | 9/16 | 10 3/4 | 17 3/4 | 84.3 | 3 1/2 | 1 5/8 | 2 | 5 1/4 | 63.9 |
| 3/4 | 1 1/8 | 1 3/16 | 2 | 8 | 1 5/8 | 2 1/8 | 3 1/4 | 9/16 | 10 3/4 | 17 3/4 | 83.6 | 3 1/2 | 1 5/8 | 2 | 5 1/4 | 61.4 |
| 25/32 | 1 1/8 | 1 3/16 | 2 | 8 | 1 5/8 | 2 1/8 | 3 1/4 | 5/8 | 10 3/4 | 17 3/4 | 83.1 | 3 1/2 | 1 5/8 | 2 | 5 1/4 | 58.9 |
| 13/16 | 1 1/8 | 1 3/16 | 2 | 8 | 1 5/8 | 2 1/8 | 3 1/4 | 5/8 | 10 3/4 | 17 3/4 | 82.6 | 3 1/2 | 1 5/8 | 2 | 5 1/4 | 56.6 |
| 27/32 | 1 1/4 | 1 5/16 | 2 1/4 | 9 | 1 3/4 | 2 3/8 | 3 1/2 | 11/16 | 11 3/4 | 18 3/4 | 83.8 | 3 3/4 | 1 3/4 | 2 1/4 | 5 3/4 | 62.2 |
| 7/8 | 1 1/4 | 1 5/16 | 2 1/4 | 9 | 1 3/4 | 2 3/8 | 3 1/2 | 11/16 | 11 3/4 | 18 3/4 | 83.3 | 3 3/4 | 1 3/4 | 2 1/4 | 5 3/4 | 60.0 |
| 29/32 | 1 1/4 | 1 5/16 | 2 1/4 | 9 | 1 3/4 | 2 3/8 | 3 1/2 | 11/16 | 11 3/4 | 18 3/4 | 82.9 | 3 3/4 | 1 3/4 | 2 1/4 | 5 3/4 | 57.4 |
| 15/16 | 1 1/4 | 1 5/16 | 2 1/4 | 9 | 1 3/4 | 2 3/8 | 3 1/2 | 3/4 | 11 3/4 | 18 3/4 | 82.5 | 3 3/4 | 1 3/4 | 2 1/4 | 5 3/4 | 56.0 |
| 31/32 | 1 1/4 | 1 5/16 | 2 1/4 | 9 | 1 3/4 | 2 3/8 | 3 1/2 | 3/4 | 11 3/4 | 18 3/4 | 82.2 | 3 3/4 | 1 3/4 | 2 1/4 | 5 3/4 | 54.1 |
| 1 | 1 1/4 | 1 5/16 | 2 1/4 | 9 | 1 3/4 | 2 3/8 | 3 1/2 | 3/4 | 11 3/4 | 18 3/4 | 81.7 | 3 3/4 | 1 3/4 | 2 1/4 | 5 3/4 | 52.5 |

**Fig. 3.—American Locomotive Company's Standard Sextuple Seam**

the welt will stand the full shear of the rivet. This should always be calculated, and if found to be less than the value of the rivet, this value must be substituted instead of the rivet value for these particular rivets. Likewise, the dimension *F* (distance from inner row to center line of the seam) shown on Figs. 1 and 2 must be sufficient so that the metal between the rivet and the edge of the plate will stand the double shear of the rivet. If it should be found less than the rivet, this value must also be substituted. To compare this shearing strength of the plate behind the rivet with the strength of the rivet itself, it is simply necessary to find the cross sectional area of the metal behind the rivet in square inches and multiply this area by 100,000 lb. The crushing or shearing value of the plate is 50,000 lb. per sq. in., and this metal being in double shear accounts for the figure given above.

Another point to be considered for possible weakness is the back pitch, or distance between the longitudinal rows of rivets, dimension *M* in Fig. 1, sextuple seam, and dimen-




| T | Dia. of Rivets | Dia. of Holes | C | P | Q | F | K' | N | U | E | F' | W | W' | L | Per cent Efficiency | S | L | M | B | Per cent Efficiency |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21/32 | 1 1/8 | 1 3/16 | 2 | 8 | 16 | 1 5/8 | 2 1/8 | 3 3/4 | 3 3/4 | 9/16 | 1/2 | 10 3/4 | 33 1/4 | 1 5/8 | 92.6 | 3 1/2 | 1 5/8 | 2 | 5 1/4 | 66.0 |
| 11/16 | 1 1/8 | 1 3/16 | 2 | 8 | 16 | 1 5/8 | 2 1/8 | 3 3/4 | 3 3/4 | 9/16 | 1/2 | 10 3/4 | 33 1/4 | 1 5/8 | 92.6 | 3 1/2 | 1 5/8 | 2 | 5 1/4 | 66.0 |
| 23/32 | 1 1/8 | 1 3/16 | 2 | 8 | 16 | 1 5/8 | 2 1/8 | 3 3/4 | 3 1/2 | 9/16 | 1/2 | 10 3/4 | 33 1/4 | 1 5/8 | 92.6 | 3 1/2 | 1 5/8 | 2 | 5 1/4 | 63.9 |
| 3/4 | 1 1/8 | 1 3/16 | 2 | 8 | 16 | 1 5/8 | 2 1/8 | 3 3/4 | 3 3/4 | 9/16 | 1/2 | 10 3/4 | 33 1/4 | 1 5/8 | 92.6 | 3 1/2 | 1 5/8 | 2 | 5 1/4 | 61.4 |
| 25/32 | 1 1/8 | 1 3/16 | 2 | 8 | 16 | 1 5/8 | 2 1/8 | 3 3/4 | 3 3/4 | 5/8 | 9/16 | 10 3/4 | 33 1/4 | 1 5/8 | 92.6 | 3 1/2 | 1 5/8 | 2 | 5 1/4 | 58.9 |
| 13/16 | 1 1/8 | 1 3/16 | 2 | 8 | 16 | 1 5/8 | 2 1/8 | 3 1/2 | 3 1/2 | 5/8 | 9/16 | 10 3/4 | 33 1/4 | 1 5/8 | 92.6 | 3 1/2 | 1 5/8 | 2 | 5 1/4 | 56.6 |
| 27/32 | 1 1/4 | 1 5/16 | 2 1/4 | 9 | 18 | 1 3/4 | 2 3/8 | 4 | 4 | 11/16 | 5/8 | 11 3/4 | 35 3/4 | 1 3/4 | 92.7 | 3 3/4 | 1 1/2 | 2 1/4 | 5 3/4 | 62.2 |
| 7/8 | 1 1/4 | 1 5/16 | 2 1/4 | 9 | 18 | 1 3/4 | 2 3/8 | 4 | 4 | 11/16 | 5/8 | 11 3/4 | 35 3/4 | 1 3/4 | 92.7 | 3 3/4 | 1 1/2 | 2 1/4 | 5 3/4 | 60.0 |
| 29/32 | 1 1/4 | 1 5/16 | 2 1/4 | 9 | 18 | 1 3/4 | 2 3/8 | 4 | 4 | 3/4 | 11/16 | 11 3/4 | 35 3/4 | 1 3/4 | 92.7 | 3 3/4 | 1 1/2 | 2 1/4 | 5 3/4 | 57.0 |
| 15/16 | 1 1/4 | 1 5/16 | 2 1/4 | 9 | 18 | 1 3/4 | 2 3/8 | 4 | 4 | 3/4 | 11/16 | 11 3/4 | 35 3/4 | 1 3/4 | 92.7 | 3 3/4 | 1 1/2 | 2 1/4 | 5 3/4 | 56.0 |
| 31/32 | 1 1/4 | 1 5/16 | 2 1/4 | 9 | 18 | 1 3/4 | 2 3/8 | 4 | 4 | 3/4 | 11/16 | 11 3/4 | 35 3/4 | 1 3/4 | 92.7 | 3 3/4 | 1 1/2 | 2 1/4 | 5 3/4 | 54.1 |
| 1 | 1 5/16 | 1 3/8 | 2 1/2 | 10 | 20 | 2 | 2 1/2 | 4 | 4 1/4 | 3/4 | 11/16 | 12 3/4 | 37 3/4 | 1 7/8 | 93.1 | 3 3/4 | 1 7/8 | 2 3/8 | 6 1/8 | 57.6 |
| 1 1/32 | 1 5/16 | 1 3/8 | 2 1/2 | 10 | 20 | 2 | 2 1/2 | 4 | 4 1/4 | 13/16 | 3/4 | 12 3/4 | 37 3/4 | 1 7/8 | 93.1 | 3 3/4 | 1 7/8 | 2 3/8 | 6 1/8 | 55.9 |
| 1 1/16 | 1 5/16 | 1 3/8 | 2 1/2 | 10 | 20 | 2 | 2 1/2 | 4 | 4 1/4 | 13/16 | 3/4 | 12 3/4 | 37 3/4 | 1 7/8 | 92.8 | 3 3/4 | 1 7/8 | 2 3/8 | 6 1/8 | 54.3 |
| 1 3/32 | 1 5/16 | 1 3/8 | 2 1/2 | 10 | 20 | 2 | 2 1/2 | 4 | 4 1/4 | 7/8 | 13/16 | 12 3/4 | 37 3/4 | 1 7/8 | 92.2 | 3 3/4 | 1 7/8 | 2 3/8 | 6 1/8 | 52.8 |
| 1 1/8 | 1 5/16 | 1 3/8 | 2 1/2 | 10 | 20 | 2 | 2 1/2 | 4 | 4 1/4 | 7/8 | 13/16 | 12 3/4 | 37 3/4 | 1 7/8 | 91.7 | 3 3/4 | 1 7/8 | 2 3/8 | 6 1/8 | 51.2 |

**Fig. 4.—American Locomotive Company's Standard Decuple Seam**

sions *U* and *K* in Fig. 2, decuple seam. Here it is essential that this distance be sufficiently great, so that the diagonal distance with two rows of rivet holes deducted, be greater than the straight distance with one row of rivet holes deducted. In other words, the net breaking strength through the diagonal must be greater than the net breaking strength through the straight rows, or the sheet might break sawtooth fashion and the calculations for efficiency be upset. (A dotted line in Fig. 2 shows what is meant by breaking diagonally between rows.) In order to be assured of the proper distance for the back pitch, it is advisable, when designing seams, to have some sort of a formula that will give the desired distance. This condition is well covered by the formulæ given in the A.S.M.E. Rules for the Construction of Boilers of Locomotives, Part I, Section III, of the A.S.M.E. Boiler Code, page 8, paragraph L-23.

Seams of high efficiency, like the decuple seam illustrated in Fig. 2 and the diamond seam, which will be discussed later, are used where a saving of weight is important, and oftentimes the welts (both inner and outer) are made thin to save weight, but there is a limit to the reduction in thickness of the welt strips. Suppose for example, this decuple seam was used on a plate 1⅛ in. thick and this seam was to have an efficiency of 92 per cent. Should the welts be made only 9/16 in. thick, both welts could then fail through row *E*, leaving this row of rivets intact in the plate itself. Therefore, it is very important that the ratio of net area of the metal in the two welts through the row of rivets next to the center line of the seam to the plate be at least equal to the percentage of efficiency of the seam.

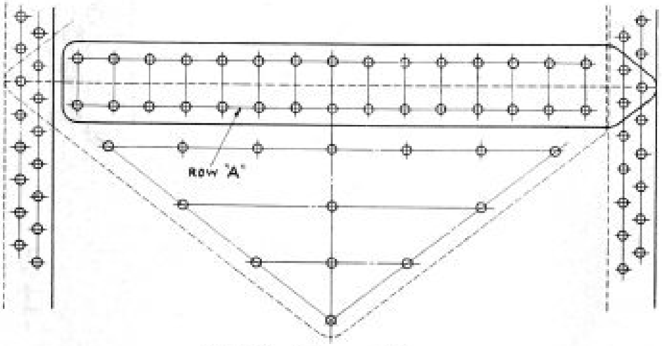



Fig. 5.—Diamond Seam

The American Locomotive Company's standard sextuple riveted seams are shown in Fig. 3, while Fig. 4 shows standard decuple seams. These tables not only show rivet pitches, rivet diameters, thicknesses and widths of welts for the different thicknesses of plates, but also carry the efficiencies for different plate thicknesses. The efficiencies shown on these standard seams are on the basis of an ultimate tensile strength of plates of 55,000 lb. per sq. in. and 40,000 lb. per sq. in. for shear of rivets. In checking the efficiencies of these seams by the method given above, the line next the bottom in Table II should be used for rivet values, or the line based on a rivet shear of 40,000 lb. per sq. in.

The question might be asked as to the reason for having both a standard sextuple and decuple riveted seam covering the same thickness of plates. The American Locomotive Company's general practice is to use the sextuple riveted seam on smaller boilers, up to approximately 65 in. diameter, and the decuple seam for larger sizes. The decuple seam has an efficiency about eight per cent greater than the sextuple seam, and by using this seam the same factor of safety is obtained with correspondingly thinner plates. In cases where a saving in weight is important, the decuple riveted seam is often used where the diameter is less than 65 in., and vice versa, larger boilers than 65 in. are built with sextuple riveted seams due to some modifying factor, such as railroad company's specification, additional weight required, etc.

It is within the limits of possibility to design a seam with a higher efficiency than the decuple seam shown, the most common type being the diamond seam illustrated by Fig. 5. This seam on long barrel courses and properly designed, can have a theoretical efficiency as high as 98 per cent. There are, however, certain drawbacks to a seam of too high an

TABLE I—REDUCTION IN TENSILE STRENGTH OF PLATES DUE TO RIVET HOLES OF VARIOUS SIZES

Based on Plates Having a Tensile Strength of 55,000 Lb. Per Sq. In.

| Diameter of rivet, inches | 1/2 | 9/16 | 5/8 | 11/16 | 3/4 | 13/16 | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Diam. of rivet hole, inches | 9/16 | 5/8 | 11/16 | 3/4 | 13/16 | 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 |
| Thickness of plate, inches | | | | | | | | | | | | | | | | |
| 1/4 | 7,734 | 8,594 | 9,453 | 10,313 | 11,172 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| 9/32 | 8,701 | 9,668 | 10,635 | 11,602 | 12,568 | 13,535 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| 5/16 | 9,668 | 10,742 | 11,816 | 12,891 | 13,965 | 15,039 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| 11/32 | 10,635 | 11,816 | 12,998 | 14,180 | 15,361 | 16,543 | 17,725 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| 3/8 | 11,602 | 12,891 | 14,180 | 15,469 | 16,758 | 18,047 | 19,336 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| 13/32 | 12,568 | 13,965 | 15,361 | 16,758 | 18,154 | 19,551 | 20,947 | 22,344 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| 7/16 | 13,535 | 15,039 | 16,543 | 18,047 | 19,551 | 21,055 | 22,559 | 24,063 | 25,566 | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| 15/32 | ...... | 16,113 | 17,725 | 19,336 | 20,947 | 22,559 | 24,170 | 25,781 | 27,393 | 29.004 | ...... | ...... | ...... | ...... | ...... | ...... |
| 1/2 | ...... | ...... | 18,906 | 20,625 | 22,344 | 24,063 | 25,781 | 27,500 | 29,219 | 30,938 | ...... | ...... | ...... | ...... | ...... | ...... |
| 17/32 | ...... | ...... | ...... | 21,914 | 23,740 | 25,567 | 27,393 | 29,219 | 31,045 | 32,871 | 34,697 | ...... | ...... | ...... | ...... | ...... |
| 9/16 | ...... | ...... | ...... | ...... | 25,137 | 27,071 | 29,004 | 30,937 | 32,871 | 34,305 | 36,738 | ...... | ...... | ...... | ...... | ...... |
| 19/32 | ...... | ...... | ...... | ...... | 26.533 | 28,575 | 30,615 | 32,656 | 34,697 | 36,738 | 38,779 | ...... | ...... | ...... | ...... | ...... |
| 5/8 | ...... | ...... | ...... | ...... | ...... | 30,078 | 32,226 | 34,375 | 36,523 | 38.672 | 40,820 | 42,969 | ...... | ...... | ...... | ...... |
| 21/32 | ...... | ...... | ...... | ...... | ...... | 31,582 | 33,837 | 36,094 | 38,350 | 40,605 | 42,861 | 45,117 | ...... | ...... | ...... | ...... |
| 11/16 | ...... | ...... | ...... | ...... | ...... | ...... | 35,449 | 37,813 | 40,176 | 42,539 | 44,902 | 47,266 | 49,629 | ...... | ...... | ...... |
| 23/32 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 39,531 | 42,002 | 44,473 | 46,943 | 49,414 | 51,885 | ...... | ...... | ...... |
| 3/4 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 41,250 | 43,828 | 46,406 | 48,984 | 51,563 | 54,141 | ...... | ...... | ...... |
| 25/32 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 45,654 | 48,340 | 51,025 | 53,711 | 56,396 | 59,082 | ...... | ...... |
| 13/16 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 47,480 | 50,273 | 53,066 | 55,859 | 58,652 | 61,445 | ...... | ...... |
| 27/32 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 52,707 | 55,107 | 58,008 | 60,908 | 63,809 | ...... | ...... |
| 7/8 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 54,141 | 57,148 | 60,156 | 63,164 | 66,172 | ...... | ...... |
| 29/32 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 59,189 | 62,305 | 65,420 | 68,535 | 71,650 | ...... |
| 15/16 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 61,230 | 64,453 | 67,676 | 70,898 | 74,121 | ...... |
| 31/32 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 63,271 | 66,602 | 69,932 | 73,262 | 76,592 | ...... |
| 1 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 65,313 | 68,750 | 72,188 | 75,625 | 79,063 | 82,500 |
| 1 1/32 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 70,898 | 74,443 | 77,988 | 81,533 | 85,078 |
| 1 1/16 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 73,047 | 76,699 | 80,352 | 84,004 | 87,656 |
| 1 3/32 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 75,195 | 78,955 | 82,715 | 86,475 | 90,234 |
| 1 1/8 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 77,344 | 81,211 | 85,078 | 88,945 | 92,812 |
| 1 5/32 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 83,467 | 87,441 | 91,416 | 95,391 |
| 1 3/16 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 85,723 | 89,805 | 93,887 | 97,969 |
| 1 7/32 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 87,979 | 92,168 | 96,357 | 100,547 |
| 1 1/4 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 90,234 | 94,531 | 98,828 | 103,125 |
| 1 9/32 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 92,490 | 96,895 | 101,299 | 105,703 |
| 1 5/16 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 94,746 | 99,258 | 103,770 | 108,281 |

TABLE II—SHEARING VALUE OF IRON AND STEEL RIVETS

| Diameter of rivet, inches | 1/2 | 9/16 | 5/8 | 11/16 | 3/4 | 13/16 | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Area of rivet, sq. in. | .1963 | .2485 | .3068 | .3712 | .4418 | .5185 | .6013 | .6903 | .7854 | .8866 | .9940 | 1.1075 | 1.2272 | 1.3530 | 1.4849 | 1.6230 |
| Diameter of rivet hole, Inches | 9/16 | 5/8 | 11/16 | 3/4 | 13/16 | 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 |
| Area of rivet hole, sq. in. | .2485 | .3068 | .3712 | .4418 | .5185 | .6013 | .6903 | .7854 | .8866 | .9940 | 1.1075 | 1.2272 | 1.3530 | 1.4849 | 1.6230 | 1.7671 |
| Shearing value of iron rivet (38,000 lb. per sq. in.) | 9,443 | 11,658 | 14,105 | 16,788 | 19,703 | 22,850 | 26,231 | 29,845 | 33,691 | 37,772 | 42,085 | 46,634 | 51,414 | 56,426 | 61,674 | 67,150 |
| Shearing value of steel rivet "Alco" (40,000 lb. per sq. in.) | 9,940 | 12,272 | 14,848 | 17,672 | 20,740 | 24,052 | 27,612 | 31,416 | 35,464 | 39,760 | 44,300 | 49,088 | 54,120 | 59,396 | 64,920 | 70,684 |
| Shearing value of steel rivet (44,000 lb. per sq. in.) | 10,934 | 13,499 | 16,333 | 19,439 | 22,814 | 26,457 | 30,373 | 34,558 | 39,010 | 43,736 | 48,730 | 53,997 | 59,532 | 65,336 | 71,412 | 77,752 |

efficiency as well as to a seam requiring a wide inside welt like the diamond seam, some of these drawbacks being as follows. Accessories to a locomotive such as air pumps and reverse gears are fastened to the boiler shell by means of brackets, and it is almost always impossible to design these brackets so that the studs attaching them to the shell will permit of as high an efficiency in the shell sheet as 98 per cent, thereby making it necessary to apply diamond shaped liners to the shell underneath these brackets, in order to keep the efficiency through these stud or bolt holes up to the efficiency of the seam, which is absolutely necessary inasmuch as the thickness of the plate is generally based on the seam. The wide seam noted above also interferes with these brackets and liners, oftentimes making it necessary to put studs or rivets in the seam itself, thereby weakening it to below its theoretical efficiency. Especially is this true in the case of handrail post studs, which very often necessarily come in the seam. Unless the seam has some rows of high efficiency as the decuple seam rows *B*, *C* and *E* where these studs can be placed, the efficiency of the seam is impaired. The difficulty in locating attachments when wide welt seams are used, accounts for the sextuple seam being used on small boilers; that is, the smaller the boiler the harder to find place for attachments, and consequently here the seam with narrower welt works out the best.

The diamond seam is even more susceptible than the decuple seam to weakness at the inner row of rivets (marked *A* on Fig. 5) due to the higher efficiency and to the fact that the rivets must be placed close together in order to get sufficient rivets in the seam. The usual spacing of rivets in this row is about 3½ in. Assuming ¾ in. plate, 1 5/16 in. rivet holes, 98 per cent efficiency, the thickness of the two welts must be as follows:

$$\frac{3\frac{1}{2} \times \frac{3}{4} \times .98}{3\frac{1}{2} - 1\ 5/16} = 1\ 3/16 \text{ in.}$$

against ½ in. and 9/16 in. welts, or a total thickness of 1 1/16 in. for the decuple seam. This greater thickness of welts, coupled with the much wider inside welt, eliminates to a great extent, if not wholly, the saving in weight in the plate itself, due to the higher efficiency, and thus the reason for the use of this seam has been defeated.

# Increasing Welding Speed

**By H. R. Pennington***

ONE of the most important questions facing the advocates of fusion welding is that of finding methods of increasing the speed of arc welding. Welding speed on a given section is fundamentally dependent upon the rate of metal deposition and the amount of metal required to effect the jointure. The first factor—rate of metal deposition—varies with the energy required to liquefy the electrode material, arc stability, current density, etc. The amount of metal which must be applied obviously depends upon the type of joint and opening necessary to effect fusion between the edges or members to be joined.

The size electrode and arc current value that can be used seem to be limited only by the thermal capacity of the base metal or joint. That is, the heat or arc current and electrode diameter can be increased until the molten metal of the weld area becomes difficult to control, or until the effect of expansion and contraction becomes an obstacle.

One of the principal obstacles encountered in the past on attempting to use large diameter electrodes, was the poor welding qualities of such materials. With ordinary large diameter bare electrodes, a violently sputtering arc, throwing out metal in all directions, is a common occurrence at arc current values exceeding 200 amperes, and at 300 amperes the disturbances render the arc control very difficult and extremely uncomfortable. No doubt one reason for this is the fact that the beneficial effect to the welding characteristic incident to drawing of electrodes in wire form are not present to the same extent in large diameter electrodes or what would commonly be classed as rods. These disturbances and poor welding characteristics of large electrodes generally resulted in inadequate penetration and ununiform fusion.

If the electrodes are coated a quite stable arc will be secured, permitting welding with metallic arc up to 500 amperes with adequate penetration, uniform fusion and with a considerably lower electrode current density than that required for bare wire.

As a working basis for comparison, the rate of deposition for the usual size bare electrode and that of ¼-in. coated, both of mild steel grade on ½-in. plate wire were determined with the following results:

| Elec. dia. | Arc amps. | Lb. elec. consumed per hr. | Ft. per hr., single fillet lap weld | Lb. of elec. per ft. of fillet | Elec. current density |
|---|---|---|---|---|---|
| 5/32 in. bare | 150 | 2.3 | 6.8 | 0.33 | 7,850 |
| ¼ in. bare | 300 | 7.7 | 10.4 | 0.74 | 6,220 |
| ¼ in. coated | 300 | 8.09 | 18.6 | 0.43 | 6,220 |

The lower speed and rate of deposition of the ¼-in. bare as compared to ¼-in. coated is due to the difficulty of controlling a high current arc when using bare electrodes. Despite the greater amount of metal deposited, high current welding resulted in over a 100 per cent increase in speed of welding of a single fillet lap joint.

These figures were obtained under ideal conditions and could not be equaled in commercial practice, as further tests have proved. However, the relative speed between small diameter bare electrodes and large ¼-in. coated electrodes with high arc current will remain practically the same. An additional factor to consider in using large electrodes is the fact that the time required to consume a large electrode is greater than that for a small one and therefore the percentage of welding time is actually increased.

Experiments with high currents and large electrodes with exceptional penetration qualities, indicate that the speed of butt welding can be increased by 100 per cent over present practice, especially since by using deep penetration electrodes the amount of scarfing necessary would be greatly reduced, if not eliminated, on plate thickness up to ⅜ in. A reduction in the amount of scarfing is also desirable where high arc currents are used.

The lap joint offers greater advantages, however, for large electrode welding than the butt joint, as the lap joint possesses inherently the requisite high thermal capacity and therefore permits a high energy concentration with an attendant high rate of fusion and deposition. In addition, lap joints with double fillet will permit the securing of 100 per cent weld strength without difficulty.

A recent check on pounds of metal consumed per hour, using ¼-in. mild steel coated electrodes with 240 amperes arc current, showed the rate of deposition to be six pounds per hour. These figures were obtained from actual shop practice on locomotive frame welding and include time for considerable cleaning necessitated by applying successive layers in a vertical position.

From the foregoing it is clear that the limit of speed and rate of metal deposition has by no means been attained in present day practice, but in order to permit the use of higher arc currents, the electrical resistance of the electrodes must be decreased by an increase of electrode area.

Attention has been drawn to the possibilities in this direction in order that those contemplating the adoption or extension of arc welding may give consideration to high arc current welding, which from present indications will be increased to at least 300 amperes for a great majority of the work now done with arc current values not exceeding 200 amperes.

*Supervisor electrical equipment and welding, Chicago, Rock Island & Pacific.

# 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, Mr. C. W. Obert, 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.

Below are given the interpretations of the Committee in cases Nos. 384 to 390 inclusive, as formulated at the meeting of March 2, 1922, and approved by the Council. In accordance with the Committee's practice, the names of inquirers have been omitted.

CASE No. 384. *Inquiry:* Is it permissible, under paragraph 191, to straighten the edges of bottom plates of fired pressure vessels by hand hammering on an anvil which is bolted to the edges of the sheet where the bottom plate has been cold pressed with sectional dies to the correct radius?

*Reply:* It is the opinion of the Committee that the straightening of edges of bottom plates of fired pressure vessels by hand hammering is prohibited by paragraph 191 of the Code. Attention is called to the fact that with proper dies and manipulation, it is possible to properly form the plate.

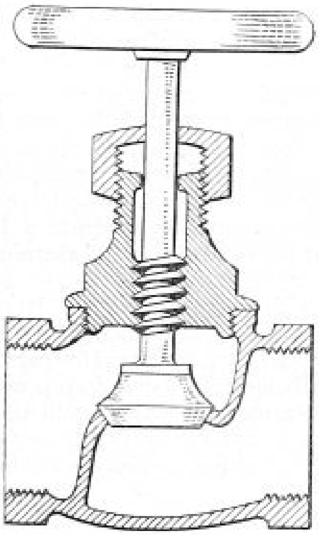


**Fig. 1.—(Par. 308) Type of Globe Valve Referred to in This Paragraph of Boiler Code**

CASE No. 385. *Inquiry:* Does the requirement in paragraph 6 for the material to be used in braces apply to the structural members referred to in paragraphs 201 and 225?

*Reply:* It is the opinion of the Committee that the structural members referred to in paragraphs 201 and 225 come under the classification of braces in paragraph 6 and should be of material that conforms to the specification for steel bars.

### Use of Prosser Expanders

CASE No. 386. *Inquiry:* Is it the intent of paragraphs 250 and 251 that expanders of the prosser type may not be used for attaching tubes and nipples in firetube and watertube boilers, and that expanders of the roller type are compulsory?

*Reply:* It was the intent of paragraphs 250 and 251 to specify that the tubes be suitably expanded by other than a peening process and the exclusion of the use of a prosser-type expander was not contemplated by the Committee.

CASE No. 387. *Inquiry:* Does the tolerance of 20 percent in the phosphorus and sulphur limits as given in paragraph 84*b* of the Boiler Code permit the acceptance of steel castings with 0.06 percent of phosphorus and sulphur?

*Reply:* The tolerance of the phosphorus and sulphur limits as given in paragraph 84*b* of the Boiler Code, applies only to the check analysis from the casting, which check analysis is not compulsory, and which is not subject to the tolerance. The reason is that the ladle analysis gives a fair average of the constituents of the steel, whereas locally in the casting, the chemical constituents may vary slightly from the average; hence the tolerance permitted.

### Continuous Feed Pipes

CASE No. 388. *Inquiry:* Would a continuous feed pipe, which is connected so as to pass lengthwise through a boiler drum with feed valves at each end of the pipe, the pipe being drilled with a number of holes ½ inch in diameter or over, spaced along its length for discharging the water into the drum, the combined area of the holes being at least equal to that of the cross-section of the pipe, be acceptable under the requirements of paragraph 314 of the Code?

*Reply:* It is the intent of paragraph 314 of the Code, that the feed pipe of the boiler shall have an open end or ends inside the boiler, and it is the opinion of the Committee that the arrangement submitted is the equivalent of an open-ended pipe and should be allowed. (See Case No. 358.)

CASE No. 389. *Inquiry:* Is it the intent of the last sentence of paragraph 308 of the Code to restrict the use of globe valves of the angle type for blow-off connections? It was pointed out that angle globe valves have a practically straightway passage through them and offer no dam or obstruction to cause accumulation of sediment.

*Reply:* It was the intent of paragraph 308 that straightway globe valves of the ordinary type or valves of such type that dams or pockets can exist for the collection of sediment, shall not be used on such connections. Accordingly, a revision of the last sentence of paragraph 308 has been suggested to read as follows:

Straightway globe valves of the ordinary type as shown in the accompanying illustration, or valves of such type that dams or pockets can exist for the collection of sediment, shall not be used on such connections.

### Electrical Steam Generator

CASE No. 390. *Inquiry:* Would it be permissible, under the rules in the Code to construct an electrical steam generator formed of large electrodes immersed in water within an enclosed vessel, for producing steam at 100 pounds gage pressure from electrical energy? The generator is to have a circular shell of a size in excess of the miniature boiler limit in outside diameter, with flat cast-steel head having the necessary openings for access, bolted to cast-steel flanges riveted to the circular shell.

*Reply:* Such a construction is not fully covered by the Code. In view of the impossibility of computing these strains in the flat circular heads with exactness when it is desired to build boilers of this type, the Committee would recommend that a test to destruction be made on a full-sized generator as provided for in paragraph 247 of the Code.

# Defective Safety Valves Cause Boiler Explosion

*The following account of a locomotive boiler explosion taken from a British Ministry of Transport Report was recently published in The Railway Engineer. The accident seems to have been due to the jamming of the safety valves which prevented relief to the boiler when the danger pressure was reached. A rather odd sequel to the report is that after determining the cause of the disaster within a reasonable limit of doubt, no attempt was made to fix the responsibility nor to correct the design of the equipment that made the explosion possible.*

THE boiler, which was installed on a Buxton, London and Northwestern locomotive, which caused the disastrous accident, reported below was constructed at the Crewe Works, England, June, 1905. It was originally designed to work at a pressure of 200 pounds per square inch.

It has been estimated that the average life of a boiler of this type is 18 years, of which 17 had been completed at the time of the explosion. Since its construction the boiler had been used on four separate locomotives, all of the Webb four-cylinder compound mineral class. It had been several times repaired, and in June, 1918, was placed on the frames of engine No. 134, where it remained up to the time of the explosion. The boiler was sent to a firm of locomotive builders for repairs some three months or more before the date of its destruction, being afterwards tested under hydraulic pressure at 205 pounds per square inch, and under steam at 200 pounds per square inch, at which latter figure the valves were set to blow off.

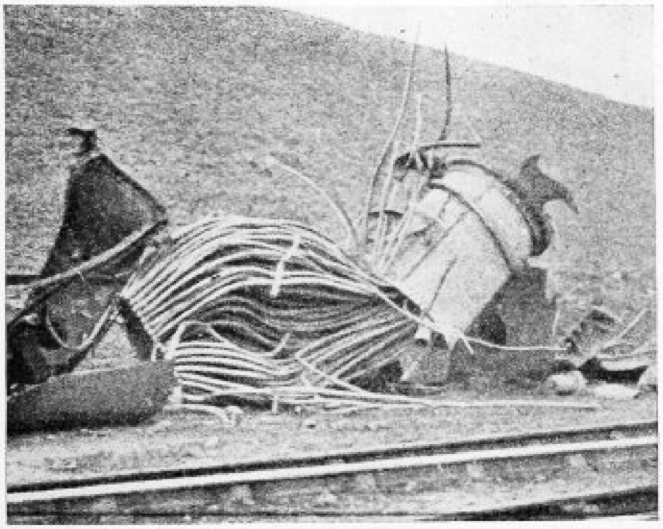


Fig. 1.—General View of Boiler Wreckage

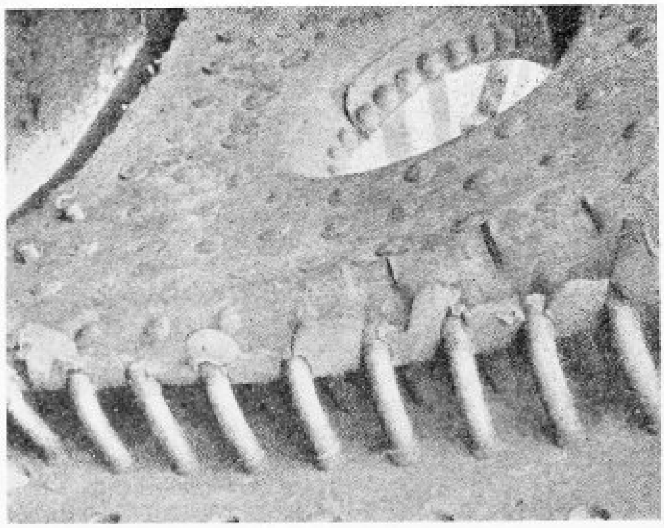


Fig. 2.—Top of Firebox Back Plate

The evidence of forty witnesses was taken, and apart from that which related to the actual occurrence, it may be said to fall under two principal heads, viz.:

(1) That of engineers, boiler inspectors, shed fitters, etc., which is mainly concerned with the conditions and performance of the engine and the shed repairs executed since it was put into service in July last. Included under this head is an extract from all reports made on the engine by engineers at the various sheds concerned since this date.

(2) That dealing with the boiler design, repairs last executed and certain tests made after the explosion.

An analysis of the evidence under the former of these headings brings to light the following points:

(a) That continual difficulty was experienced by engineers in working their injectors when the boiler was high in steam, and that, in consequence, most engineers appear to have made a practice of working with pressures below 200 pounds. The engine was reported for defective injectors 12 times in the three months.

(b) That the steam gage was reported defective four times.

After the inquiry, a hydraulic test to destruction was carried out on a similar boiler of about the same age and repaired by the same firm. This boiler held up to a pressure of nearly 600 pounds per square inch before failure.

The boiler was of the ordinary locomotive type, with telescopic barrel and straight top; the barrel, the outside firebox plates and the smokebox tube plate were made of steel, the inside firebox and the firebox stays of copper. The barrel was formed of three rings of plates, and was 4 feet 5½ inches mean internal diameter by 15 feet 6 inches long; the longitudinal seams were made with double butt straps treble riveted, and the circumferential seams were lapped and double riveted. The barrel and firebox casing plates were ⅝-inch thick; the smokebox tube plate was ⅞-inch thick. The back casing plate was supported in the steam space by five longitudinal stays 1⅜ inches in diameter at the threads, reduced to 1⅛-inches in diameter at the body, secured to a cast steel bracket riveted to the barrel. In addition to this four gusset stays were fitted to the smokebox tube plate.

### Details of Boiler

The boiler was fitted with 239 steel tubes 1⅞ inches in diameter; the total length of the boiler was 22 feet 4 inches. The inner firebox was 6 feet 2⅞ inches long inside at the bottom and 5 feet 11 15/16 inches at the top, 5 feet 8¼ inches high inside at the back and 5 feet 9¼ inches at the front, and 3 feet 3⅞ inches wide inside at the bottom; the sides were parallel for a distance of 3 feet 1¾ inches from the bottom, and were continued in a concave cylindrical form to the crown plate joint. The firebox crown plate was ½ inch thick, the tube plate where perforated for the tubes was 1 inch thick, the lower part of the tube plate and the side and back plates were 9/16 inch thick. The firebox crown plate was supported by eight rolled steel girders spaced 5 inches apart center to center, which were tied in pairs of about one quarter of their length from each end to the top of the outside firebox by means of pairs of links connected to transverse cast steel brackets riveted to the casing wrapper plate. The links were connected to each pair of girders by pins 1¾ inches in diameter, secured by split pins at each end; a bar 1¾ inches in diameter at the ends, reduced to 1½ inches in diameter at the body, connected the front and back pairs of links of each pair of girders to their respective transverse brackets, cotters 1⅜ inches wide by ⅜ inch thick were fitted through each bar to retain the front pair of links and the front link of the back pair in position, and the back link was secured to the adjacent one by means of a steel clip 1¼ inches wide by ¼ inch thick. There were, therefore, 16 links connected to the eight girders by 16 pins 1¾ inches in diameter in double shear, and to transverse brackets by the equivalent of eight pins of the same diameter also in double shear. The links were steel forgings, the lower eye of each link had an elongated hole to allow the firebox to expand upwards, and the sectional area of the metal at the weakest part of each link was 2¼ square inches. The girder staybolts were 1 inch in diameter and were made of steel; they were pitched 4 inches apart longitudinally and 5 inches transversely. The firebox stays were screwed 11 threads per inch and were 1 1/16 inches to 1⅜ inches in diameter at the threads, the bodies of the stays between the plates were reduced in diameter to that of the bottom of the thread. The stays were pitched 4 inches to 4½ inches apart horizontally and 3 5/16 inches to 4½ inches vertically, and the ends were riveted over. The firebox tube plate was supported between the tubes and the screwed stays by seven palm stays 1 inch in diameter riveted to the barrel.

## NATURE OF THE EXPLOSION

The explosion was of a very violent character; the firebox crown was forced down bodily into the firebox, and the sudden admission of steam into the firebox through the large opening resulted in the complete destruction of the boiler. The most serious damage to the locomotive below the frames occurred directly under the firebox; the cylinders and valve gear and the tender sustained very little damage. The right-hand trailing wheel was driven off its axle, and was projected about 17 yards to the right; the left-hand trailing wheel was started from the axle, the wheel center was cracked, and the wheel and axle were displaced to the left; the back ends of the engine frames were bent outward. The firebox foundation ring fractured at each corner; the casing wrapper plate to which the firebox side plates and a portion of the right-hand of the throat remained attached was ripped off, opened practically flat and projected about 172 yards. The casing end (front) plate with firebox back plate attached, being released initially

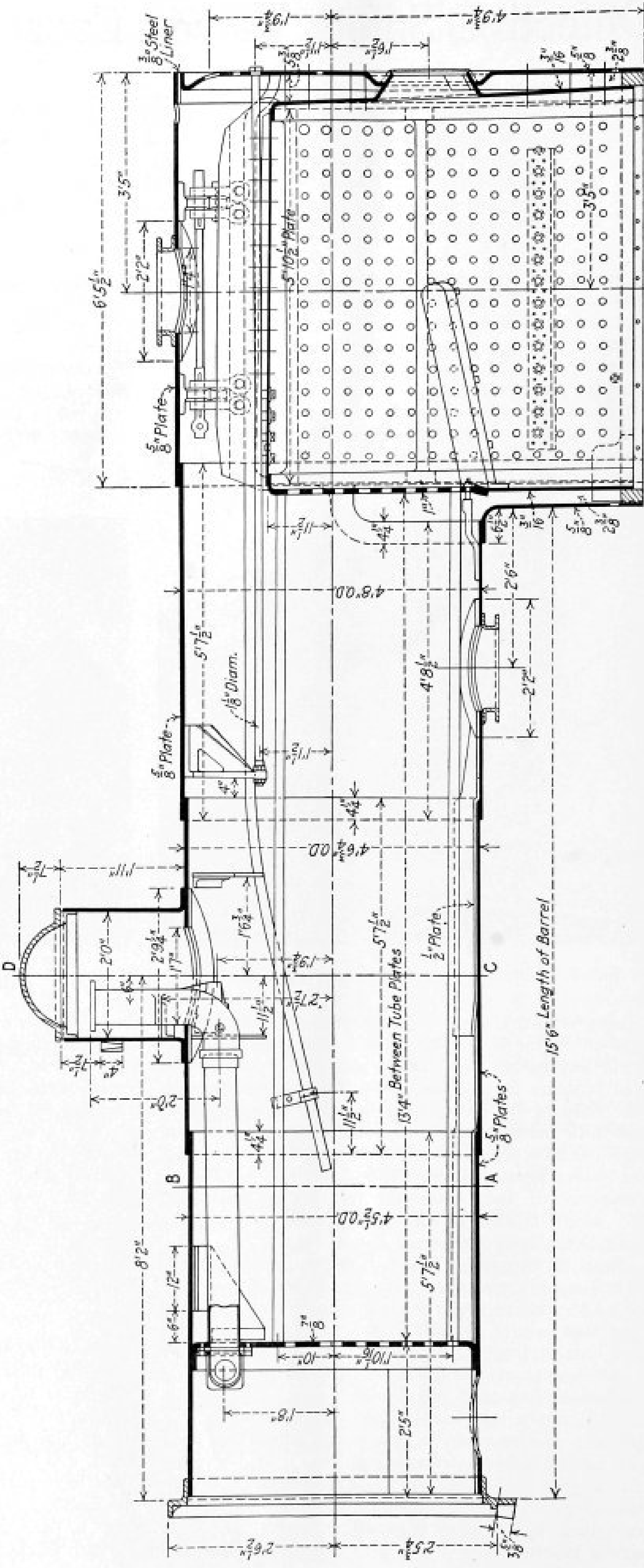



Fig. 3.—Boiler for 4 feet 3 inch Compound Engine on Which Explosion Occurred

from the bottom, swung upwards and came to rest at a distance of 222 yards from the engine. The firebox crown plate with the girders attached was found completely separated from the casing wrapper plate. The flanged portion of the upper part of the firebox tube plate was parted from the firebox crown and side plates, and also from the part of the tube plate into which the tubes were expanded. The ends of most of the tubes projected slightly through the tube plate, which was distorted, and the palm stays were broken.

The back ring of barrel plating to which the throat plate remained attached fractured diagonally through the solid plate from the top of the right hand side of the throat plate to about the center of the line of rivets which secured the longitudinal stay bracket; the fracture followed the line of rivets circumferentially and extended into the front part of the longitudinal seam. This ring of plating opened out, and in doing so buckled the throat plate and tore the middle ring of barrel plating along the circumferential seam.

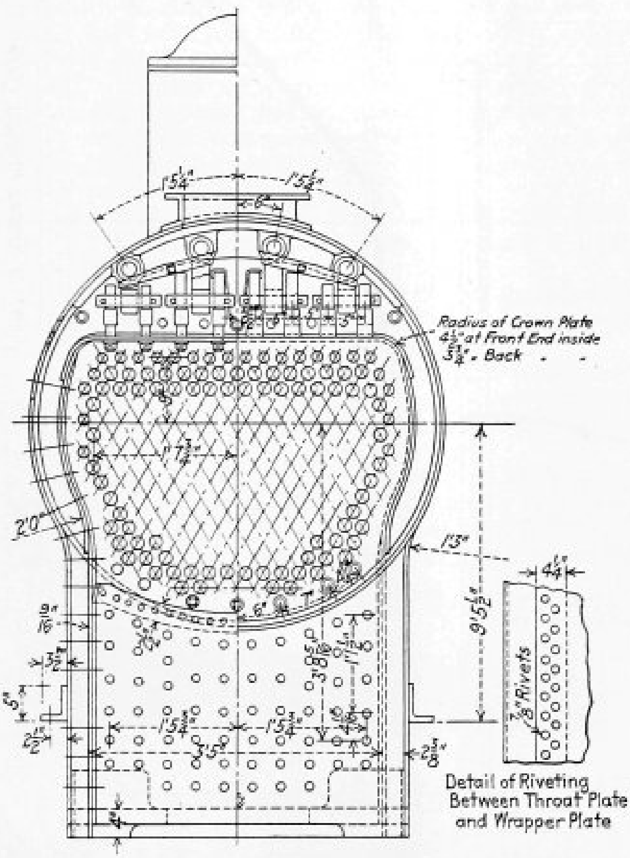



Fig. 4.—Section of Boiler

The lower part of the copper tube plate was severely damaged and was found in three pieces, of which one only remained attached to the throat plate. It was apparent, however, that the failure at this part was subsequent to that of the firebox crown; there were distinct marks on the copper plate which corresponded with the feet of the crown girders and the left hand portion of the plate was pierced and ripped off the stays by one of the feet of the girders. The middle part of the copper plate which remained attached to the throat plate by four stays near the bottom had evidently been torn from the other stays after the initial failure of the crown, and the right hand portion of the copper plate was apparently forced from the stays by the distortion of the throat plate at that part.

The middle ring of barrel plating fractured longitudinally through the solid plate and in opening out separated from the front ring along the circumferential seam. The latter ring of plating was practically undamaged except at the circumferential seam. The smokebox tube plate was slightly distorted; some of the tubes were set forward through the plate, and a few were pulled out.

On examining the wreckage after the explosion, it was apparent that the boiler had failed through over pressure, and that the initial failure occurred at the firebox crown suspension system, which was unable to support the excessive load on the crown; and it is thought that the surging of the water in the boiler towards the firebox when the engine started, gave the slight additional load necessary to start the destruction.

From the appearance of the parts, it was clear that the suspension system had been correctly fitted and assembled; there were unmistakable signs that the whole system had been subjected to a very severe load, and that each part of the system had been unduly strained. Two of the back links were broken and a number of links were slightly cracked at the corners of the holes in the upper eyes; the long hanging pins which connected the links to the brackets were sheared and bent, and some of the lower pins were bent and drawn from the girders. The fractured edges of the broken links showed evidence of slight cracks at the corners of the holes having existed for some time, and the fractures were somewhat crystalline with little reduction of area.

| | Area in Square Inches | Ultimate Tensile Strength in Tons Per Square Inch | Ultimate Elongation in 2 Inches, Percent. | Angle Through Which Sample Was Bent Cold Without Fracture | Fracture |
|---|---|---|---|---|---|
| Specimen from broken link.. | .25 | 37.0 | 23.5 | 180 degrees | Silky |
| Specimen from sound link... | .25 | 35.6 | 30.0 | 180 degrees | Silky |

Specimens were taken from the copper firebox back plate near the line of fracture at the top, and were tested with the following results:

Tensile Test.

| Area in Square Inches | Ultimate Strength Tons Per Square Inch | Ultimate Elongation in 8 Inches, Percent | Fracture |
|---|---|---|---|
| .493 | 15.72 | 28.00 | Dull Brick, Red |

A boiler similar to the one on which the explosion occurred was tested to destruction at Crewe Works by hydraulic pressure. The test was terminated by the breaking of a defective roofing bar bolt when the pressure was 600 pounds per square inch but there were no signs of barrel weakness at that pressure.

## General Conclusions

The general conclusions arrived at by the inspecting engineer, Major Hall, are set out by him at the end of the report in the following words:

I agree with the opinions expressed and the conclusions arrived at both in regard to the nature and cause of the accident, namely, that the explosion, which was due to over pressure, originated in the firebox crown; that there were probably several contributory causes which prevented the safety valves from relieving the excess pressure, the main contributory cause being the small amount of clearance between the valve webs and the seats when cold. Certain other suggested causes have been submitted, both by letter and in the public press, and due attention has been paid to these. A suggestion has also been current that the explosion may have been due to the presence of an explosive in the fire. Not only, however, is there a total absence of evidence to support this theory, but the nature of the damage and the course of the explosion are both decidedly at variance with it.

The case is a remarkable one, and its investigation has presented considerable difficulty, chiefly in respect of determining, first whether excess pressure could be proved; and second, how such excess pressure could have arisen.

It is clearly impossible, in a case of this kind, to arrive at a conclusion as to the correctness of which there is no element of doubt, but in the light of the evidence submitted, and the various tests and measurements carried out, there is, in my opinion, no other solution which would so adequately cover all the facts of the case as that advanced.

There is nothing in evidence dealing with the boiler repair work carried out by the locomotive firm to suggest either defective workmanship or inadequate supervision. On the contrary, every care appears to have been taken to turn out a job which would be as satisfactory to the railway company as if it had been done in their own works. It was certainly unfortunate that the valves and seats were faced to the in-

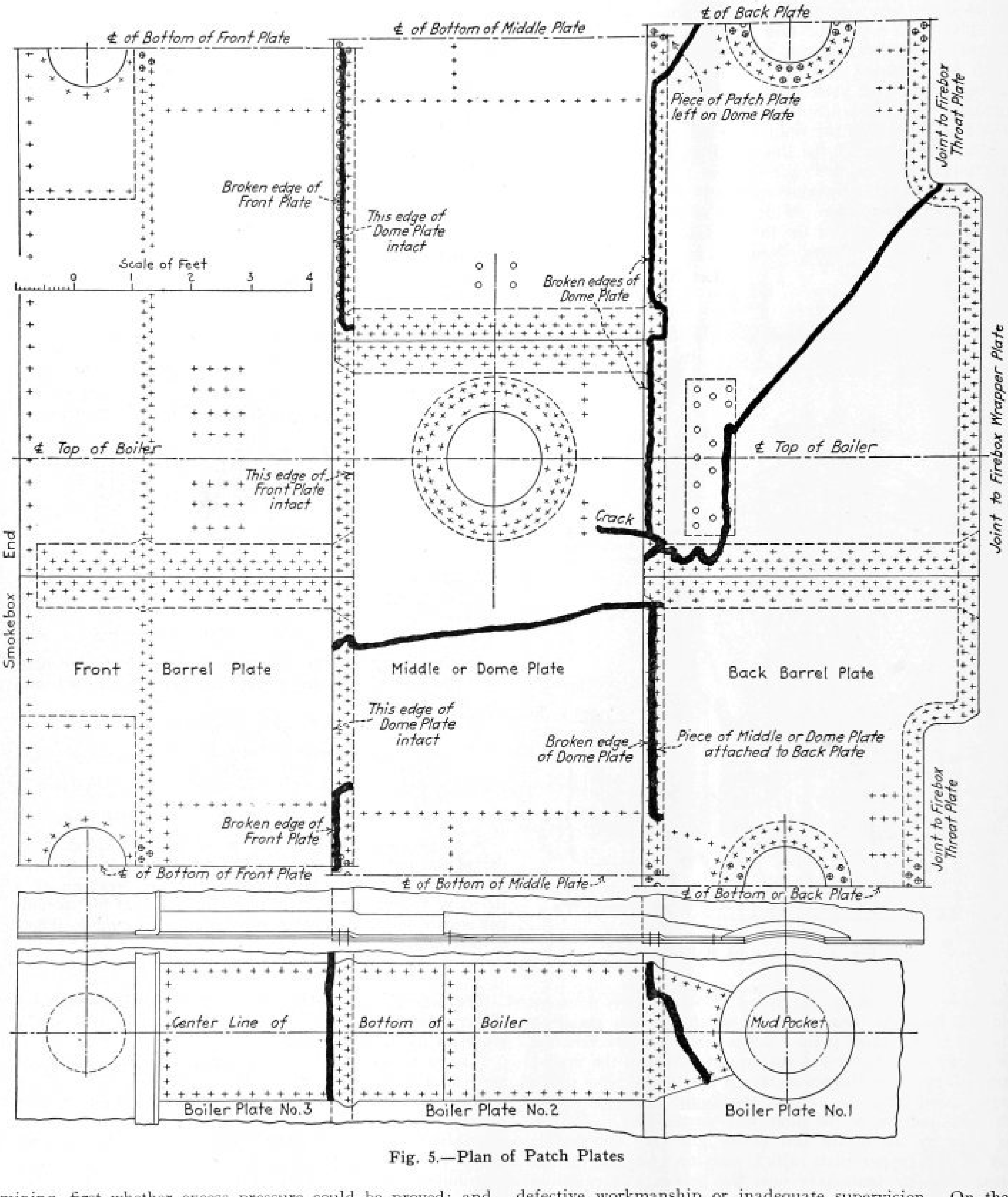



Fig. 5.—Plan of Patch Plates

(Continued on page 148)

# The Life Story of Two Staybolts*

*Here we have the story of two staybolts,—one much wasted and thinned from age, hard service and bad contact, and the other nearly its original size and almost perfect in shape but split in two parts lengthwise. These two characters of our story meet on the scrap pile with their period of usefulness ended and, after having become acquainted, the following dialogue takes place:*

OLDE *Staybolt:* Look out, Longfellow, and watch who you are rubbing against!

*Newe Staybolt:* Beg pardon, sir, I did not mean to rub you so hard; but who are you anyway? You certainly look pretty much used up.

*Olde:* Oh, I don't know! You look like a split in the Democratic party yourself, but I see that you are but one staybolt when you are pulled together.

*Newe:* Now don't get rusty. Even if you did nearly lose your head while on the job. Let's be friends, since we have both reached the end of our usefulness in our present state. Let's have your history. How old are you, and where have you put in your time?

*Olde:* Perhaps my story won't be so interesting when you hear it, because I was on the job when three men were killed, due to a weakness of myself and seven companions.

*Newe:* You don't mean that, do you? Surely, you were not guilty of killing three men?

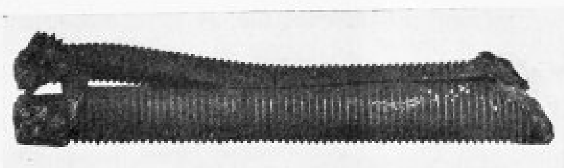
*Olde:* Yes, but I couldn't prevent the loss of the innocent lives. I offered resistance to it to the last ounce of strength in my body, but finally had to give way.

*Newe:* Well, I'm interested. Tell me the history of your life experience. We both have plenty of time now; we may be here in the scrap pile for several months.

*Olde:* Well, I was put in a horizontal firebox boiler, commonly called the oil-well type, nearly twenty years ago.

*Newe:* Pardon me, but what do you mean when you say, oil-well type? Why do you use that term?

*Olde:* Oil-well, or oil-field, boilers, are boilers designed light in weight and cheap in price and usually built without any special supervision. They are made light in weight because they are often taken to hilltops and mountainsides that



**Newe Staybolt**

are sometimes almost inaccessible places. I have also heard old-time oil and gas men say that boilers built of thin plate were quick steamers, especially when made with thin crown sheets. Owing to the difficulties of moving them these boilers are often left standing idle where used, as the cost of taking them to another location would about equal the cost of a new boiler.

*Newe:* You say that the boiler was built without any special supervision. Do you mean that there was no shop inspector on the job when it was built?

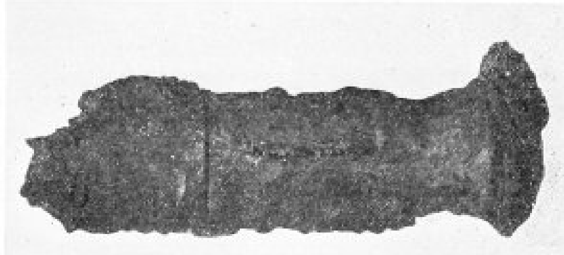
*Olde:* Inspector! No! not on oil-well boilers. They are built and used without inspection.

*Newe:* I'm surprised! Who, for the love of Pete, determined the pitch of the staybolts and the joint efficiency, and so on?

*Olde:* Oh, the boilermaker, or sometimes a shop draftsman did that. In what they miscalled the good old days, the old-time boilermaker was guided by the Government marine rules. Of course these rules are ancient, but you know some folks don't believe in newfangled rules and butt straps for steam boilers. You see, they could make oil-well boilers fast. They punched the rivet and staybolt holes full size or very nearly so, and if the plates at the joints did not fit snugly, a 200 pound boilermaker would put them together by the judicious use of a 16 pound sledge.

*Newe:* Gee! But wouldn't the plates be flat along the longitudinal seams?

*Olde:* Sure thing, for a short space, but no one objected. There was no inspector on the job, and the purchaser knew



**Olde Staybolt**

next to nothing about boilers. The rivet holes would be brought in line by the use of a drift pin. Of course the metal was abused and fatigued some, but after the riveting was done, no one could see that.

*Newe:* Well, go on with your story.

*Olde:* That is easy enough to tell, but how to get the proper parties to profit by the experience is what bothers me. You see, I was 7/8 inch diameter over the threads when put in the side sheet of the boiler nearly twenty years ago. Now a 9/32 inch sheet does not have many threads, but I managed to keep a pretty good hold in the plate all these years. The metal around the hole in the plate which was abused and tortured when the hole was punched, was eaten away and grooved some by the acids in the feed water. These same acids, of course, attacked the material of my body and a slow but positive action began, not only on my body but on that of nearly all the other staybolts, and we became thinner and thinner at certain points, and I knew it would be only a question of time until some of us would give way. When I started in service, the steam pressure carried on the boiler was 100 pounds per square inch and all was lovely then. We bolts were spaced 5 inches by 6 inches or 30 square inches to the bolt; that was 3,000 pounds to the square inch and we could stand that load without any trouble. But the boiler changed hands several times and some of the fool firemen insisted on overloading the safety valve; that increased our load considerably at times.

*Newe:* Was the safety valve overloaded when the accident occurred?

*Olde:* Oh, no! Not a pound. Myself and seven of my nearby companions became reduced in body by corrosion until we were approximately 1/4 inch in diameter. And although the boiler was nearly twenty years old, they still carried 100 pound pressure at times, and the load of 3,000 pounds each was too much for us and when we reached our limit of resistance, we had to let go. When eight of us let go at the

*Reprinted by courtesy of *Power*.

same time, the side sheet bulged out, pulled over the heads of many of the other bolts, then tore up along the sides and stripped loose from most of the crown bolts and ripped along one side and was blown downward. The escaping steam and hot water scalded three men, causing their death, and the force of the explosion blew the boiler in the air and about fifty yards away.

*Newe:* That was tough on the men and harder on their families. But I've been turning over a few figures in my mind and I find that if your body was reduced to approximately ¼ inch, or a cross-sectional area of .049 square inches, the load on you at 100 pounds steam pressure would equal about 61,224 pounds per square inch or what was about the tensile strength limit of the material. No margin, no factor of safety. Surely, failure was inevitable. Such conditions are certainly to be condemned. But tell me, was the boiler never inspected during all the years that your body was wasting by corrosion?

*Olde:* The only inspections consisted of the "once overs" by country mechanics, who usually looked over the outside and in the furnace door, and several times they were well pleased with the appearance of the boiler because it had a heavy coat of tar paint. Had anyone looked in the handholes with a light placed inside the boiler during the last ten years they could have detected our badly wasted condition, and would probably have prevented the loss of human life.

*Newe:* Well, my story is shorter than yours. My time of service was mighty short; in fact, I cannot claim to have given any service, as I was found defective before the boiler had a fire put in it. The material of which I was made was of good quality, but the heating of it was not just right, and when the round rod was rolled a portion of it was not properly welded, in other words, I was not homogenous. The imperfection did not show on the surface of the rod, and of course it got by the rolling-mill inspector. The material was compact enough to stand threading and still not show defective. Finally, I was screwed into the side of a large locomotive boiler—one end in the side sheet of the furnace, the other in the wagon top or wrapper sheet. This caused the defect in my body to become more pronounced. When the material at the ends was upset or beaded over, the shocks caused by the blows of the hammer split me practically from end to end. The separation of material was not noticeable at the ends and while I was seriously split throughout inside the boiler, this could not be seen, and I thought I was booked to give service although defective. I missed my guess, however, as you will see. The boiler was of a standard requiring the ends of the staybolts to be drilled. So there was a 3/16 inch hole drilled in the outer end, extending ½ inch inside the inner surface of the outer plate. The standard specification called for a hydrostatic pressure test of 1½ times the allowable working pressure. When this test was put on the boiler, the inspector was on the job and discovered very slight leakage through the telltale hole. He ordered me taken out, and when removed I was found as you see me, split from end to end, defective, and detected by modern inspection methods. So you can see, *Olde Staybolt*, there are modern methods of making steam boilers safe.

*Moral:* Steam boilers should be designed, constructed and operated under modern safety standards.

# Method of Laying Out a Compound Wye

**By P. W. McDonough**

*The following problem is an advanced type of development for those who have had long experience at the laying out bench. This wye offers an excellent outline of the methods used in finding true angles and angles of rotation encountered in complicated layout problems.*

THE original print from the Yuba Construction Company of Calif., for whom the wye was constructed, consisted of Fig. 1 and Fig. 2, with the absence of the seams as shown. They are drawn in approximately to give an idea of the completed work. In developing the problem seams are not needed in either of these two views.

There are in this problem three elements to be determined and when found the problem is reduced to an ordinary wye. The first of these is the true angle which when rotated on one of its legs brings about the desired horizontal and vertical angle. The second element is the degree of angle of rotation necessary to bring about the two angles. The third is the amount the rising leg of the angle is revolved by the rotation of the horizontal leg. These three elements then are, first the true angle, second the angle of rotation, third the angle of revolution.

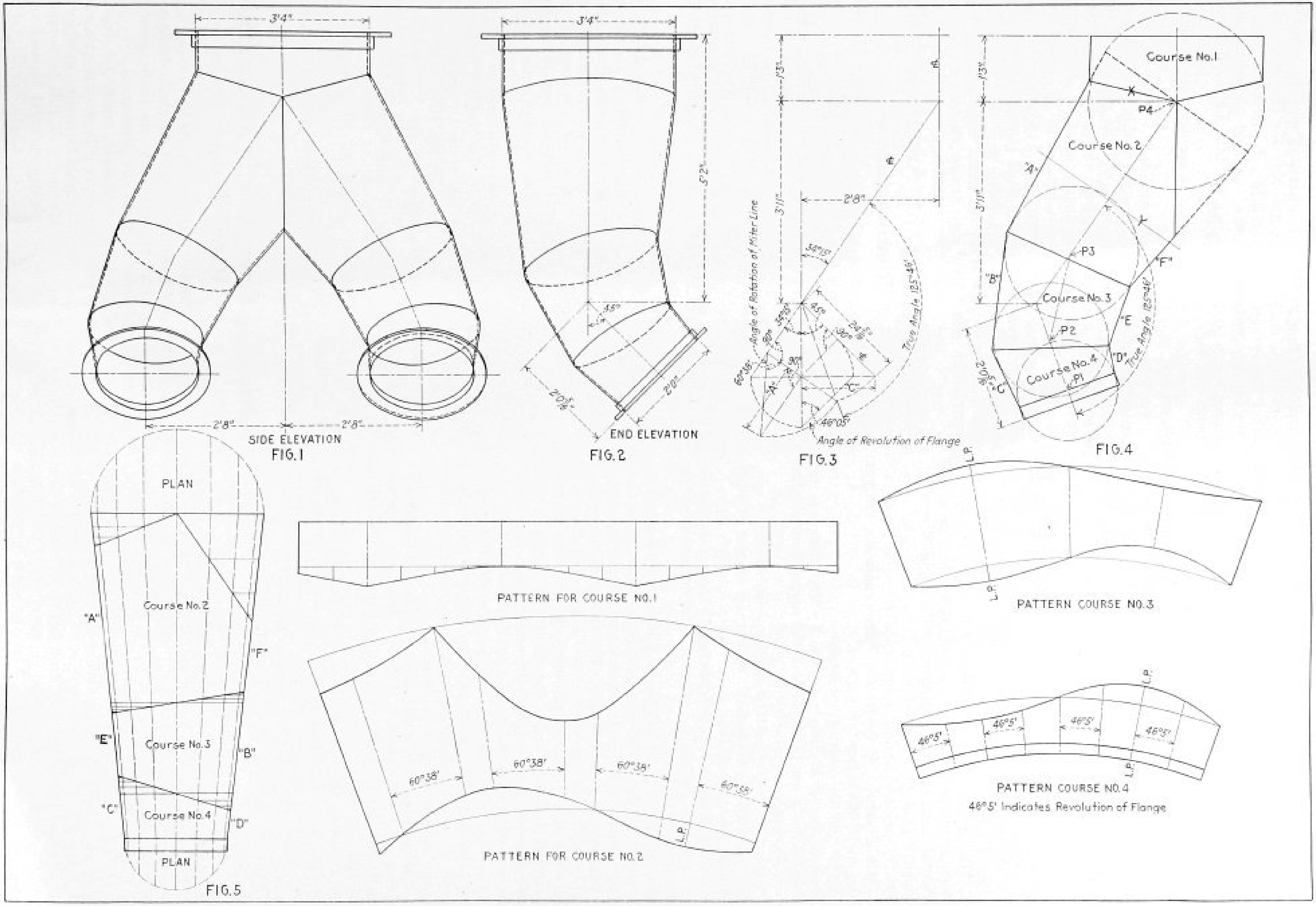
### Skeleton Outline of Wye

To explain, in Fig. 3 is shown the actual movements of these angles, center lines only being used. To construct Fig. 3 draw the two center lines shown to be parallel and 2 feet 8 inches apart. Locate a point 1 foot 3 inches from the face of the largest flange, and then parallel 3 feet 11 inches from the point just found locate a point on the other center line. Draw a diagonal line from point to point and the true horizontal angle or 34 degrees 15 minutes is drawn. Then erect a 45 degree angle, the hypothenuse of which is 24 5/16 inches long as shown in Fig. 3. Imagine this angle turned up vertically and the line 24 5/16 inches long with the diagonal line of the horizontal angle gives the skeleton of the completed wye. With these two angles drawn we can now find the three unknown and necessary elements.

To find the true angle and the angle of rotation, proceed further with Fig. 3, as follows: Draw the diagonal line of the horizontal angle indefinitely beyond the point. At right angles to this line and through the point of the vertical angle draw a line indefinitely. This gives the small angle indicated by 34 degrees and 15 minutes and the vertical leg by 90 degrees. To obtain the true angle the figure is to be rotated on the diagonal line to the height of *C* or *A*, which are the same. Next draw a line at right angles to the one last drawn as indicated by line *A*. Complete this angle as shown. The height of this angle or *A* is the height of the true vertical angle shown as *C*. Complete the angle as shown. The angle 60 degrees 38 minutes is the second element or the angle of rotation. Using the hypothenuse of the angle just drawn as a radius, drop a line as indicated by *ARC* to the base of the extended angle. Draw a line through the point just obtained to the point of intersection of the diagonal line in the horizontal angle. The diagonal line of the true horizontal angle and the line just drawn describe the first element or the true angle or 125 degrees, 46 minutes.

### Finding the Angle of Rotation

To obtain the third element or angle of rotation, draw in the right angle as indicated by the angle of 45 degrees and




**Layout and Patterns for a Compound Wye**

90 degrees on the true vertical angle. Draw arcs as shown, and the including angle, or the one indicated by the angle of 46 degrees and 5 minutes is the angle of revolution or third necessary element.

The development of Fig. 3 is the graphic method to obtain the three unknown elements. The mathematical method and formulae are as follows.

1. To find the true angle of a known horizontal angle and a known vertical angle, multiply the cosine of the horizontal angle by the cosine of the vertical angle and the product equals the cosine of the combined angle or true angle.

Cosine 34 degrees and 15 minutes is .8266.

Cosine 45 degrees is .7071.

.8266 x .7071 equals .5844 or Cosine of the angle 54 degrees and 14 minutes.

180 degrees minus 54 degrees and 14 minutes equals 125 degrees 46 minutes.

2. To find the angle of rotation:

Tangent of the vertical angle divided by the sine of the horizontal angle equals the tangent of the angle of rotation.

Tangent 45 degrees equal 1.0000.

Sine 34 degrees 15 minutes equals .5628.

1.0000 divided .5628 equals 1.7768 equals the tangent of the angle 60 degrees 38 minutes.

3. To find the angle of revolution:

Sine of the vertical angle divided by the tangent of the horizontal angle equals tangent of the angle of revolution.

Sine 45 degrees equal .7071.

Tangent 34 degrees and 15 minutes equal .6809.

.7071 divided .6809 equals 1.0384 equals tangent of angle 46 degrees and 5 minutes.

With Fig. 3 drawn or calculated and properly understood it is a simple matter to complete the remainder of the problem.

To construct Fig. 4, proceed as follows: First draw the true angle exactly as obtained in Fig. 3. Then of any convenient length draw a line as shown dotted connecting the two legs of the true angle. This is for the purpose of making the leg of the wye in three courses. To complete Fig. 4 it is now necessary to resort to Fig. 5. To construct Fig. 5, the length of the cone will be the length of three center lines in Fig. 4. The diameter at the largest end will be 3 feet 4 inches, and at smallest end 2 feet and 0 inches. On Fig. 4 at *P-1, P-2, P-3,* and *P-4* draw circles the diameters of which correspond with their relative positions on Fig. 5. Then tangent to these circles draw lines which give the completed figures as shown.

Complete Fig. 5 by marking on its sides the dimensions as shown as *A-B-C-D-E-F*, Fig. 4. Draw the necessary radial lines and all work necessary to commence the layout of patterns is done.

As a caution, the line shown as *X* on Fig. 4 is shown as a straight line. In actual practice this line is not straight, but as a general thing its deflection is so small its curve can generally be disregarded in the actual layout.

The layout of course No. 1 is so simple it will not be explained.

### Pattern Layout

In laying out course No. 2 care must be taken. Course No. 2 as shown in Fig. 5 does not show the twist or what we previously called element No. 2, or the angle of rotation. Study Fig. 4, course No. 2, note line *Y*. The part above line *Y* remains fixed. The part below is rotated upwards towards Fig. 3, 60 degrees and 38 minutes. This is performed on pattern sheets by laying out the upper part of course No. 2 as if an ordinary wye. Then towards the left draw four new center lines, 60 degrees and 38 minutes from original as shown on the pattern course No. 2. To lay out the lower portion of course No. 2 it is necessary to use these new center lines. The shortest portion of the elbow as indicated by line *F*, Fig. 4 is placed on the new center line as indicated on pattern course No. 2. The curve of the miter line is taken off course 2 Fig. 5. It will be seen that this twisting of the miter line of the lower portion of pattern course No. 2, 60 degrees 38 minutes, brings about the desired compound angle.

Course No. 3 and course No. 4 are developed exactly as they are in Fig. 5.

The longest points of patterns No. 2, 3 and 4 fit together as indicated by mark *L.P.* In a job of this kind it is necessary that the flange, bolt holes straddle the center lines. This requires the use of the third element, or the angle of revolution. When the miter line of course No. 2 was rotated 60 degrees and 38 minutes it resulted in the flange center lines being revolved 46 degrees and 5 minutes to the left. To square up the flanges they must be moved to the right 46 degrees and 5 minutes as shown in the pattern of course No. 4. The same pattern reversed would be used for the second leg of the wye.

## Annual Meeting of American Boiler Manufacturers

THIS year's meeting of the American Boiler Manufacturers' Association, which is scheduled to be held June 5, 6 and 7 at Buckwood Inn, Shawnee-on-Delaware, Pa., promises to be a most interesting and valuable one to all the members. As has been customary for the past few years the business sessions will occupy the mornings while the afternoons will be devoted to a golf tournament.

In addition to the routine business and reports of standing committees, the program on Monday, June 5, will include the president's address and papers by Joseph F. Scott and C. O. Myers, chairman and secretary respectively of the National Board of Boiler and Pressure Vessel Inspectors. E. C. Fisher of the Wickes Boiler Company, Saginaw, Mich., will also read a paper on "A Study of Thickness of Shell Plates in Return Tubular Boilers." There will also be a report by Charles E. Gorton, chairman of the American Uniform Boiler Law Society. On Monday evening R. Sanford Riley, president of the Sanford Riley Stoker Company, will give an illustrated lecture with moving pictures "Close-Up of the Riley Underfeed Stoker."

On Tuesday, June 6, an address will be made by M. W. Alexander, managing director of the National Industrial Conference Board. L. E. Connelly of the D. Connelly Boiler will present a report on "Proper Setting Heights of Return Tubular Boilers." R. B. Dickson of the Kewanee Boiler Company, Kewanee, Ill., will report on "Steel Heating Boilers." The annual banquet will be held on Tuesday evening.

On Wednesday, June 7, an address will be made by Dr. Charles Aubrey Eaton of the American Educational Association and a report made by the committee on "Rules for Inspection of Materials and Boilers."

## Scheduling Operations in a Locomotive Repair Shop

*(Continued from page 125)*

assistant is kept informed by means of the check sheets of all the work under his charge and there can be no excuse of ignorance for delays occuring in any department.

Actually, the scheduling system is practically frictionless and, combined with piece work, will accomplish a maximum productive efficiency in locomotive repair work; for the real incentive to work quickly and well will be supported by an excellent system of inter-departmental support which is only possible when the work is properly coordinated and routed.

# Modern Tendencies in Locomotive Design*

## Proper Proportioning of Tubes, Grate Areas and Heating Surfaces Increases Economy in Modern Locomotive Operation

By James Partington†

THE types, weights and general details of construction of locomotives have undergone striking changes in the last 20 years. A study of these changes will show in a great measure the modern trend of locomotive design.

Modifications of type may be briefly summarized as follows: Eight-wheel passenger locomotives have been superseded by Pacific and Mountain types; Consolidation freight locomotives have been superseded by Mikado and Santa Fe types, and to some extent by Mallets; four and six-wheel switchers have been, to a large extent, superseded by eight-wheel switching locomotives.

The weight per axle has been increased from time to time as track and bridges would permit so that 60,000 lb. per axle is a common axle load today and 70,000 lb. is sometimes reached.

The boiler of moderate size with a narrow firebox between the frames or between the drivers has been superseded by a modern steam plant with wide firebox above the wheels, fitted with superheater, brick arch, flexible staybolts, feedwater heater, thermic syphons, circulating devices, combustion chambers, exhaust steam injectors, etc.

Stephenson valve gear and slide valve cylinders have been superseded by piston valve cylinders with outside steam pipes and outside valve gears of a number of different types.

### Some Prime Requisites

All locomotives should conform to certain prime requisites that may be stated as follows: (1) A drawbar pull that will handle the largest tonnage that road conditions permit; (2) The production and delivery of drawbar horsepower at minimum cost; (3) Careful designing to embody road standards, to meet Interstate Commerce Commission requirements and to keep maintenance charges down to a minimum.

To meet the first requirement all the physical conditions of the road must be carefully studied, the horse power curves of different types of locomotives at the speeds they will have to operate analyzed and the type selected that best fulfills the needs of the service.

### Importance of Economy

In designing locomotives to meet the second requirement, all the devices which make for economy of fuel must be considered. The application of a brick arch in the firebox and a fire-tube superheater are items of general design which have shown noteworthy reductions in coal and water and are being applied in all modern locomotives. The use of a feedwater heater or an exhaust steam injector is a comparatively recent development in American practice although each of these devices has shown marked saving in fuel in European operation. The use of these is now becoming more common on our railroads. On many designs of locomotives the use of a combustion chamber, providing a longer flame-way and an opportunity for secondary combustion before the flame and gases enter the tubes, shows an economy which is available with but slight additional first cost.

A more careful consideration of diameter of tubes as a factor of the length over tube sheets may also be cited. For the best results with bituminous coal the length of the boiler tubes should be approximately within the following limits:—

| Out. diam. of tube | Distance over tube sheets |
|---|---|
| 2 in. | 18 ft. 0 in. to 19 ft. 6 in. |
| 2¼ in. | 22 ft. 6 in. to 24 ft. 6 in. |
| 2½ in. | 28 ft. 0 in. to 30 ft. 0 in. |

These proportions are based on the evaporative values of tubes of varying lengths and can serve only as a guide in deciding tube diameters, especially for the intermediate lengths not covered by the table where a choice of either of two diameters can be made without sacrificing efficiency. For example, 2 in. or 2¼ in. tubes may be used for a length over tube sheets of 21 ft. unless there are special conditions of draft or fuel which require separate consideration.

The tendency which was frequently indicated after the introduction of superheaters, to curtail the steam space of the boiler, is being avoided to as large an extent as possible in the locomotive of today. Sufficient steam space and a throttle designed and located to deliver dry steam to the superheater are recognized items having an important bearing on the performance of the locomotive.

The type of throttle usually applied now is designed to permit entrance to the boiler through the dome without removing the throttle, thus avoiding the use of an auxiliary or inspection dome.

The boiler and cylinder proportions of modern locomotives are such that extravagant forcing of the fire is unnecessary, the heating surface and the grate area being sufficient to provide the maximum amount of steam required with a coal consumption per square foot of grate per hour not exceeding 120 lb. for bituminous coal, and not exceeding 55 lb. to 70 lb. for anthracite.

Present day locomotives are usually designed to be as large and powerful as the roadbed, bridges and clearances will permit. This makes it necessary to apply automatic stokers to supply the large amount of coal consumed, the limit per hour for hand firing by one fireman being about 6,000 lb.

In connection with the economical production of steam there are a number of other devices coming into use, important among which the following may be mentioned:

The application of two or three thermic syphons; the number depending on the width of the grate. These provide a considerable amount of additional heating surface in the most effective location, *i. e.*, in the firebox, and contribute toward a better circulation of water over the firebox crown.

Another method of improving circulation which has been applied on a number of recent locomotives, embodies the application of a horizontal plate laterally in the boiler shell, located so that about one-half of the tube heating surface is above this plate, the balance below it, causing a lower circulation of water toward the back tube sheet and sides of the firebox and an upper circulation forward.

A generous use of flexible staybolts is noticeable in all modern boilers on account of the noteworthy saving in frequency of inspection and cost of renewals.

On account of the weight necessary to provide for boilers of ample size and the auxiliary attachments necessary for the most economic production of steam, the weight of the machinery parts must be carefully proportioned to keep them down to a safe minimum. This has caused a demand for the

*Abstract of a paper presented April 7, 1922, at the Newport News meeting of the American Society of Mechanical Engineers, Virginia Section.

†Estimating engineer, American Locomotive Company, New York.

employment of special alloy steel for many parts subject to severe stress and fatigue.

To secure materials which can be readily repaired or replaced by the ordinary railroad shop the present trend is toward the employment of alloy steels which will give the required additional strength and tenacity without the necessity of heat treatment of these special forgings.

The employment of a booster to gain additional tractive power by utilizing the adhesive weight on truck wheels and the application of cylinders on the tender in a number of cases may be noted as one of the recent developments intended to provide increased tractive power for emergencies, such as short steep grades, starting trains on a grade, etc.

### Maintenance Cost Must Be Kept Down

In designing locomotives to meet the third requirement—keeping down the maintenance charges—the engineers of the railroads and of the locomotive builders are giving special attention to the following points:

Careful determination of the stresses in all parts of the locomotive and tender and securing proportions and materials which will withstand these stresses and avoid costly failures in service.

Adoption of designs which will reduce the number of parts as much as possible thus keeping bolted connections to a minimum.

Avoidance of construction which cannot readily be removed for repair or renewal or repaired in place at reasonable cost.

Due consideration of the question of lubrication and making the engine parts accessible for lubrication and inspection. Nearly all bearings on modern designs are arranged for grease lubrication.

### Possible Future Developments

Whether the design of locomotives of the future will continue along conventional lines will depend largely on experiments along new lines and the success or failure of such experiments.

The writer believes we will see more successful adaptation of three-cylinder locomotives in which the advantages secured will be greater and the complications of construction will be simplified. Increased efficiency will also be sought by the employment of higher boiler pressures and higher degrees of superheat. To secure higher boiler pressures without entailing prohibitive increased charges for boiler maintenance, a new type of boiler may be necessary. To secure higher degrees of superheat, the changes involved can readily be worked out and adapted as required.

It may be that the merits of internal combustion will be tested out on our railroads, although the complications involved do not appeal strongly to the maintenance departments. Several locomotives of this type are being developed in other countries.

Progress is being made abroad in condensing turbine driven locomotives and the results thus far obtained have been encouraging.

Further improvements in the draft appliances and reduction in the back pressure of exhaust are being diligently sought. The improvement of locomotives from the standpoint of design and operation is a fascinating subject on which much time and study has been expended in the past, is being expended at the present time and will undoubtedly attract as much if not greater effort in the future. The promise of the future is bright. May the accomplishments of the next decade equal, yes, may they exceed what has been attained in the past one.

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Charles P. Patrick, president of the Master Boiler Makers' Association, has recently been appointed to the position of general boiler maker foreman of the Meadville Machinery Company, which has taken over the Meadville, Pa., shops of the Erie Railroad.

# Final Plans Made for the Master Boiler Makers' Association Convention

ALL of the members of the Master Boiler Makers' Association are by this time familiar with the plans for making the convention this year at the Hotel Sherman, Chicago, May 23-26 a success. Final announcements and programs have been sent out by the secretary and these are repeated here briefly for the convenience of our readers.

The secretary will have an office at the hotel for the transaction of general business of the association outside the convention.

Registration will begin at 8 A. M., Monday, May 22, when badges and instructions for the procedure to be followed by members during the convention will be issued. All members should make an effort to register early in order that the lists may be complete and the records for the official proceedings accurate. Those who have not previously paid their dues may do so at the time of registration.

Announcements were published in the April issue of THE BOILER MAKER of the exhibits to be given by members of the Supply Men's Association. It is understood that these exhibits will be especially interesting this year to members of the Master Boiler Makers' Association as many new developments have been made in the supply field. A special program of entertainment for members of the association and the ladies auxiliary will be issued by the Supply Men during the convention. The committee in charge of arrangements consists of E. J. Reardon, P. J. Conrath and L. W. Markey.

The business sessions of the convention will be held as follows:

### FIRST DAY

TUESDAY, MAY 23, 1922

Registration of members and guests continued at 8 A. M.

In order to participate in entertainments badges will be required. None will be issued unless dues are paid and members are properly registered. No deviation from this rule.

BUSINESS SESSION

Convention called to order 10 A. M.

Invocation:
  Past President John H. Smythe, Chaplain of the Association.
Address of Welcome:
  Hon. William Hale Thompson, Mayor.
Address:
  H. T. Bentley, S. M. P., C. & N. W. R. R.
Annual Address:
  Charles P. Patrick, President of the Association.
Routine Business:
  Annual report of the Secretary, Harry D. Vought.
  Annual report of the Treasurer, W. H. Laughridge.
Miscellaneous Business:
  Unfinished business.
  New business.
Appointment of special committees to serve during convention:
  President's address.
  Resolutions.
  Memorials.
Announcements.
Adjournment.

### SECOND DAY

WEDNESDAY, MAY 24, 1922.

Convention called to order 9 A. M.

Addresses, 9.30 to 10.30 A. M.:
  A. G. Pack, Chief Inspector of Locomotives, I. C. C.
  A. R. Ayres, S. M. P., N. Y. C. & St. L. R. R.
Committee Reports:
  Report of Special Committee on Autogenous Welding. Thomas F. Powers, Chairman; John F. Raps, C. E. Elkins, John Harthill, H. J. Wandberg, W. J. Murphy. 10.30 A. M. to 12 M.
  "Oxy-Acetylene Welding"—D. A. Lucas, Chairman; H. J. Wandberg, Thomas Lewis. 2 to 3 P. M.
  "Electric Welding"—H. H. Service, Chairman; I. J. Pool, R. W. Clark. 3 to 4 P. M.
Announcements.
Adjournment.

(*Continued on page* 148)

# The Boiler Maker

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WE GUARANTEE, that of this issue 5,500 copies were printed; that of these 5,500 copies, 4,567 were mailed to regular paid subscribers; 16 were provided for counter and news company sales; 64 were mailed to advertisers; 24 were mailed to employees and correspondents, and 829 were provided for new subscriptions, samples, copies lost in the mail and office use; that the total copies printed this year to date were 26,250, an average of 5,250 copies a month.

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Request for change of address should reach us two weeks before the date of 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.


## CONTENTS



The two important conventions of the year in the field of boiler making—that of the Master Boiler Makers' Association and of the American Boiler Manufacturers' Association, are scheduled to take place within a few days of each other, as announced elsewhere in this issue. Plans have been completed by the officers of each to make them of the utmost value to members.

The success of the conventions is now entirely in the hands of the members and if by chance there are some who have not arranged to be present there still remain a few days of grace in which to reach the conventions in time. Members should by all means make every effort and sacrifice necessary to attend; for it will be at least a year before the opportunity is again available and a great deal of valuable information may be lost through failure to be present.

The reports which are to be presented at the Master Boiler Makers' convention were published in the October and November, 1921, issues of THE BOILER MAKER. A review of these and a complete report of the proceedings and discussions at this convention will appear in the June issue of the magazine. An account of the American Boiler Manufacturers' meeting will also appear in the June issue.

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The list of states which have agreed to accept boilers bearing the stamp of the National Board of Boiler and Pressure Vessel Inspectors has been increased by the announcement that New York will recognize such inspection as equivalent to that of state inspectors.

This decision became effective April 7 by the state order "that the requirements of the National Board of Boiler and Pressure Vessel Inspectors be and the same hereby are accepted as the equivalent of the State Standard within the meaning of the New York Code and the official stamp of said National Board is hereby accepted as evidence that any boiler so stamped is the equivalent of a New York State Standard boiler."

Boilers built in states other than New York, if duly inspected and stamped by a certified inspector of the National Board, will now be accepted in New York as standard A. S. M. E. Code boilers. This action of New York brings into the group of states accepting the National Board's stamp one of the large users of power boilers and indicates real progress in establishing the standards of construction and inspection under the A. S. M. E. Boiler Code.

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The British locomotive failure reported in this issue of THE BOILER MAKER demonstrates a condition that to a slightly less extent attends investigations of locomotive disasters in this country—the failure of those responsible for the construction and maintenance of locomotives to eliminate defects that have directly or indirectly been the cause of trouble.

The entire complicated investigation of the explosion here cited means exactly nothing; for after the probable cause had been decided upon, the officials absolved from blame everyone who had been in any way connected with the operation and maintenance of the locomotive. The principal cause of the disaster was the jamming of the safety valves in their seats which prevented them from lifting at the desired pressure. In spite of this knowledge, however, nothing was done to correct this design valve in other locomotives.

Here in the United States, year after year, recommendations are made in the annual reports of the Bureau of Locomotive Inspection to increase the safety of locomotive operation, but many roads are lax in adopting the practices suggested. In addition to the annual review, each individual explosion is reported upon and the causes determined so far as it is possible to do so. The road on which an accident occurs may possibly attempt to correct the defective conditions, if they exist on other units of its motive power, but the effect is to a great extent lost on other roads until similar disasters take place.

The point to be borne in mind is that the knowledge gained from an explosion should be incorporated in the design of future boilers and used to correct similar conditions if they exist in boilers already built.

# Engineering Specialties for Boiler Making

**New Tools, Machinery, Appliances and Supplies for the Boiler Shop and Improved Fittings for Boilers**

## Machine for Cutting Accurate Staybolts

Defective or poorly fitted staybolts cause a large number of boiler casualties and much expensive boiler repair work. Perhaps the most striking feature of the new line of Lassiter-Millholland staybolt machines just placed on the market by the Dale Machinery Company, New York, is the provision of a lead screw insuring uniformly accurate pitch and continuous lead for all threads cut. The machines are made in two easily convertible types A and B. Model A, illustrated in Fig. 2, is made for reducing centers, turning and threading both ends of rigid side staybolts; also for cutting them off from bar stock. This is an entirely new machine, rigid and well-proportioned, with a special feed box, apron and lead screw designed to prevent lagging or creeping of the die head when threading.

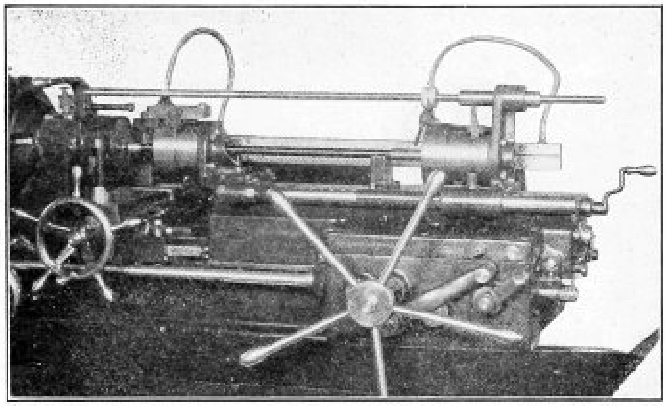

Fig. 1.—Model B Equipment for Turning and Threading Crown Stays

With two sets of chasers the die head has a capacity to cut ⅞ inch to 1¼ inch bolts to any standard pitch desired. Bolts 12 inches long can be turned.

The Lassiter-Millholland Model B staybolt machine shown in Fig. 1, is equipped to turn the taper and straight diameters simultaneously and thread both taper and straight surfaces in uniform pitch and continuous lead; also simultaneously. The turning and threading operations are done separately but both can be performed on the same machine by replacing cutters by chasers. The bolt is gripped at the square end in a special collet with adjustable stop, the turning feed is then engaged from a friction in the apron and two turning heads on the slide are fed over the portion of the bolt to be finished.

Modern die heads with solid cutters for turning and chasers for threading are used. Both the cutters and heads readily operate as a hollow mill, the front head being equipped with a taper attachment and tapered cutter, giving its cutters a slight opening movement as it feeds forward.

The heads are held in a constant relation on the slide which is fed forward by a nut and lead screw in the apron. The result is a bolt with threads on both taper and straight ends concentric and in continuous lead and uniform pitch. The rear die carrier is adjustable on the slide by means of a fine pitch screw and may be set for any bolt from 14 to 36 inches long. A V-block on the slide prevents the bolt from dragging in the chasers when the die heads are open. A permanent spacer bar, accurately made, is furnished with each machine to set the die heads in continuous lead when changing for length. For button head radial staybolts a cross slide is provided for facing the button heads.

The machine has a capacity to turn and thread bolts ¾ inch to 1½ inch diameter by 14 inches to 36 inches long. The length of the slide is 34 inches, the maximum turning length being 5 inches. The approximate floor space is 2 feet 8 inches by 8 feet, the approximate net weight being 3,500 pounds. Both machines can be furnished in geared head type arranged for single pulley or motor drive.

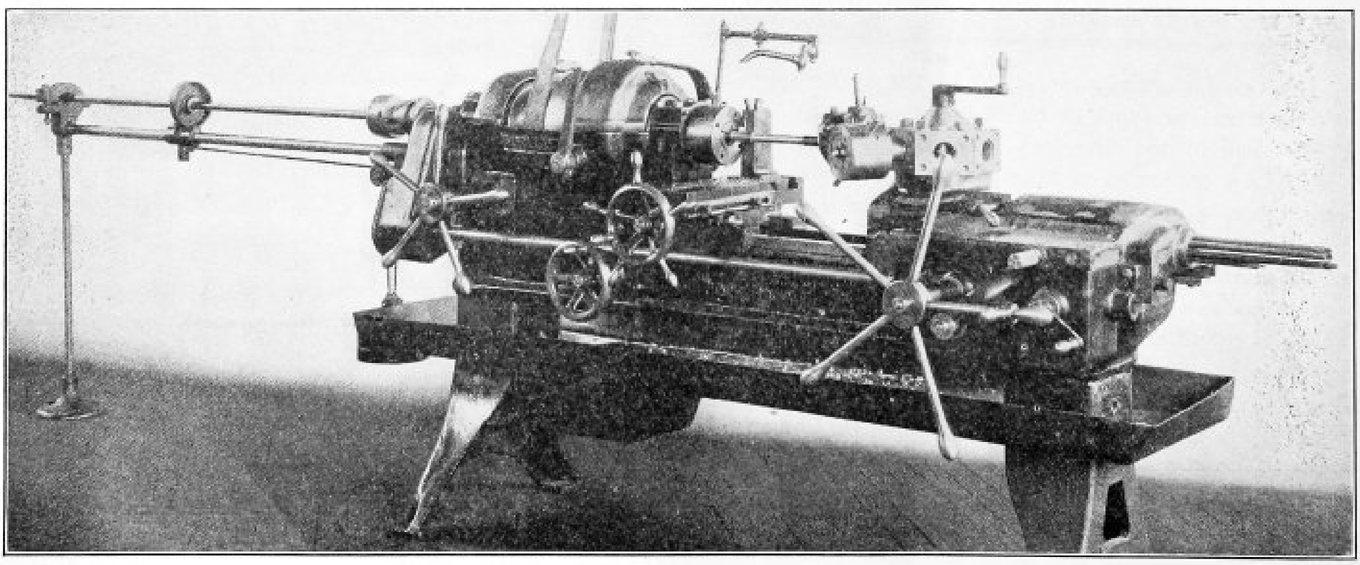

Fig. 2.—Lassiter-Millholland Model A Machine Equipped for Cutting Side Staybolts from Bar Stock

## Portable Universal Radial Drill

Several types of radial drilling machines of improved modern design have been developed by William Asquith (1920), Ltd., Halifax, England. These machines include a portable universal radial drill illustrated in Fig. 1, a 7-ft. and an 8-ft. central thrust elevating arm boiler shop radial, and a triplex radial drilling machine. The first machine is made in two sizes of 4 ft. 9 in. and 5 ft. 9 in. radius respectively. A traveling bogie is usually provided as shown in the illustration but if required, a special base can be arranged for bolting to the shop floor. The machine is particularly adapted for boiler drilling operations, having ample power for the work and the desired range of feeds and speeds which are easily controlled.

Six changes of speed are available from 41 revolutions per minute to 300 revolutions per minute through a three-speed

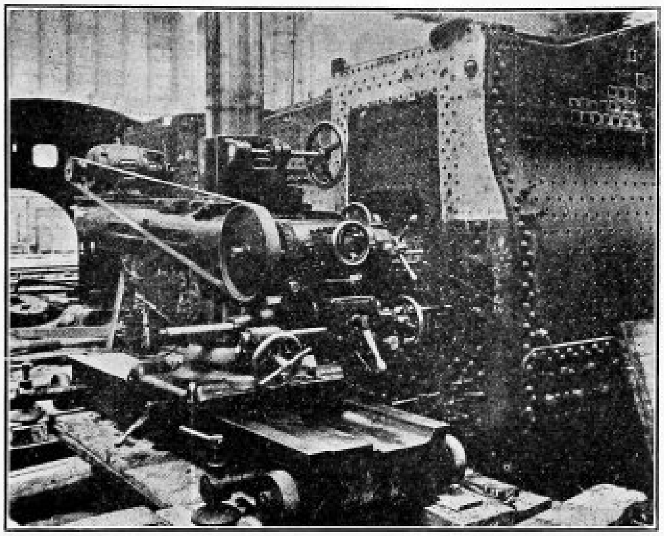

Fig. 1.—Asquith Portable Universal Radial Drill

gear box and double gear on the drilling head. A special reversing motion enables taps to be withdrawn at approximately three times the speed of insertion, this quick reversal being obtained automatically without changing the speed in the gear box. The radial arm can be traversed across the column easily by means of a hand-wheel; it can also be elevated on the column by either hand or power. Secure locking devices are provided for each of these movements. The column is of strong section, being fitted at the top with a plug carrying the lifting hook. Drive is by means of a 3 horsepower self-contained reversible motor mounted on the arm end plate through a single pulley and gear box.

The triplex radial drilling machine mentioned consists of three radial units and is employed to advantage for drilling holes in boiler fireboxes and similar work. A pit is arranged at the front of the bed to accommodate the larger boilers and other deep objects.

The drilling heads have power adjustments along the bed either simultaneously or independently in the same direction so that the work does not need to be moved after the initial setting. On this machine locomotive frames can be drilled in sets. One or more frame plates are accurately marked out and checked, being then used as jig plates for the remainder of the frames. When work is arranged on both sides of the bed the drilling heads can be kept continuously engaged and no time is lost.

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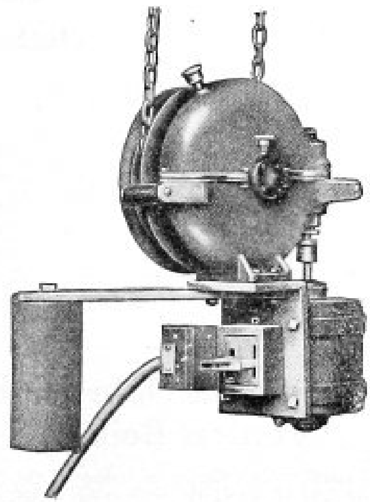
The Detroit Seamless Steel Tubes Company, Detroit, Mich., has established a branch sales office in the Canadian Pacific Building, 342 Madison Ave., New York. H. C. Kensing is sales manager for the New York territory.

## Electric Chain Haul for Hand Hoists

An electric machine now manufactured by the New Jersey Foundry and Machine Company, 90 West street, New York, will be of interest to users of hand power hoists of 5 tons and larger capacity. This machine may be suspended in the bight of the operating chain and will overhaul 128 feet of hand chain per minute and give a chain a pull of 130 pounds. This permits a load lifting speed of approximately



"Handiman" Chain Haul

four times that obtainable by hand power and but one man is required for operating.

Current is supplied to the unit by a flexible conductor atached to convenient sockets or it may be suspended from the hoist if it is more desirable to bring the feeders to that point. The machine is self-balancing, weighs about 160 pounds and can be furnished for operation on either alternating or direct current. Hardened gears are used throughout running in an oil bath.

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## Drop Forged Welding Flanges

The Scully Steel and Iron Co., Chicago, Ill., has recently announced the production of flanges by the drop forging process that are of a material suitable for welding purposes. Special descriptions of the process of production and of the different design flanges have been prepared and these will be sent to any one interested in the matter. The Scully Company states that flanges can be made to suit special requirements.

## OBITUARY

Dr. William Newton Best, dean of the science of burning liquid fuel, and president and consulting engineer of the W. N. Best Furnace & Burner Corporation, New York, died April 11 in his 63d year. He was born at Clayton, near Quincy, Ill., on June 3, 1860. After learning the trade of a machinist at Creston, Iowa, in the C. B. & Q. Railroad shops in 1877, he rose from machinist to superintendent, his last railroad work being a connection with the Los Angeles & Salt Lake Railroad. In 1901 he began the manufacture of inventions of his own. At the time of his death he had United States letters patent covering 44 inventions. Practically his entire life was devoted to the study of oil burners. It is estimated by engineers that 65 percent of furnaces in this country burning oil for refining glass, steel and other metals, are using his inventions. He was author of "The Science of Burning Liquid Fuel."

# Questions and Answers for Boiler Makers

## Information for Those Who Design, Construct, Erect, Inspect and Repair Boilers—Practical Boiler Shop Problems

**Conducted by C. B. Lindstrom**

*This department is open to subscribers of* THE BOILER MAKER *for the purpose of helping those who desire assistance on practical boiler shop problems. All questions should be definitely stated and clearly written in ink, or typewritten, on one side of the paper, and sketches furnished if necessary. 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 permission to do so.*

## Flanged Heads and Ogee Fireboxes for Vertical Boilers

Q.—I have had considerable difficulty in laying off the heads for vertical boilers so that they will fit inside the shell and furnace sheet without too large a gap between the head and shells; also the compound curve section at the bottom which is flanged to take the place of a mud ring. Will you please indicate in THE BOILER MAKER how I can overcome this difficulty.

T. S.

A.—A sectional view of the firebox is shown in Fig. 1. The development of the pattern of the head is shown in Fig. 2 and the pattern for the ogee firebox in Fig. 3. In each of these developments the work is laid off from the neutral section, that is the center line of the plate section. The diameter of the disk required for the flanged head must equal the sum of the lengths $a + b + c + b + a$, measured on the neutral line of the head, Fig. 1. The arc length $b$ can be calculated as follows:

Consider a plate thickness of ½ inch and that the knuckle of the flange is turned to an inside radius of ¾ inch, then the arc $b$ is a part of a circle drawn with a radius of $\frac{3}{4} + \frac{1}{4} = 1$ inch. The ¼ inch is one half of the plate thickness. The arc length equals one-fourth of the circumference of a circle 2 inches in diameter or $\frac{3.1416 \times 2}{4} = 1.57$ inches. As the arc length is the only dimension that is calculated, the other lengths $a$ and $c$ are found by laying off a view of the head on the neutral line of the material, either to scale or full size dimensions, then measure lengths $a$ and $c$. By making the calculations and the layout work according to the dimensions on the neutral line of the plate, no allowances need be made for stretching or contraction of the metal which arises in the bending or flanging operations.

### LAYOUT OF OGEE FIREBOX

This problem consists in laying off a profile of the ogee curve full size, according to the dimensions required for drawing the arcs $d$ and $e$ which are taken on the center of the plate section. With a traveling wheel the arc lengths $d$ and $e$ are then measured. These could be determined by calculation, but the method given is quicker probably and answers the purpose.

The next step is shown in Fig. 3. Draw the line $x$—$x$ and make its length equal to the circumference of the shell of the firebox by multiplying the neutral diameter $o$, Fig. 1, by 3.1416. Then in Fig. 3 establish the center point $y$ and draw the arcs $a$—$a$ from point $y$. With the trammels and $a$—$a$ as centers draw arcs intersecting at $c$. Connect $y$ and $c$ with a straight line. Set the trammels equal to $g$, Fig. 1, and with $x$—$y$—$x$ as centers in Fig. 3 draw arcs at $m$. Tangent to the arcs $m$ draw a straight line. From $g$ set off the arc lengths $d$ and $e$ and the length $f$ equal to the corresponding lengths in Fig. 1.

The next step is to figure the length or circumference of the base of the ogee by multiplying the neutral diameter $p$ by 3.1416. Lay off this length on the base of the pattern. It will be noted in Fig. 1 that the ogee starts to flare from the top point of arc $d$ to the base at the lower extremity of arc $e$. To take care of this the pattern must have sufficient metal to form the curved sections and so the ends will overlap for the riveted joint. This can be determined by figuring the

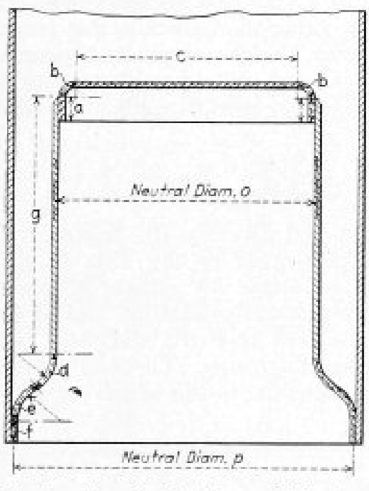


Fig. 1.—Sectional View of Firebox

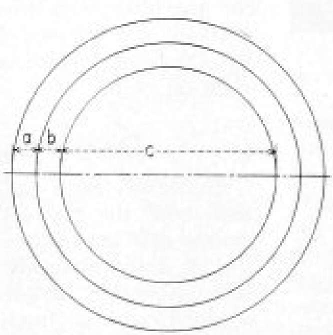


Fig. 2.—Development of Pattern for Head

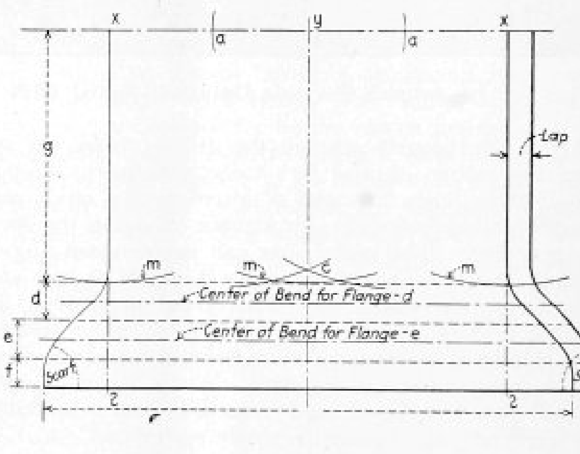


Fig. 3.—Pattern for Ogee Firebox

net area on the center line of each curved section, but this is unnecessary since the material can be allowed approximately and laid off as shown in the pattern. It is well to thin down or scarf the lower corners where the plate overlaps so that there will not be a large offset in the plate where it is riveted to the outer shell.

## Hemispherical Bottom Construction

Q.—Please explain through THE BOILER MAKER how to develop the patterns for a hemispherical bottom as shown in the enclosed sketch. All holes to be punched before the plates are dished; plates to be divided under a sectional flanging machine.—H. C.

A.—In the development of sections for hemispherical tanks, etc., when heavy plate is used there are several important points to follow. (1) The layout must be made so as to take care of all allowances required in the process of forming or pressing the gores into shape. This is necessary since the plate contracts on the inside and stretches on the outside. (2) Accurate construction in the location of the rivet holes must be produced, otherwise the rivet holes will stagger each other and form blind holes that will have to be either reamed or drilled out in place.

### General Method of Construction

The general construction of the problem is shown in Figs. 2, 3 and 4 and involves the principles of projection. Lay off a sectional plan and elevation, indicating the relative arrangement of the sections, as taken on the rivet lines. This work is laid off to the rivet center lines and to the neutral layer of the metal. By working to the neutral layer of the plate no further allowances are necessary for the forming process.

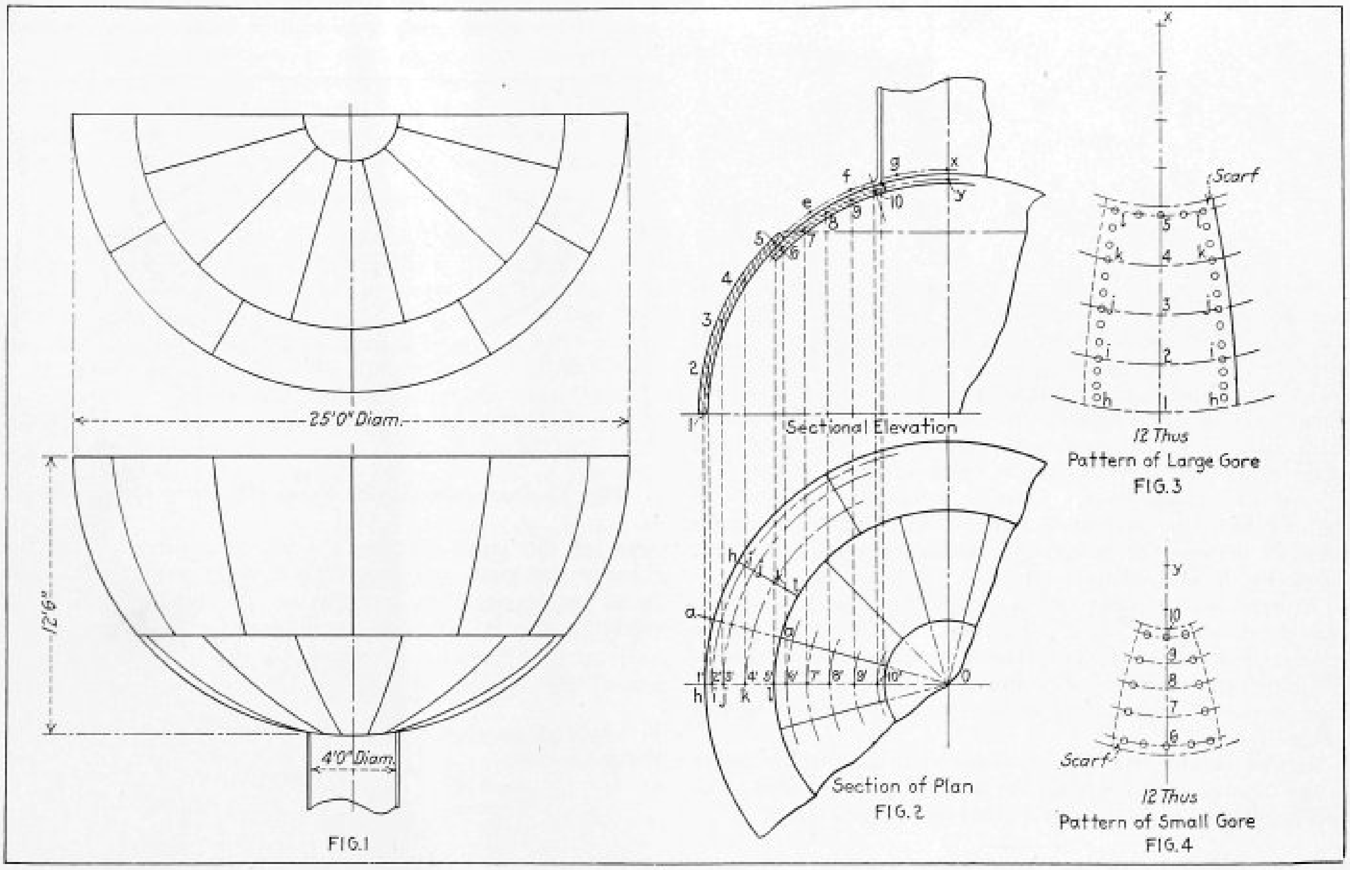
In the elevation the arcs for the respective gore sections are divided so that the rivet holes come directly in the plane of the arcs of each section, thus making it convenient to locate the rivets in the development of their patterns. Project the points *1*, *2*, *3*, *7*, *8*, *10*, etc., to the center line in the plan, and from the center point *o* describe the arcs *h-h*, *i-i*, *j-j*, *k-k*, etc.

In this example the sections are shown overlapping each other, but practically the same method would be applied if the side joints were butted and cover straps used, except in the latter case no laps would be allowed since the rivet lines would come inside of the boundary lines, that is, the outline of the gore sections, as shown in the plan. The stretchout of the gore sections as assembled should be figured at both top and bottom and from the neutral layer of the plate, to insure that the sections will form the required overall dimensions of the object.

### Laying Out Patterns

Having the data furnished as in Fig. 2, the patterns for the gores are laid off as in Figs. 3 and 4. The center lines of the plate sections of the elevation are extended to intersect the vertical center line as at *x* and *y*. On the center line of Fig. 3 lay off a stretchout equal to the length of the arc *x-1* of the elevation and also lay off the respective arc lengths *1* to *2*, *2* to *3*, *3* to *4*, etc. With *x* as a center describe arcs *h-h*, *i-i*, etc., from the plan, Fig. 2, locating these lengths on the corresponding arcs, Fig. 3. The outline of the pattern as determined on the rivet lines can now be drawn in.

Allow the lap material as needed for either single or double riveted joints. Fig. 4 is laid off in a similar way, using the data as furnished for the small gores of the plan and elevation, Fig. 2. By following the scheme of rivet arrangement as explained you should have no trouble in securing satisfactory results in lining up the holes to come fair in the assembly.




**Hemispherical Bottom Built in 2 Courses with 12 Plates in Each Course**

## Quick or Sharp Radial Stays

Q.—Will you please be kind enough to give me an answer as to what is meant by "quick" or "sharp" radial stays in a locomotive boiler?—W. L. W.

A.—For some time the so-called *tapered buttonhead* stays have been applied in some of the rows each side of the center of the crown sheet of locomotive boilers. This type of stay was considered more efficient in the support of the crown

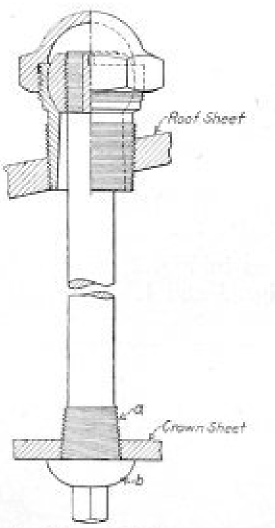



**Fig. 1.—Tapered Button-Head Stay**

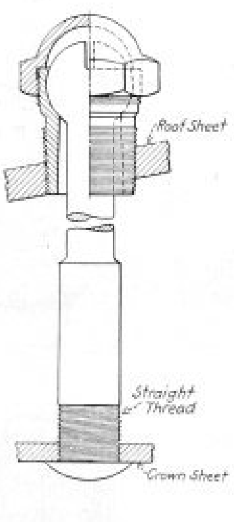



**Fig. 2.—Plain Threaded Radial**

sheet in the event of low water. In the case of straight threaded stays, with the crown end riveted over, there is danger of shearing the threads and of the stay being pulled through the crown plate, in case of low water. The tapered thread buttonhead proved troublesome, however, and presented certain difficulties in their installation. One of the main difficulties is in getting the thread, *a*, to fit tight, and at the same time have the face of the buttonhead fit properly against the crown sheet. Usually calking is necessary to get and keep the stay ends tight. Furthermore, the large mass of material at *b* becomes overheated and burns off, especially in oil-fired locomotives.

Tapered head radials with a sharper taper and the crown ends hammered over are a better form. Tighter stays can be made and the mass of the stayhead is considerably reduced. A plain threaded radial stay, Fig. 2, is also used. The roof caps or sleeves are made in various ways, in both screw and welded types.

The expression "quick" or "sharp" radial probably refers to the tapered radial having the heads hammered over. We will be pleased to hear from our readers on this point.

## Diagonal Seam Efficiencies

Q.—Would you kindly inform me if there is a formula or other means of figuring or determining the constant of an angle? In figuring the efficiency, factor of safety, etc., of boiler patches, most formulæ use the constant of the angle, that is, the angle formed by the girth seam of the boiler and the outbranching patch rivets.—J. M. W.

A.—The methods of patching boilers, using diagonal joints and the calculations involved in determining the efficiency of such joints was explained some time ago. In February's issue of THE BOILER MAKER an article by William C. Strott on "Helical Joint Design" fully covers this subject.

To illustrate the calculation of diagonal joint efficiency, consider the construction as shown in Fig. 1. The joint is a single riveted lap seam, diameter of rivets driven size 13/16 inch; plate thickness, 3/8 inch; pitch of rivets, 2 inches. The tensile strength of plate is 55,000 pounds per square inch and the shearing strength of rivets 38,000 pounds per square inch. The joint efficiency is figured as for a regular horizontal seam, using as a basis a length equal to the 2-inch pitch. The strength of the solid plate section in a length of 2 inches without rivets equals $55,000 \times 2 \times 3/8 = 41,250$ pounds. Strength of metal between rivets in a 2-inch pitch equals $(2-13/16) \times 3/8 \times 55,000 = 24,492$ pounds. Efficiency of plate section between the rivets as compared with the solid plate equals $24,492 \div 41,250 = 59.4$ percent.

The rivet efficiency is found as follows:

Area of rivet driven size equals $13/16^2 \times 0.7854 = 0.5185$ square inch. Then $38,000 \times 0.5185 \times 1$ (rivet in 2-inch pitch) = 19,703 pounds shearing strength of 1 rivet. Strength of rivet as compared with solid plate section equals $19,703 \div 41,250 = 47.8$ percent efficiency. The joint may fail in other ways, as crushing the plate in front of the rivet. In all cases the lowest joint efficiency should be used in basing the allowable working pressure.

It can be proven that for a given pressure, the stress per inch of joint is twice as great in the longitudinal seam as in the girth seam, hence the girth seam need only be one-half as great as the efficiency of the longitudinal seam. This explains why the girth seams are usually single riveted. The ratio of the stress being 2 to 1, it is clear that a diagonal

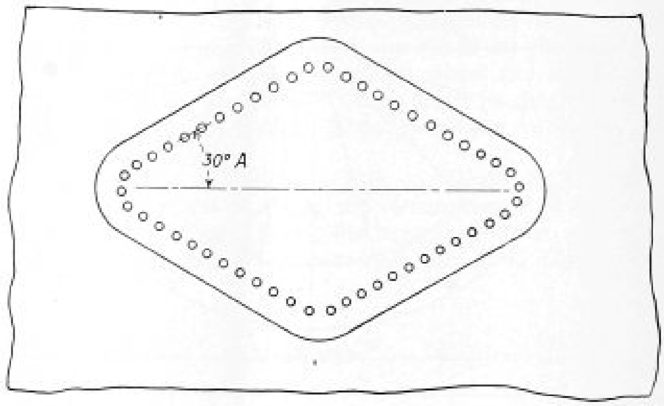



**Fig. 1.—Demonstration of Seam Efficiency Calculation**

seam of the same character as the longitudinal seam lies between the girth and longitudinal seam efficiencies. The factor to be used in multiplying the longitudinal seam efficiency may be found by the formula:

$$\text{Factor} = \frac{2}{\sqrt{3 \times \sin^2 A + 1}}$$

in which $A$ equals the angle the diagonal seam makes with the girth seam.

| *Angle A Degrees* | *Factor* |
|---|---|
| 30 | 1.51 |
| 32 | 1.47 |
| 34 | 1.44 |
| 36 | 1.40 |
| 38 | 1.37 |
| 40 | 1.34 |
| 42 | 1.31 |
| 44 | 1.28 |
| 46 | 1.25 |
| 48 | 1.23 |
| 50 | 1.20 |
| 52 | 1.18 |
| 54 | 1.16 |
| 56 | 1.14 |
| 58 | 1.13 |
| 60 | 1.11 |
| 62 | 1.09 |
| 64 | 1.08 |

The inclination of the diagonal seam is 30 degrees and from the table the factor is 1.51. Using the lowest efficiency in the example 47.8 we have, $47.8 \times 1.51 = 72.18$ percent, the efficiency of the diagonal joint.

# Letters from Practical Boiler Makers

**This Department Is Open to All Readers of the Magazine —All Letters Published Are Paid for at Regular Rates**

## Making a Leaky Boiler Tight

The writer was recently called upon to inspect and determine the repairs necessary to a locomotive boiler that had given the owners considerable trouble due to leakage at the calking edge of the junction of the firebox flue sheet and the wrapper sheet. The accompanying sketches and photograph give a rough outline of the general conditions encountered. While the sketches were made by a man more or less unfamiliar with boiler construction and are inaccurate as to scale and details, they will suffice to illustrate the defects.

An internal inspection of the boiler, indicated defects practically as shown by the sketches. The photograph shows a section of the joint where the shanks of the rivets were plainly visible between the sheets and where it was possible to run a scale between the plates to the calking edge.

### Details of Firebox

The original firebox construction had been a 3/8-inch wrapper sheet and a 1/2-inch flue sheet, the boiler being of the "OG" type about 60 inches in diameter. The flue sheet having worn out, the boiler was sent to a repair shop some months ago for a new back flue sheet. For some reason best known to some one other than myself, a 5/8-inch sheet was applied without scarfing the flange and the defective conditions illustrated were the result of applying a heavy ill-fitting sheet apparently without any post repair inspection. I cannot conceive that anyone claiming to be an inspector or foreman would ever pass such a job.

As the sketches and the photograph indicate there were many places around the sheet where the shanks of the rivets on one side were visible and where a "feeler" could be sent home with no difficulty, that is, from the water side, where the calking edge had not even been calked. The flue sheet was much too small in many places; apparently the staybolts had not been removed in the first row adjacent the flange, to allow for adjustment of the wrapper sheet and the result was that the plates could only be brought together at the calking edge in the firebox. In addition to this, it was found

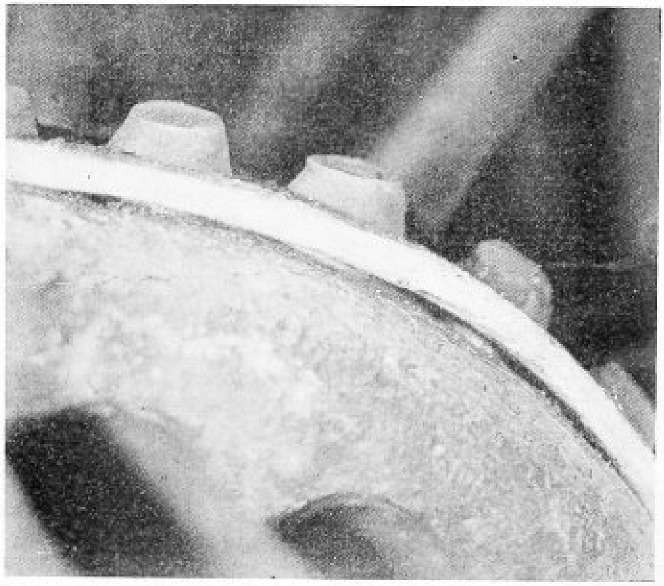


Fig. 1.—Sheets Separated, Showing Where Leakage Occurred

that the lap on the wrapper sheet outside the rivet holes was at least 1/4-inch too long, thus exaggerating the defective condition by extending out well onto the heel of the flange.

### Carrying out the Repairs

An estimate of the situation indicated the necessity of removing 60 flues to make room for operations, and very little

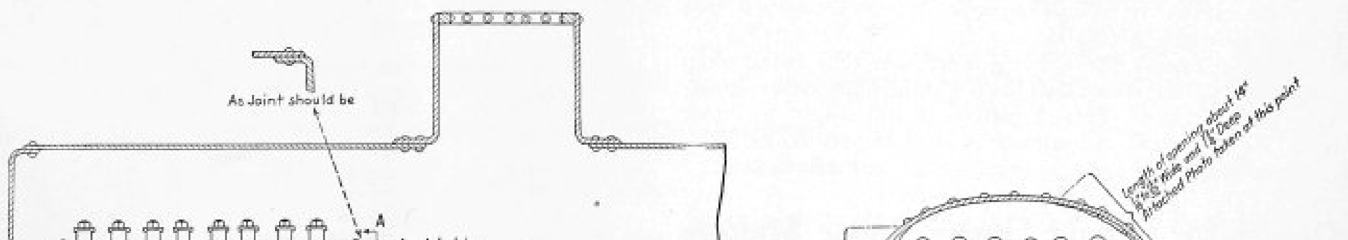



Fig. 2.—General Condition of Firebox Flue Sheet Where Leakage Occurred

room at that, and the necessity of removing 60 rivets in an attempt to get the plates together before re-riveting. We were then ready to put into effect our plans for repairs. Fortunately there was compressed air and an oxy-acetylene outfit available. After the removal of the flues the countersink head rivets were burned out with the oxy-acetylene torch. It may be mentioned here that in an attempt to stop the leakage from the seam, that the rivet heads and the calking edge had been electrically welded making the tearing down process a very difficult one.

In order to simplify the laying up of the plates and to eliminate future fire cracks the flue sheet flange was scarfed down beginning at the back of the holes and tapering off to about 5/16-inch at the calking edge. The long lap on the wrapper sheet was trimmed off wherever it could be reached. The oxy-acetylene torch was used to heat the plates and both plates were worked and pulled until we had "iron to iron." This was done at every hole, the holes were reamed and bolts put in alternate holes until a rivet was driven in the hole next to it. We then had sheets that fitted and were ready for riveting.

As all boilermakers know, down the leg of a flue sheet, by the time that a rivet is in the hole and the "bucker up" on it with his bar, that usually the rivet is too cold to drive successfully. Generally four or five rivets go into a hole before one is driven. We had no such trouble as we proceeded along the line of least resistance by driving hot rivets in every hole.

The rivets were first heated to a bright red and then placed in the hole with a "spoon" over the head and a wedge bar driven down tight to hold the rivet. The use of the spoon prevents crowding the rivet head off to one side when driving on the wedge bar. It made but little difference in the time taken for the "bucker up" to get on the rivet as the heating of the rivet was but a preliminary one to shorten the time later, as the main heat was then made by the oxy-acetylene torch after the rivet was set tight against the sheet. The rivet, white hot, was then driven down, the radiating heat helping to get the sheets tightly together. After the riveting was completed, the rivets were lightly calked with a "frenchman" and the calking edge, both sides, was gone over lightly with a "fuller." Five minutes' touching up on the hydrostatic test completed the job.

This job merely illustrates the necessity for proper preparation before beginning a repair. The original one could have been done as well as the last one had a little more time been spent laying up the plates prior to riveting. However, in any case, the job should never have gotten out of the shop without some one seeing it and the mystery is that it could ever have been tested.

This emphasizes the writer's contention that boiler shop foremen handling over thirty men should have either assistants or inspectors. This I believe should apply to either repair or new work on locomotives or stationary boilers.

Aspinwall, Pa. C. E. LESTER.

## Don'ts for Round House Boiler Makers

*Don't* think a leak will take up, but get it while the getting is good.

*Don't* go into a firebox with a chipping hammer and hit staybolts that leak. Find out what causes the leak. Ninety-nine times out of a hundred it is scale. Hold on these bolts and re-drive them with a long stroke air hammer. By doing this, you tighten the bolt in the sheet and also knock off all the scale from around the firebox sheet. Destroy the germ and you cure the disease. Try it on your piano if your staybolts don't leak.

*Don't* start shifting the petticoat pipe and diaphragm plate, if an engine is reported not steaming. First examine the smoke arch for air holes; for a small hole here and there will make a wonderful change in the steaming of your engine. Examine the ashpan and see if there are enough air openings in it.

*Don't* for heaven's sake let an engine go out with a shaker bar that is an improper fit. The Interstate Commerce Commission report states that 85 men were injured by improper shaker bars last year.

*Don't* by all means overlook the apron. See that the bolts are tight and two nuts on them. If the apron is worn slick have it roughed, for the Interstate Commerce Commission again tells us that men were injured by defective and slick aprons last year. Be a safe and sane boiler maker.

Deming, N. M. C. R. KIRKWOOD,
Boiler Inspector, A.T. & S.F. Ry.

## Master Boiler Makers' Convention

(*Continued from page* 140)

### THIRD DAY

THURSDAY, MAY 25, 1922

Convention called to order 9 A. M.

Address:

Committee Reports:

"What are the Advantages and Disadvantages of Treated Boiler Feed Water?"—T. P. Madden, Chairman; George Austin, E. W. Young. 10 to 11 A. M.

"Describe Present and Best Method of Welding Safe Ends on Locomotive Tubes"—P. J. Conrath, Chairman; J. A. Doarnberger, Alfred F. Stiglmeier. 11 A. M. to 12 M.

"Which is the Better Crown Stay for the Different Classes of Locomotives: the Stay Screwed into the Crown Sheet with the Taper and Riveted Over, or the Button Head Crown Stay?"—Lewis Nicholas, Jr., Chairman; Thos. F. Powers, J. J. Mansfield. 2 to 3 P. M.

"How Can the Deterioration of Firebox Sheets Behind Grate Bars and Supports be Eliminated?"—C. E. Elkins, Chairman; C. F. Petzinger, John J. Orr. 3 to 4 P. M.

"What is the Cause of the Boiler Shell Cracking Through Girth Seam Rivet Holes?"—Andrew S. Greene, Chairman; Wm. A. McKeown, T. W. Lowe. 4 to 4.30 P. M.

Announcements.

Adjournment.

### FOURTH DAY

FRIDAY, MAY 26, 1922

Convention called to order 9 A. M.

Address:

"What is the Best Type of Side Sheets to be Applied to Narrow and Wide Firebox Locomotives?"—C. R. Bennett, Chairman; William F. Fantom, J. P. Malley. 10 to 10.30 A. M.

Report of Committee on Law—George W. Bennett, Chairman; A. N. Lucas, John Wintersteen. 10.30 to 10.35 A. M.

Report of Committee on Topics for 1923 Convention—J. W. Kelly, Chairman; John B. Tate, Thomas Lewis. 10.35 to 10.40 A. M.

Unfinished Business:

Report of Committees on President's Address. 10.40 to 10.45 A. M.

Report of Committees on Resolutions. 10.45 to 10.50 A. M.

Report of Committees on Memorials. 10.50 to 10.55 A. M.

Election of Officers. 10.55 to 11.45 A. M.

Good of the Association and General Discussion. 11.45 to 12.30 P. M.

Announcements and Closing Exercises of the Convention. 12.30 to 1 P. M.

## Defective Safety Valves Cause Explosion

(*Continued from page* 134)

correct angle, which resulted in their being lowered in the bushes; but although this was probably one of several contributory causes of the eventual explosion, it would not in itself necessarily have led to any danger. There is, in fact, proof not only that the valves lifted correctly on test, but they continued to do so for some months in service.

My general conclusion in this very serious case is that so many factors, some of them not necessarily constituting an element of danger in themselves, contributed to the result, that no responsibility can fairly, in the circumstances, be assigned to any individual.

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Assistant Chief Inspector—J. M. Hall, Washington, D. C.

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Executive Board—John F. Raps, general B. I., C. R. R., 4041 Ellis avenue, Chicago, Ill., chairman.

## TRADE PUBLICATIONS

Forty Years of Progress.—The history of the forty years' growth of the Heine Boiler Company, St. Louis, Mo., and the announcement of the change of name from the Heine Safety Boiler Company and of the new control are given in a bulletin just sent out by the company. Various types of Heine boilers are also briefly described. It is the purpose of the company to extend the assistance of its facilities and engineering service to all those who design, erect and operate power plants in which Heine boilers are used.

Hand Cut Files.—A catalogue listing the various type quality files produced by Murcott & Campbell, Inc., Brooklyn, N. Y., is being distributed. Standard types of pillar and flat files, mill saw files, square and round files, half round, etc., with illustrations and details of numerous special types are given together with sizes and prices. The various "cuts" in general use, as rough, bastard, second cut, smooth, dead smooth and the like are described for the information of those desiring to adopt files best suited to their requirements.

Electric Rivet and Metal Heaters.—The story of the development and application of Berwick electric rivet heaters is contained in a well illustrated catalogue which the American Car and Foundry Company, New York, has recently published. Since 1912 the company has been experimenting with devices for heating rivets electrically and in November, 1919, machines for this purpose were perfected. Complete details of the various types and capacity heaters are given with comments from railroads, boiler shops and other shops where the heaters are being used. Information is given on automatic heaters which are now being developed for heating bolt blanks, drop forgings, bar stock 20 to 30 feet in length of any cross sectional area from 3/8 inch diameter up to 1½ inches, for spot welding and the like. The company is also interested in developing electric heaters for practically any special requirement and will be glad to supply the catalogue to readers of The Boiler Maker on request.

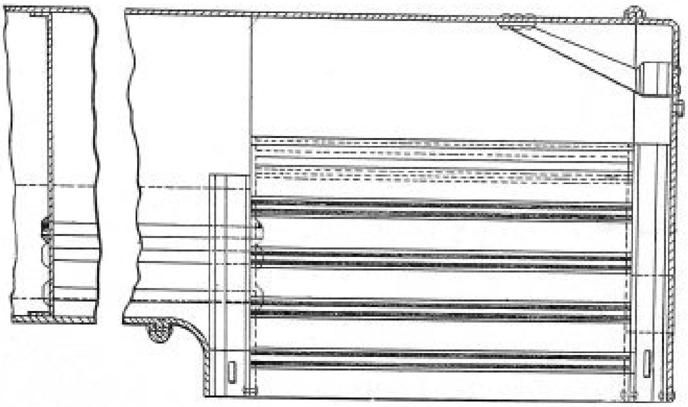
# SELECTED BOILER PATENTS

Compiled by
GEORGE A. HUTCHINSON, Patent Attorney,
Washington Loan and Trust Building,
Washington, D. C.

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

1,408,717. BOILER. ELVIN ASH, OF BERKLEY, VIRGINIA.

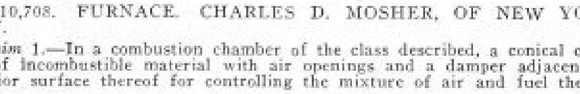
*Claim* 1.—The combination with a boiler shell and stay members extending longitudinally along the walls and top thereof, of a firebox insertible longi-



tudinally into the shell, stay members thereon at the top and sides thereof and insertible into engagement with the stay members on the shell during the insertion of the firebox into the shell, a front plate movable across the front end of the shell, and into engagement therewith, and stay members upon the firebox and front plate movable into engagement with each other during such positioning of the front plate to tie the front plate to the firebox.—Three claims.

1,412,277. TUBE EXPANDER. THOMAS J. DIXON, MADISON, WISCONSIN.

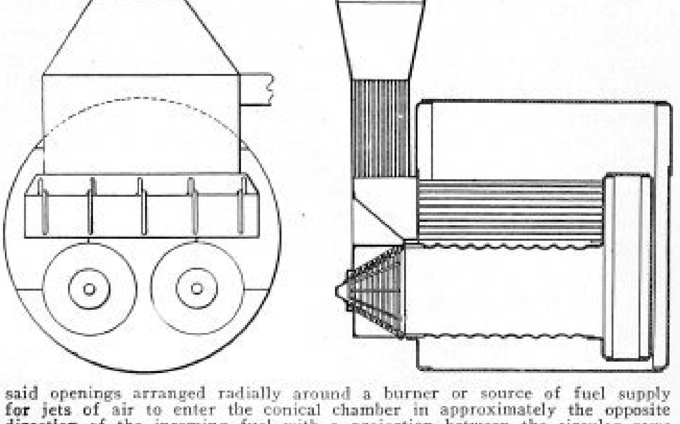
*Claim.*—In a tool of the character described, the combination with a tubular body having a plurality of longitudinally extending radial slots, an opposite pair of bearing boxes radially slidable within each of the slots, an expanding roller within each slot having end journals that rotatably engage their respective end bearing boxes, a tapering flaring disk rotatably mounted



on the outer one of the expanding roller journals, the said disk being loosely mounted on the said journal, that end of the expanding roller engaging the disk being bevelled whereby to hold the disk at an angle with respect to said expanding roller and with its inner edge in a plane with the mandrel engaging surface of the expanding roller and its outer edge projected outwardly at an angle with respect to the tube engaging surface of the roller to flare the outer edge of the tube, a tapering mandrel and tension devices engaging the tubular body and with opposite bearing boxes tending to normally move the expanding roller and the flaring disk against the tube being worked.

1,410,708. FURNACE. CHARLES D. MOSHER, OF NEW YORK, N. Y.

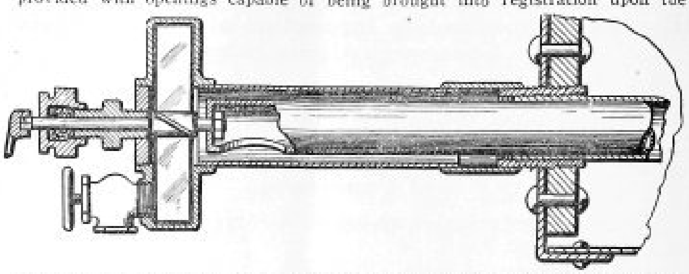
*Claim* 1.—In a combustion chamber of the class described, a conical chamber of incombustible material with air openings and a damper adjacent the exterior surface thereof for controlling the mixture of air and fuel therein,



said openings arranged radially around a burner or source of fuel supply for jets of air to enter the conical chamber in approximately the opposite direction of the incoming fuel with a projection between the circular rows of holes to prevent or baffle the fuel from entering said air openings. Five claims.

1,410,312. STEAM-BOILER CLEAN-CUT DEVICE. MIKE HUFFMAN, OF DES MOINES, IOWA.

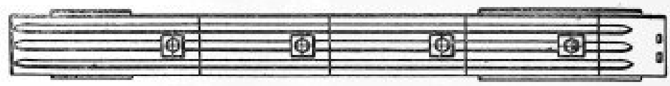
*Claim* 1.—In a device of the character described, the combination of an outer and an inner tube, one rotatable relative to the other and both being provided with openings capable of being brought into registration upon the



turning of the rotatable tube, said tubes being designed to be placed into a steam boiler near its bottom and extended outwardly through the boiler to a point of discharge, and a water motor fixedly connected to the rotatable tube at a point exterior to the boiler, said parts being so arranged that the water forced through the registering openings in the tubes will pass through the water motor and cause the water motor to rapidly rotate said rotatable tube.

1,409,205. FURNACE GRATE BAR. JOHN VAN BRUNT, OF NEW YORK, N. Y., ASSIGNOR TO COMBUSTION ENGINEERING CORPORATION, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

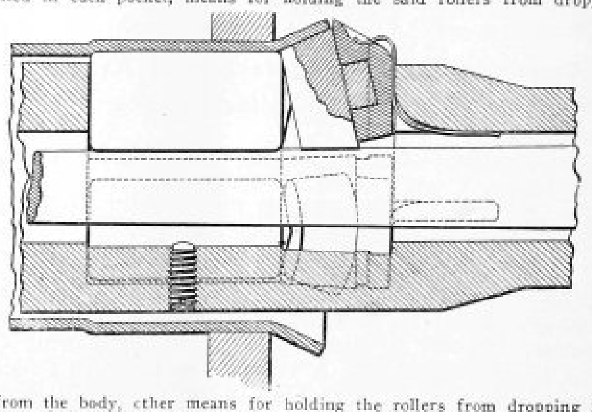
*Claim* 1.—In a tubular grate bar having inlet and discharge ports on its under side for receiving air at one end and discharging it in heated condition



at the other, the combination of a trough-like base portion and a removable top therefor, and bolts securing said top to said trough-like portion, said top being impervious to air and provided on its bottom surface with heat radiating vanes. Five claims.

1,412,278. TUBE EXPANDER. THOMAS J. DIXON, OF MADISON, WISCONSIN.

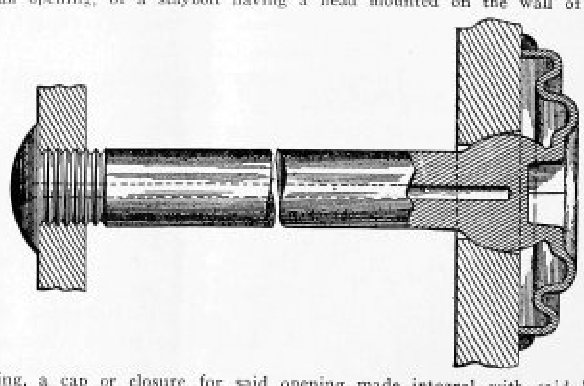
*Claim* 1.—In a tube expander, the combination with the body having an axial bore, the said body having at least one pocket that extends radially from the bore through the periphery of the body, an expanding roller mounted in each pocket, means for holding the said rollers from dropping



out from the body, other means for holding the rollers from dropping into the bore of the body, one end of one of the expanding rollers being tapered, a tapering mandrel adjustable through the axial bore of the stock and adapted for engaging and expanding rollers and for projecting them to the flue engaging position, a flaring disk, a bearing box removably mounted within the body, the box and the disk having journal and bearing connections, the said disk engaging the tapered end of the adjacent expanding roller and means for holding the box from dropping out of the body.

1,409,162. STAYBOLT STRUCTURE. JOHN ROGERS FLANNERY, OF PITTSBURGH, PENNSYLVANIA, ASSIGNOR TO FLANNERY BOLT COMPANY, OF PITTSBURGH, PENNSYLVANIA.

*Claim* 1.—In a staybolt structure, the combination with a boiler sheet having an opening, of a staybolt having a head mounted on the wall of said



opening, a cap or closure for said opening made integral with said head, said cap or closure having bent portions whereby the same will be yielding and said integral cap or closure having a peripheral portion seated on and disposed at right angles to the boiler sheet, and a weld surrounding said peripheral portion of the cap and uniting the latter to the boiler sheet.

# THE BOILER MAKER

JUNE, 1922

# Difficulties Experienced in Maintaining Mud Drums

## Frequent Replacement of Mud Drums Necessary Due to Rapid Corroding and Pitting Action

By J. P. Morrison

THE mud drum, as used with fire tube boilers, is practically a thing of the past, and with new installations, as with many of the older plants, the blow-off pipe directly connected to the boiler shell is serving every purpose satisfactorily.

However, there are a sufficient number of mud drums in use to cause the inspector some worry, for many of the drums were not provided with a suitable manhole opening and the handhole affords hardly more than an opportunity to make an intelligent guess as to the internal condition of the shell plates and heads forming the drum. Frequently the external surfaces are inaccessible for inspection, either because the drum is unprotected, and the ash has accumulated around it for years, or because a brick protection has been provided, without considering the necessity of examining the drum when the boiler is inspected.

Failure of Blind Mud Drumhead on Horizontal Tubular Boiler

### Purpose of the Mud Drum

Where a mud drum is used, its purpose is to act as a feed water receiver, in which the comparatively cold water may have its temperature increased, causing the precipitation of at least a part of the scale-forming sediment and also to act as a receiver for the solids which are expected to be carried to the rear of the boiler by the circulation, there to settle into the mud leg, for removal through the blow-off valve, or through the handhole or manhole opening. Unfortunately things do not always operate just as they should, or as planned, so it was soon found that very little of the foreign matter precipitated in the mud drum as the water entered the boiler and less settled there when the boiler was in operation. Furthermore, the presence of the mud drum had a detrimental influence on the work of cleaning the boiler, for the fireman, or boiler washer, quite naturally reasoned that the mud drum would do all its name implied, so when the small amount of scale which was found in the mud drum when the boiler was opened, had been removed, further cleaning was neglected. As a result, the water spaces between the tubes of boilers having mud drums, have frequently been found completely filled with hard scale.

The feed water, on its way through the mud drum to the boiler, naturally followed the shortest and easiest path, so the lower part of the drum lacked circulation and pitting followed. This pitting was often increased by the friction of the metal hoe used to draw the sediment within reach of the manhole or handhole opening, and the manhole plate left a path of pitting where it repeatedly fell and rocked upon the inner surface of the shell. This difficulty could, of course, have been prevented by using a rope to hold the manhole plate, thus preventing it from reaching the shell.

The external surface of a mud drum, which has no protection from the furnace gases, may overheat, but is more likely to be seriously affected by the corrosion, as a result of the action of the ash and soot and such action is particularly rapid in the presence of moisture. It is difficult to imagine the presence of moisture in the combustion chamber of a boiler which is in service, but the ash and soot accumulation at the rear of the bridgewall is frequently wet-down, to facilitate its removal, and, in fact, some furnaces are arranged so the combustion chamber may be cleaned with hose pressure. This procedure is not always satisfactory.

The moisture which reaches the external surface of the mud drum, in this way, or as the result of tube and seam leakage, combines with the sulphur in the ash and soot, forming sulphuric acid. This acid has a strong affinity for iron, which dissolves into a heavy rust scale and this action, when continued for a number of years, will ultimately penetrate the sheet.

The majority of mud drums are provided with protection of some kind. This covering may consist of a brick arch, or two thin brick walls and a cap of sheet iron or cast iron plates. In either case, the head containing the clean-out opening, is exposed to the atmosphere outside of the furnace wall, while the other head is given such protection as the ash, or brick casing affords. Seldom is the brick arch, or plate covering, sufficiently tight to prevent soot and ash from reaching the shell plates and corrosion can continue undetected unless there is considerable room between the drum and the casing, or the covering plates are lifted, to make examination possible. A mud drum located in the combustion chamber may be looked upon with suspicion, after it has been in operation a few years and the external surface, as well as the internal surface, should be examined thoroughly, even if it is necessary to remove the ash, the covering plates, or brick arch, to do so.

### Repairing the Mud Drum

When the deterioration has reached the limit permissible, repairs are necessary, and, at times, present a real problem for solution. If the boiler is set independently, that is, when there is no other boiler over the same grate, the mud drum may be removed at the seam securing the water leg to the boiler. The opening in the rear shell plate of the boiler may be closed with a round patch of proper size, onto which a blow-off flange has been riveted, to give proper holding threads for the blow-off pipe, which will be used instead of the mud drum. The blow-off pipe should not exceed 2½ inch pipe tap size in diameter and smaller sizes are sufficient for boilers under 60 inches in diameter. The blow-off fitting should be of steel of extra heavy weight and must be extended from the boiler to the blow-off valve without a reduction in size. The vertical part of the blow-off pipe is usually protected from the furnace heat by a V-shaped brick pier, and the horizontal section may be placed in a brick, or other refractory casing.

If the feed water pipe has entered the mud drum, it is necessary to provide a front head, or upper shell plate feed water connection. If the front head is chosen, the opening is drilled of sufficient size to tap for a brass bushing, into which the outer section of the feed pipe, as well as the inner extension of the feed pipe, is secured. The internal extension should be extended towards the rear of the boiler about three-fifths of the distance to the back head, and the discharge opening should be submerged when the water is at the lowest safe level.

If the feed water pipe is to enter the shell plate, a plan frequently chosen so as to avoid extending the outer section of the feed pipe through the furnace wall, or through the cast iron boiler front, an opening should be made along the center line on which the steam, safety valve and manhole openings have been located. The point usually selected is about two feet from the front head, if no head brace prevents making the internal connection at that place. An opening nearer the rear of the boiler would answer as well, but would require a greater length of external feed pipe, if the feed valve is to be located where readily accessible for the fireman.

Unless the shell plate is exceptionally heavy, it will be necessary to rivet a flange, or pad, onto the shell at the feed opening, to give the proper thickness for the pipe threads.

Of course the furnace wall will need to be closed where the mud drum extended through it, and then, with a new blow-off pipe and a new feed pipe, the boiler is again ready for service, with repairs made as cheaply and simply as possible.

### Boilers Connected to Single Mud Drum

However, if two or more boilers are in the same battery, that is, over one grate and connected to the same mud drum, the repair is not so easily made. Such a battery of boilers frequently has but one water column and in many cases the mud drum acts as an equalizer of the water line, so but one water glass is depended upon. Even if each boiler is provided with a glass, when one of the boilers is filled, of course all are filled, and, as a common grate serves all, when one is fired-up, all are heated. There is a very good adage—"when boilers are fired together, they should be filled together," and the practice of using one grate under several boilers which have no equalizing connection, has resulted in overheating an empty boiler more than once.

Frequently, when replacing a mud drum serving two or more boilers is discussed, the plan of installing an independent feed water connection and water gages for each boiler is suggested, but unless a similar division can be made in the furnace, so the boilers can be fired independently, the plan is a poor one to adopt. The use of an equalizing pipe between the blow-off pipes, solves the problem, if the feed water contains no scale-forming ingredients, but perfect feed water is seldom found, so there is danger of the equalizing pipe choking with scale, or one of the blow-off pipes may become obstructed and remain undetected until it burns off, for, when an equalizing pipe is used, it is not possible to determine that all of the blow-off pipes are clear, and are functioning properly, when a blow-off valve is opened.

### Necessity of Cleaning the Mud Drum

So if a mud drum connected to two or more boilers is no longer dependable, it should be replaced with a new mud drum of such size as will permit locating a manhole opening, at least in one head, so the interior may be properly cleaned and examined. The protection from the heat should be so arranged as to permit a thorough examination of the exterior at reasonable intervals, without the necessity of removing a considerable amount of brick work, for the owner of a boiler quite naturally does not wish to employ a brick mason each time his boilers are cooled for cleaning and inspection.

The photograph which is reproduced, illustrates clearly the failure of the blind head of a mud drum connected to a horizontal tubular boiler. This mud drum, with the exception of the head containing the handhole opening and blow-off and feed water connections, was completely encased in masonry in such a manner that the boiler setting would be disturbed if the drum were uncovered for examination. The handhole opening afforded an opportunity to examine but a small part of the interior, so the inspector was not able to determine the true condition of the mud drum, although his conclusions were correct, and upon his recommendation, the mud drums connected to two of the three boilers operated in the plant, had been replaced with blow-off pipes and front head feed water connections, which were operating entirely satisfactorily.

The condition of the mud drums removed from two of the boilers, led to the conclusion that the mud drum of the third boiler should likewise be replaced and plans had been perfected to put on a blow-off pipe at the earliest opportunity. The boiler was to have been cooled on Saturday night for the purpose of making repairs, but early Saturday morning the mud drum head separated at the head flange, where the breathing action, resulting from the head being flat and the internal and external corrosion, had reduced the material to a knife-edge thickness.

Had the damage been confined to the mud drum, the failure would have caused but little regrets, as no one was injured, but the furnace walls were wrecked, the front casting irreparably broken, and some damage was done to the boiler house.

If there is an old mud drum to remove, DO IT NOW.

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Holes in boiler plates should not be punched or drilled flat and then be expected to line up when the plates are rolled. They should be drilled small, then when the plates are rolled and bolted up, the holes should be reamed out to size. The old practice of lining up the holes with a drift pin with consequent mutilation of the metal and tendency for holes to leak is no longer acceptable in boiler construction.

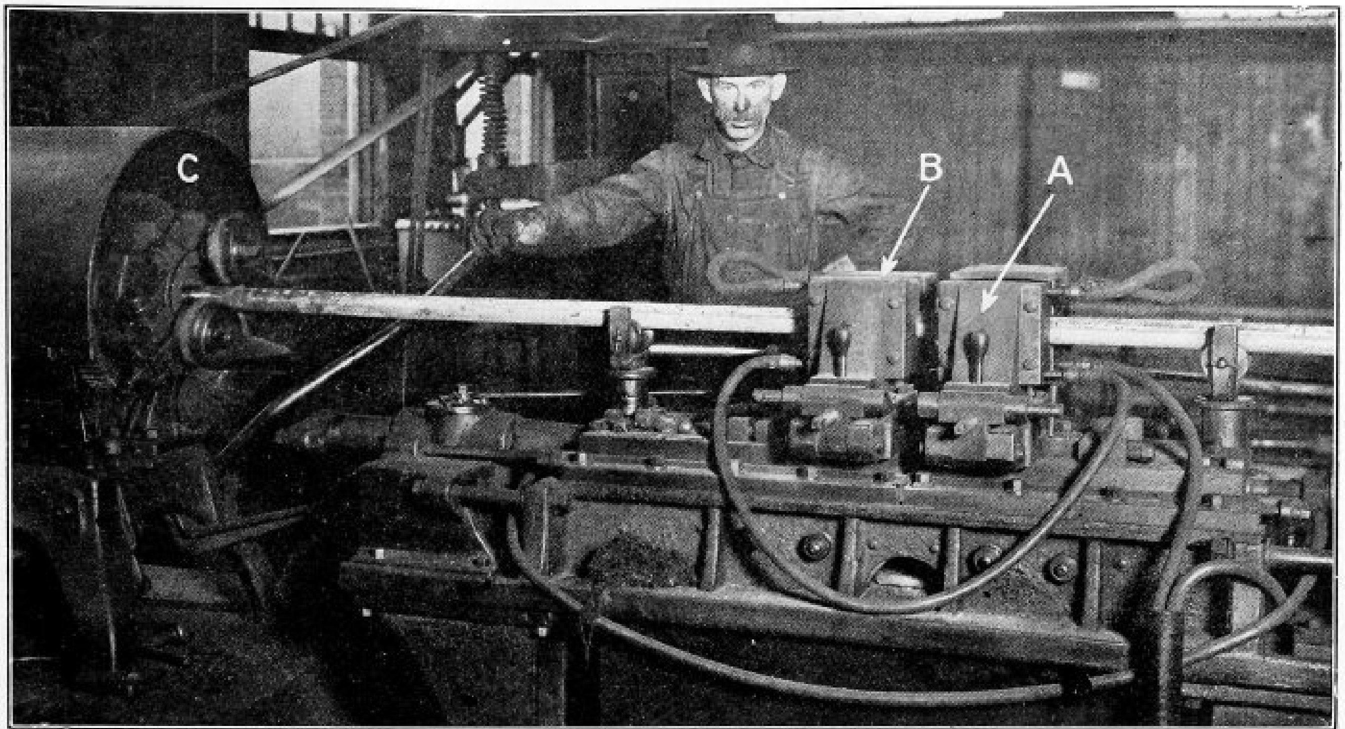



Fig. 1—Rolling a Boiler Tube After It Has Been Safe Ended in a Thomson Electric Welder

# Electrically Safe Ending Boiler Tubes

## Summary of Results in Safe Ending Boiler Tubes and Flues with the Thomson Electric Butt Welder at Nashville, Tenn.

**By J. J. Sullivan***

THE recent revival of interest in the application of safe ends to boiler tubes and flues by the electric butt welding process is indicated by the published report of the Master Boiler Makers' Association Committee on Welding Safe Ends. According to that report the Norfolk & Western now has in service about 280,960 tubes welded by this method, 152,000 of which were welded in 1919 with no failures reported. The Union Pacific was reported to be able to weld about 60 tubes per hour and to have more than 700,000 electric welded tubes in service with only two failures.

The practice on the Nashville, Chattanooga & St. Louis at the Nashville shops is summarized in the following article which includes two illustrations, Fig. 1 showing the welding machine and flue roller and Fig. 2 being a plan of the flue shop with the movement of tubes and flues through the shop.

The process of electrically butt welding safe ends to all sizes of boiler tubes and flues has been used at Nashville since August, 1916, so that the results given were secured over an extended test period during which the electrically welded tubes and flues gave excellent service without failures. The type 40-A electric welding machine used is made by the Thomson Electric Welding Company, Lynn, Mass., and has a capacity of welding up to and including 5½ in. flues. The general principle of the machine is that heat is induced by passing a large volume of electric current at a low voltage through the butting tube and safe end to be welded, the heating effect being caused by the resistance of the metal to the flow of current. The greatest resistance to the flow of current is between the butting ends which therefore become hot first and when they reach the proper welding temperature, the current is turned off and pressure applied mechanically to force the molten ends together, thereby producing a weld.

The machine, shown in Fig. 1, was developed especially for welding boiler tubes and flues, and its general construction is evident from the illustration. In the operation of welding, the tube is held in the clamp jaws or dies *A* which are forced together mechanically, clamping the tube and serving as one electrical contact. The safe end is similarly gripped in dies *B*. The electric current is turned on by means of a switch and the butting ends of the tube and safe end instantly begin to heat. The operator learns to judge by experience when the welding temperature is reached and when the metal is hot enough, dies *A* and *B* are moved mechanically towards each other which forces the two molten ends of the tube and safe end together. At the same time the operator turns off the current, and the weld is made. The pressure on the dies is released, allowing the tube to be pushed through to rolls *C*.

The weld is in full view of the operator all the time and no smoked glass or goggles are needed, as there are no flying sparks. Another advantage is due to the method of heating which prevents oxidation as would occur with an open fire. Consequently no welding compound is necessary. The operator has complete control of the electric current by means of a current regulator and switch and can quickly obtain any heat desired from a dull red to the melting point of the metal. As soon as the weld is made, the current is switched off and expense for power stops. Another advantage is the low voltage characteristics of the machine and consequent elimination of danger from this source.

Extended experience has shown that the cost of electrically butt welding safe ends on 2-in. boiler tubes at Nashville is

*Superintendent of Machinery, Nashvile, Chattanooga & St. Louis, Nashville, Tenn.

3½ cents each, the time averaging about 1.12 min. each. This is the labor cost, and the cost for power, as determined by meter readings for a large number of welds is .224 cents

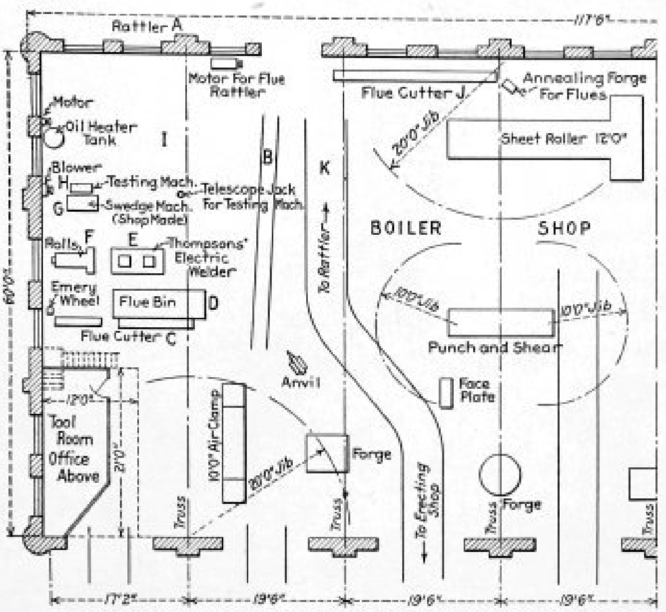



Fig. 2—Plan of Flue Shop and Course of Flues Through the Shop

for each 2-in. tube. The labor cost for safe ending a 5½-in. boiler flue is 15 cents, the time required 4 min. and the power cost 2.016 cents for each flue. One welder and one helper are necessary for the most efficient operation.

Referring to Fig. 1, the device for rolling the tube immediately after being welded is shown at *C*. The tube is pushed along on two supporting rolls as soon as the weld has been made and the welding dies release their grip on the tube. This arrangement saves practically one handling of the tubes and with a helper to facilitate handling tubes into the welder a considerable increase in production is obtained.

The method of handling tubes and flues through the shop at Nashville will probably be of interest and referring to Fig. 2 this movement will be readily understood. The tubes are cut from the boiler in the erecting shop loaded on a truck and moved to the rattler *A* outside the shop. After being rattled a sufficient length of time to loosen and clean off the scale, the rack of tubes is moved into the shop by means of the flue rattler motor and stored on track *B*. When opportunity offers the tubes are then placed conveniently to the flue cutter *C* and the firebox ends cut smooth and square. An emery wheel is provided as shown for removing burrs. From bin *D* the set of tubes is moved to the electric butt welder *E* where they are welded and rolled quickly with the expenditure of a minimum amount of time and effort.

The next operation is to swedge the tubes which is performed on a shop made machine. The tubes are tested and moved to *J* where they are cut for length and have the front ends annealed in the forge shown. The tubes are then ready for application to the boiler, being sent to the erecting shop along passageway *K*. The only back movement is from the rattler back to the first flue cutter, a condition which cannot be prevented in this particular case owing to the local shop lay out.

# Exports of Boilers from Great Britain

## Details of the Market Values and the Latest Export Statistics for the Sale of British Boilers

**By T. Sington**

SOME details of British exports of boilers may be of interest to readers, including the quantities, values and countries forming a market for boilers. There is considerable competition and the depressed condition of trade throughout the world is likely to make it keener. Prices are far above the pre-war level due to increase of wages, decreased output of work per man, higher prices for coal, greater railway and shipping charges and vastly increased taxes, both national and local.

There is very little likelihood of any material reduction in these items. Most experts assert that higher prices have come to stay. As regards prospects of improved demand, there are optimists who can see it coming, but most of those interested take a gloomy view of the immediate future.

Most of the British boiler workshops have been erected in inland towns, so that railway charges are an important item. Boilers may be divided for the purpose of this article into several classes or types, differing very much in construction and detail: Marine boilers, those internally fired, such as the well known Lancashire, Cornish and Galloway types; boilers of the locomotive type for stationary purpose; water-tube and others. Economisers, feed-water heaters, steam superheaters and condensers form a sub-group of boiler machine shop output and are also exported in considerable quantity.

The most recent and the last pre-war peace year exports are given below, showing an increase; but that is misleading as the quantities exported are much less and the increase is due to inflated prices.

| Last Pre-War Peace Year Exports | Most Recent Annual Exports Published | Increase |
|---|---|---|
| $8,511,300 | $11,869,500 | $3,358,200 |

Before the war India, Russia, France, Australia and South Africa were the largest buyers of boilers, as shown by the following figures:

| | Tons | Values | Average Price per Ton |
|---|---|---|---|
| India | 9,310 | $1,180,500 | $126 |
| Russia | 5,587 | 768,000 | 137 |
| France | 5,052 | 403,000 | 79 |
| Australia | 4,699 | 654,000 | 139 |
| South Africa | 4,332 | 470,000 | 108 |

The great variation in the prices paid per ton indicate the varied types of boilers required in different countries. The buyers of boilers on a more limited scale include Belgium, Canada, Mexico, Chile, Spain and the Argentine Republic in the order named.

Passing to the most recent annual returns, the first deals with internally fired Lancashire (two flues), Cornish (one flue) and Galloway boilers; these were exported to the extent of 7,295 tons, valued at $2,636,200; giving an average price of $361 per ton. The number of boilers exported was 605, giving an average price of $4,355. The largest buyer was India, 449 boilers were exported, of 5,348 tons, valued at $1,903,560, giving an average price of $4,239.

Other buyers were:

| | Number | Weight | Value |
|---|---|---|---|
| France | 10 | 307 | $123,000 |
| China | 30 | 495 | 168,500 |
| Japan | 19 | 225 | 78,200 |
| Canada | 10 | 244 | 77,300 |

India, China and Japan may provide the United States with a market, more especially China where there appears to be a boom in cotton mill erection. It may be of interest to compare the price per ton given above, the most recent $361, with the average pre-war price per ton, for 1913, $124, showing an increase due to the war of $237 per ton.

The next are boilers of the locomotive type for stationary purposes; 448 were exported, weighing 2,554 tons, valued at $1,272,000; equal to an average price of $2,835 and $498 per ton. It is important to note that all these prices are free on board at a British port and do not include freight and other charges for transporting the boilers to the buyers' premises. Nearly 45 percent of these boilers went to India; the Argentine Republic and Japan bought some; other countries only took small quantities.

Watertube boilers are exported in considerable number; 761, weighing 12,531 tons, valued at $4,670,400, equal to $6,137 each, at $372 per ton. The largest buyers were as follows:

| | Number | Tons | Value |
|---|---|---|---|
| India | 118 | 2,536 | $938,500 |
| Spain | 109 | 1,793 | 760,800 |
| Japan | 95 | 1,666 | 492,000 |
| Argentine Republic | 42 | 923 | 350,400 |
| China | 39 | 637 | 280,000 |

Canada, Australia, Brazil, Mexico, Italy, Portugal and France were also small buyers.

Ship boilers were exported in considerable number and to a great amount: 352, costing $9,661,200, giving an average of $27,446.

The principal buyers were as follows:

| | Number | Value |
|---|---|---|
| Norway | 102 | $2,890,000 |
| France | 90 | 2,508,000 |
| Holland | 29 | 1,010,400 |
| Italy | 23 | 845,000 |
| Greece | 18 | 578,400 |
| Belgium | 27 | 531,000 |
| Sweden | 15 | 490,500 |

Other boilers of various types are grouped together, the markets took 908, weighing 7,551 tons and costing, free on board at British ports $3,295,000. The largest buyers and their purchases are given below:

| | Number | Tons | Value |
|---|---|---|---|
| Spain | 87 | 1,831 | $818,000 |
| India | 263 | 1,352 | 563,000 |
| France | 80 | 1,044 | 437,000 |
| Holland | 42 | 581 | 228,500 |

Economisers, feed-water heaters and steam superheaters are the output of firms closely allied with boiler makers. They also had a considerable market in different parts of the world, amounting in all to $1,433,000 for 3,144 appliances weighing 6,967 tons. France was the largest buyer, taking 1,709 weighing 2,610 tons for $379,000; India and Japan were the next largest buyers. There are also small markets for condensers, the total purchases abroad reached $384,000 for 490 tons, giving an average of $783.

## Explosion of a Fireless Locomotive

ONE type of locomotive that is used in industries where the presence of an open fire would be dangerous is that which uses a pressure tank containing a large amount of water which is heated to a high degree and raised to a correspondingly high pressure by the admittance of live steam at a charging station. The water acts as a reservoir for the heat, and steam is given off at a continuously decreasing pressure as the locomotive is used. Such engines are frequently known as "fireless locomotives" in distinction to "compressed air locomotives." That they may become dangerous is well shown by an article which appeared in the Austrian publication, *Zeitschrift der Dampfkesseluntersuchungs-und Verischerungs-Gesellschaft a G.*, under date of August, 1921, which gives an account of the explosion of one of these locomotives.

The boiler of this locomotive, which was built in 1915, was 67 inches in diameter and 13½ feet long and was designed for a maximum pressure of 190 pounds. On July 14, 1921, it was being charged from a boiler built for 260 pounds and the driver had just given the signal to stop charging when the head of the boiler opposite the cab tore off circumferentially in the turn of the flange. The shell and the other head of the boiler were thrown a distance of 1,550 feet, in which flight it is said the boiler struck the earth and the roofs of buildings six times. The driver of the locomotive was instantly killed.—*The Locomotive.*

## 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, C. W. Obert, 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.

Below are given the interpretations of the Committee in Cases Nos. 392 to 394 inclusive, as formulated at the meeting of April 6, 1922, and approved by the Council. In accordance with the Committee's practice, the names of inquirers have been omitted.

CASE NO. 392. *Inquiry:* If the holes in a plate are drilled full size in the plate before the sheet is rolled and holes in butt straps are also drilled full size before being attached by tack bolts to the plate, would this meet the requirements of paragraphs 253 and 254 of the Code?

*Reply:* The intent of the requirement in paragraph 253, that the plates shall be firmly bolted in position for drilling, is to make the holes match perfectly and it is the opinion of the Committee that this can be accomplished only by reaming or drilling the plates after rolling and with the butt straps in position.

CASE NO. 393. *Inquiry:* Should the factor "E," in L-43*b* of the Locomotive Boiler Code, be calculated in a longitudinal direction, or transversely, as is "s"?

*Reply:* "E" refers to the minimum efficiency of the wrapper sheet through joints or stayholes located on a longitudinal section, as explained by the paragraph immediately following the formula.

CASE NO. 394. *Inquiry:* Is it permissible to stamp A.S.M.E. Standard on a low-pressure heating boiler which has autogenously welded joints and stays but complies with all requirements of the present Code?

*Reply:* At the time the heating boiler code was adopted, the use of autogenous welding in the construction of boilers for this service was not contemplated, and no permission for their use is contained in the Code. However, it is the opinion of the Committee that properly designed and constructed welded steel-plate boilers built of material in accordance with the specifications in the heating boiler section of this

(*Continued on page* 162)

# Boiler Manufacturers Hold Annual Convention

## Industrial Relations and Progress in Adoption of Uniform Construction and Inspection of Steam Boilers Discussed

In opening the thirty-fourth annual convention of the American Boiler Manufacturers' Association, which was held at the Buckwood Inn, Shawnee on Delaware, Pa., on June 5, 6 and 7, A. G. Pratt, of The Babcock and Wilcox Company, New York, president of the association, stated that one reason for the delay of business in returning to normalcy and good business has been the uncertainty of the effect upon industry of laws still in the making. Laws and definite policies on such important questions as tariff, taxes and governmental economy must be definitely worked out and in successful operation before industry can proceed with confidence in the future.

### Abstract of President's Address

"Our industry," said Mr. Pratt, "in common with most industries with which we are familiar, has been passing through a most trying period and while we are not as yet entirely upon the high road of large business and prosperity, I feel that we, and manufacturers in general, are to be congratulated in having arrived thus far with so relatively few signs of the hardships which we have encountered. It is a source of satisfaction that we have weathered the storm and are now ready for the better business which is coming, slowly but surely.

"Many of us have our houses in better shape physically and financially than ever before at the end of such a period of business depression. We have learned many lessons—some at a considerable cost to ourselves—by which we should benefit in the better times ahead.

"I do not feel that we are about to enter a period of great prosperity immediately, but rather that conditions will continue to improve, slowly but surely, and in a manner which will build for permanence. As a matter of fact, we do not desire again to go through a period of inflation such as occurred in the latter half of 1919 and the first half of 1920, only to go over the precipice and find nothing to cushion against at the bottom, as we found to our sorrow in the middle of 1920.

"Ours is a seasonal business and we must not lose heart, if the volume obtained during the first three or four months of this year seems to shrink as the year goes on. We have had materially better volume so far this year than during any period of last year and I venture to predict that the volume for each quarter of this year will surpass that of the corresponding quarter of last year, and that next year we shall have considerably better business than during the year 1922. Many projects are well advanced and will come to fruition just as soon as the community can properly support them.

"Labor conditions are still bad in many localities. A large part of these labor difficulties are due to the fact that organized labor either assumes to be a law unto itself, as at present in Chicago, or else is specifically exempted by law from compliance with statutes to which the large majority of the community must subscribe. We, who believe in the open shop, would have no fight with organized labor, if it would put its house in order, place business men instead of business agents in responsible positions and if, further, organized labor were made amenable to the same laws as the rest of the community."

Mr. Pratt quoted at length from the minutes of a meeting of six hundred representatives of trade associations held in Washington on April 12, showing the attitude of the Department of Commerce and of various government officials toward trade associations, so that the American Boiler Manufacturers' Association may be better prepared to discuss cooperation with the Department of Commerce. Mr. Pratt concluded by saying that he hoped that Congress will eventually pass a law which will enable trade associations to appear before some specific government commission and learn what activities they may lawfully pursue.

### Economic Problems Confronting Industry

Following the reading of the president's address, the convention was addressed by Mr. M. W. Alexander, managing director of the National Industrial Conference Board. At the outset Mr. Alexander pointed out that twenty-five years' industrial experience had brought him in contact with several hundred thousand men and enabled him to dig below the surface into some of the problems vitally affecting American industries. In order to deal constructively with these problems the National Industrial Conference Board had been formed which represents the federation of thirty-two associations covering industries in which some seven or eight millions are employed.

This board, said Mr. Alexander, has a two-fold purpose; first, to find the facts of the economic situation confronting us, to analyze these facts fairly and impartially and to put the results in such shape that they can be used for guidance; and, second, to afford the members of the associations a post graduate school of study of the economic problems. By means of a research staff of eighty-two experienced men and women, which the Conference Board has developed for the investigation, analysis and presentation of facts for discussion, industrial executives can bring their deductions to bear upon the problems in their industries.

Before taking up the problems at present demanding solution, Mr. Alexander showed by comparison with other countries what the United States actually is industrially and how it ranks in the world with respect to natural resources. Irrespective, however, of the commanding position held by the United States on account of its size, location, natural resources and variety of climate, he declared, it is the character of its people and their spirit that will determine what the country really is.

Analysis of the 1920 census shows that of the total population of the United States forty percent is gainfully occupied and that of those gainfully occupied the greatest percentage (30.8 percent) is engaged in manufacturing, showing that whereas forty years ago the United States could rightfully be called an agricultural country, today, it is more essentially an industrial country. Furthermore, in 1919, of the 290,000 manufacturing concerns, only four-tenths of one percent employed more than 1,000 people and only six-tenths of one percent between 500 and 1,000, while ninety-nine percent employed less than 500 each, showing that we are a country of small workshops where the owner is closely associated with the workers in the shop. Under such conditions, Mr. Alexander pointed out, there is not much danger of strikes and similar troubles and notwithstanding sensational newspaper headlines 99 percent of our manufacturing concerns are going on with their business in comparative harmony.

Among the important problems confronting American industry today, Mr. Alexander touched briefly upon the following: Exchange, immigration and industrial relationship, or the relationship of men to men.

As to the condition of exchange and its effect upon American industry, the speaker warned that price conditions in various countries should be contrasted before assuming the effect of currency exchange values and he gave the following illuminating figures showing relatively what United States currency will actually buy in foreign countries: United States, 1; England, 1.13; France, 1.09; Italy, 1.01, and Germany 1.65. While Germany can buy to advantage in no country and Switzerland can buy in all, the United States can buy to advantage in all but Switzerland, and England only in Germany.

In discussing immigration, Mr. Alexander explained how the present restriction of immigration by the Government, which has just been extended for another two years, is depriving us of the most desirable element of immigration, the element we need most, that is, common labor, and predicted that as a result there will soon be a labor shortage and a consequent demand by unskilled labor for increased wages.

Referring to the problem of industrial relationship, or the relationship of men to men, the fact was emphasized that of the three principal factors involved, that is, wages, working conditions and stability of labor, the latter is of first importance. Stability of employment, it was stated, is far nearer the heart of the worker than wages or other conditions and will do more to allay socialism and labor unrest than anything else. Mr. Alexander deplored the fact that practically nothing has been done to solve the problem of unemployment and stated that no actual results could be expected from Washington conferences or politics. The continued demand for shorter hours he characterized as merely the war cry of labor agitators and not the demand of the men themselves.

The question of wages, while the most talked of, Mr. Alexander considered as second in importance. To arrive at a true basis of the level of wages it is not so much a question of what one can earn as it is of what one can buy with what he earns. Analyzing the present levels of wages and the cost of living (the latter figured on retail prices the worker has to pay for necessities, not the wholesale prices of commodities), the pertinent fact was brought out that as a matter of fact the real earning or purchasing value of wages is now 24 percent higher than in 1914.

In concluding, Mr. Alexander made an urgent plea for individual managers to become the leaders of their own people in their own factories and to settle their differences directly without outside interference from a third party, either the Government or otherwise. Of very first importance, he said, is the growing social responsibility of the employer for safer factories, better working conditions and greater contentment among the workers.

REPORT OF THE SECRETARY-TREASURER

The annual report of the secretary-treasurer, which was read just before adjournment of the morning session, showed that the membership of the association comprises 1 honorary, 77 active and 21 associate members. The financial standing of the association showed a satisfactory balance.

Applications for associate membership were received from three companies during the meeting.

## MONDAY EVENING SESSION

At the evening session of the convention on Monday the following paper was read by E. C. Fisher, of the Wickes Boiler Company:

## A Study of Thickness of Shell Plates in Return Tubular Boilers

### By E. C. Fisher

This paper is an attempt to report to you in condensed, organized form the result of a correspondence which has been carried on between J. A. McKeown, L. E. Connelly, G. S. Barnum, G. Welter and myself, since the winter meeting of the association held in Pittsburgh, February 13, 1922. All of these gentlemen have contributed in this correspondence the matter presented in this paper.

You will remember this subject was first introduced at the thirty-third annual convention held at Bedford Springs, Pa., June 20-22, 1921. At that meeting the A. S. M. E. Boiler Code Committee requested that this association have a full discussion upon this subject and reach a decision, if possible, with a recommendation for a limitation in thickness of shells in return tubular boilers.

The question was presented for the A. S. M. E. Boiler Code Committee by E. R. Fish, who is chairman for this association of the A. S. M. E. Boiler Code Committee, and representative of the association upon the A. S. M. E. Boiler Code Committee. Mr. Fish at that meeting stated the following:

"The Boiler Code is at present being revised to some extent and one of the points not covered is the maximum thickness of shells of return tubular boilers. The point has come up and I was asked to find out from the manufacturers of such boilers what their ideas are as to the limitations of such thicknesses. I would like to have an expression of opinion."

After some discussion of the request no final decision was reached but it was decided that a questionnaire be sent to all the members manufacturing that type of boiler, with a request for their answer. The task of preparing and sending out the questionnaire was delegated to the commercial committee of this association, W. C. Connelly, chairman.

At the winter meeting of the association, held in Pittsburgh, Mr. Connelly presented the answers received to the questionnaire and a long discussion followed. During this discussion J. A. McKeown stated that in his opinion the A. S. M. E. Boiler Code in its present writing limited the thickness of shell plates in return tubular boilers. This was a discovery and, I think, a new thought to the majority of the members of the A. S. M. E. Boiler Code Committee. No decision was, therefore, reached upon this subject by this association at the Pittsburgh meeting, but it was laid over for further deliberation.

Shortly after the Pittsburgh meeting a letter was written by J. A. McKeown to L. E. Connelly relative to the subject, which Mr. Connelly kindly forwarded to G. S. Barnum and myself. There then followed a correspondence between us, which, condensed into usable form, is the substance of this paper.

It is well known that the resistance of a shell to rupture in a transverse section is double the resistance longitudinally. Therefore since the allowed pressure on a shell is based on the efficiency of the longitudinal joint for a given plate thickness, the efficiency of the circumferential joint must be 50 percent of the efficiency of the longitudinal joint based on the *same thickness*. Due to the staying power of the tubes and through braces the A. S. M. E. Boiler Code requires the efficiency to be only 35 percent instead of 50 percent of that of the longitudinal joint. Paragraph 184c also requires that in circumferential joints exposed to the products of combustion the shearing strength of rivets shall be not less than 50 percent of the full strength of plate, corresponding to the *thickness at the joint*. This paragraph was put in the Code as a detail of construction that would aid to eliminate fire cracks.

Bearing in mind the relationship between the resistance to rupture in the longitudinal and circumferential joints, stated above, as well as their comparative efficiencies, it is seen that there will be a point reached, as the plate thickness is increased, where failure takes place in the girth joint. The following is copied from Mr. Barnum's letter of March 11, and is made up from a joint milled to ½-inch thickness, with 1-inch rivets in 1-1/16-inch holes at 2½-inch pitch:

| A<br>Thickness of Shell Plate, Inches | B<br>Efficiency of Longitudinal Joint, Quadruple Riveted | C<br>Efficiency of ½-Inch Milled Girth Joint Based on Full Thickness of Plate in Shell | D<br>35 Percent of Longitudinal Joint in Column B |
|---|---|---|---|
| 3/4 | 92.7 | 37.8 | 32.4 |
| 13/16 | 92.3 | 34.9 | 32.3 |
| 7/8 | 91.2 | 32.4 | 31.9 |
| 29/32 | 90.5 | 31.3 | 31.6 |
| 15/16 | 90.1 | 30.25 | 31.5 |

The figures in column C were obtained by the following formula, the efficiency used being the lesser of the values obtained using the two formulæ. In this table the figures were not carried below ¾-inch plate because it is apparent that the efficiency stated in column C increases rapidly as thinner shell plates are used.

$$E = \frac{ss}{p \times T \times 55{,}000} \text{ or } \frac{(p - d) \times t \times 55{,}000}{p \times T \times 55{,}000}$$

Where E = Efficiency tabulated in Column C
ss = Shearing value of one rivet in single shear
p = Pitch of rivets in girth joint, inches
T = Thickness of plate in shell, inches
d = Diameter of rivet, inches
t = Thickness of plate at joint = 0.5 inch where shell is over 9/16 inch thick.

The curve in Fig. 1 was prepared to show how the efficiency values shown in columns C and D approached one another and crossed at the point where the girth joint does not continue to meet the requirements of Paragraph

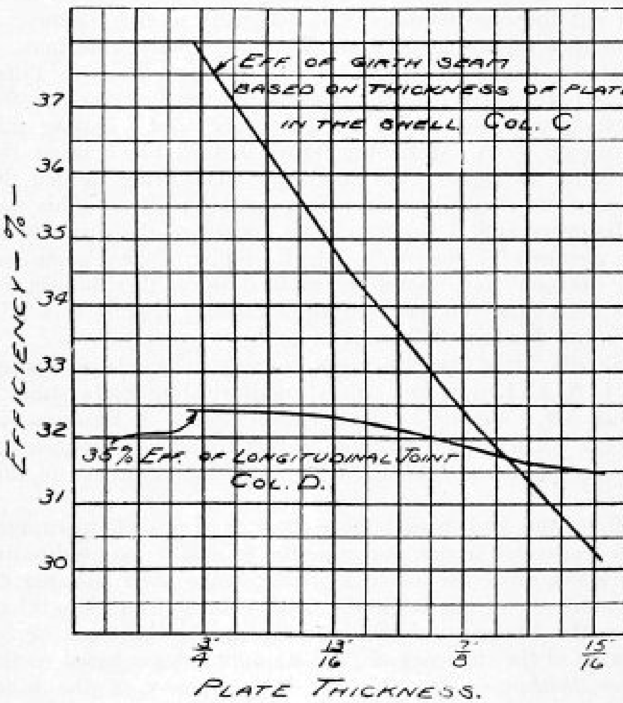



Fig. 1

184b in that the efficiency in column C becomes less than 35 percent of the longitudinal joint efficiency as plate thicknesses increase. However, it should be pointed out that these curves will vary slightly, depending on the type of longitudinal joint selected and its efficiency.

Paragraph 185 of the Boiler Code requires that where the shell plates are thicker than 9/16-inch they must be milled to ½-inch. As shown in the table and by the curve in Fig. 1, the plates fail to comply with the requirements of Paragraph 184b when the plate thickness reaches approximately 57/64-inch.

This problem can be approached from another angle. The longitudinal joint is based on a factor of safety of 5 and to be equally as strong the girth joint efficiency is only required 50 percent of the longitudinal joint. However, the Code, due to the holding power of the tubes, allows the efficiency of the girth joint to be only 35 percent instead of 50 percent. The factor of safety under these conditions can be obtained by direct proportion as 35:50::X:5, in which we find X= 3.5. This is the minimum factor of safety on a girth joint to meet the Code requirements. While this is merely another way of stating the problem it seems to me to be an aid toward a clearer understanding.

Mr. Welter objects to stating the problem in this manner because he believes it might be construed by some to mean that a part of the boiler is allowed a factor of safety of only 3.5 while by figuring the staying power of the tubes and braces it is actually over 5. However, in presenting

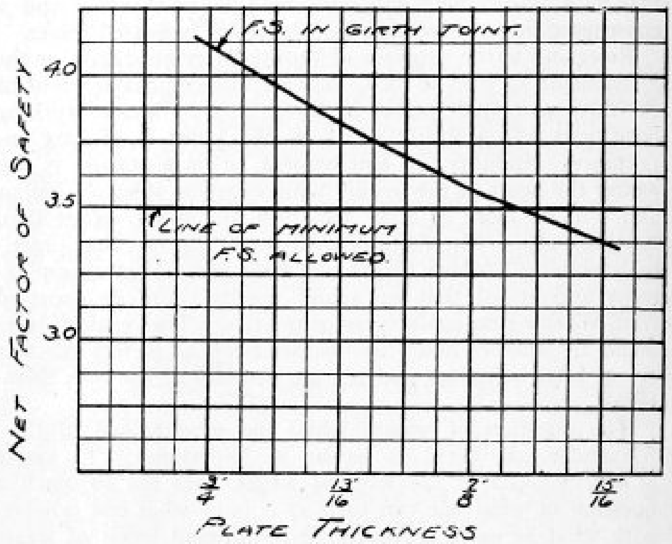



Fig. 2

this you will note that I have qualified every statement that a factor of safety of 3.5 is allowed as given in Paragraph 184b, because of the additional holding power of tubes or through stays.

The curve in Fig. 2 is plotted by assuming efficiencies of longitudinal joints as based on Mr. Barnum's table. The thickness of the plate in the shell determines the pressure allowable on the longitudinal joint. The upper curve on this plot, therefore, varies according to the thickness of the plate as it affects the pressure and is also based on the strength of the circumferential joint with a plate thickness of ½-inch as required under Paragraph 185. It is important to note that this curve will also vary slightly with the type of longitudinal joint and its efficiency.

This plot shows that the maximum thickness is exactly the same as shown in the first curve, or approximately 57/64-inch.

The conclusions are, therefore, that:

1. The A. S. M. E. Boiler Code in Paragraph 184b limits the thickness of plates in horizontal tubular boilers.
2. This thickness, as shown by Mr. Barnum's table and the curves plotted, is approximately 57/64-inch, depending on the character and efficiency of the longitudinal joint.
3. The factor of safety required in the circumferential joint is 3.5, neglecting the holding power of the tubes and stays.

## Motion Pictures of Stoker Furnace in Operation

R. Sanford Riley, president of the Sanford Riley Stoker Company, Inc., Worcester, Mass., assisted by F. H. Daniels, general manager of the company, gave a very interesting and instructive talk, illustrated by still and moving pictures, showing actual conditions in a stoker-fired furnace. These are the first moving pictures taken of combustion in a boiler furnace and the difficulties involved in photographing an object approaching 3,000 degrees F. in temperature required the exercise of extraordinary inventive ingenuity and perseverance. The pictures showed the process of combustion in the furnace of an 822 horsepower Stirling watertube boiler equipped with a nine retort extra long Riley underfeed stoker at the plant of Bird and Son, Inc., East Walpole, Mass.

## TUESDAY MORNING SESSION

The first order of business at the Tuesday morning session of the convention, which convened at 9:30 o'clock with President Pratt in the chair, consisted in the reading of a report by E. R. Fish, of the Heine Boiler Company, the association's representative in the A. S. M. E. Boiler Code Committee and in the American Uniform Boiler Law Society. Mr. Fish's report was, in part, as follows:

### A. S. M. E. Boiler Code

"While the Boiler Code was in process of development it was decided to have a revision of the Code about every four years. The first revision was made in 1918. Another four years have nearly elapsed and further revisions are now being made. These revisions are based largely upon inquiries for interpretations indicating where there is a lack of clearness, as well as in suggestions for changes in material, methods, etc. The committee will be exceedingly pleased to receive any suggestions you may have for revision of the code.

"There are a few states and municipalities where the Code has been made statutory law and in those cases it involves more or less legislative action to make the changes as they come about, but fortunately in the majority of cases the Code is put into effect through enabling legislation that does not have to be changed. It is enabling legislation of this sort which is highly preferable over that which puts the Code on the statute books verbatim.

"Having gotten the Code covering boilers in pretty good shape, the committee is now actively engaged upon other phases of the work delegated to them by the council of the society. In this connection several sub-committees have been appointed as follows: On air tanks and pressure vessels, on boilers of locomotives, on miniature boilers, on steam piping, valves and fittings, on welding and on rules for inspection. Of these, the committee on locomotive boilers has made its report which has been adopted and published.

"The committees on heating boilers; miniature boilers; pipes, valves and fittings and on air tanks and pressure vessels have all made tentative reports after having held public hearings. After some further modifications these will doubtless be shortly approved and published. Of these the code covering air tanks and pressure vessels, which is more generally known as the committee on unfired pressure vessels, has been through many vicissitudes. A suggested code was prepared and submitted over two years ago and at a public hearing held at the spring meeting of the society in St. Louis in May 1920 it was quite evident that the matter of welding had not been adequately provided for and it is the settlement of this question which has been responsible for the delay in finally completing this code. The great variety of purposes for which pressure tanks of all sorts are used and the fact that welding is a method of construction very extensively employed, coupled with the great difference in practice and opinion of manufacturers, has made the settlement of the question exceedingly difficult.

"The question of welding was referred to the sub-committee on welding which has been co-operating with the American Welding Society. A number of hearings has been held and much progress has been made. At times it seemed as though a reconciliation and even an approximate agreement could hardly be expected but by being patient and taking time there is every evidence to support the belief that a constructive and generally acceptable code will be forthcoming.

"That there is a great need for something of this sort is generally conceded and which is quite evident by reason of the very considerable number of serious failures, particularly of welded air tanks, which take place from time to time. To this attempt to formulate a code covering construction of unfired pressure vessels may be credited a widespread activity on the part of a number of manufacturers, both of pressure containers and welding apparatus, to make a more careful investigation of welding processes and limitations, which has brought out a very considerable amount of valuable information. When completed I believe that this code will be found to be of great value both to manufacturers, users and the public.

"The committee on heating boilers has also had its troubles because of the introduction of welding methods in the construction of heating boilers but after a more or less stormy meeting an agreement generally acceptable was arrived at. The committee on miniature boilers also had its troubles but these were relatively easily adjusted.

"There is plenty of evidence to support the belief that these various activities of the Boiler Code Committee are of real value to the manufacturing trade and to the various inspecting agencies, whether they are merely commercial or legally constituted, by providing a basis of construction which is the work of many capable minds carried out in a way which would be practically impossible for a less broadly organized body to do, while the interests of the public are conserved by the certainty of reasonably safe construction which results."

Referring to the work of the American Uniform Boiler Law Society, Mr. Fish said that owing to the not infrequent changes of personnel with the varying fortunes of political parties, it seems absolutely necessary to maintain some organization whose principal function it is to prevent changes in the rules for boiler construction. This the American Uniform Boiler Law Society is doing by maintaining constant contact with the various inspection departments, and he vigorously reiterated a plea, often made heretofore, for members of the American Boiler Manufacturers' Association to continue their liberal support of the Uniform Boiler Law Society.

### Activities of the Uniform Boiler Law Society

In a report on the work of the American Uniform Boiler Law Society, Charles E. Gorton, its chairman, stated that during the past year little has been accomplished in the enactment of boiler code legislation as in only five Southern states had legislatures convened. In Georgia the boiler code bill was killed because of opposition to the qualifications required for inspectors. In California the society was instrumental in adjusting several matters in dispute. Differences, involving lawsuits, existed in Oregon between certain classes of manufacturers of all-welded low-pressure boilers but the society, acting in an advisory capacity to the Industrial Commission of Portland, was able to adjust matters and the lawsuits were dropped. It was the intention last year to introduce a code bill in Virginia but, owing to the introduction of three other bills in the state, the bill was not pushed. Conditions appear favorable, however, for the enactment of such legislation at the next term of the legislature. A bill was introduced in Kentucky and, although opposed, was allowed to remain on the calendar for future consideration. Opposition developed in Maryland, although hearty cooperation was received from the inspectors, the Governor and other officials. In Indiana a change has been made in the inspection department and slight differences have been smoothed out.

After referring briefly to several industrial matters of national importance, including the renewal of the German patent treaty and the patent bill recently introduced in the Senate, Mr. Gorton discussed the financing of the National Board of Boiler and Pressure Vessel Inspectors. He pointed out that, if the manufacturers will register their products with the board, the present fee of $2 can be materially reduced. The speaker felt certain that the National Board will be self-supporting, if the manufacturers who desire it will support it. The Uniform Boiler Law Society, he said, has legislative responsibilities and its time is largely taken up in combating legislation inimical to the interests of the National Board and of the American Boiler Manufacturers Association but he hoped that the National Board could hold an annual convention.

## National Board of Boiler and Pressure Vessel Inspectors

Joseph F. Scott, chairman of the National Board of Boiler and Pressure Vessel Inspectors, in his report stated that he had been able to realize a considerable advantage and a great advance towards uniformity since the secretary's office of the National Board has been in operation and that he feels certain it must be a profitable advantage to the boiler manufacturer, and especially to the ultimate consumer, as the expense of having an inspector travel a long distance to cover the inspection of a boiler during construction, through the National Board, has been eliminated.

"The American Uniform Boiler Law Society," Mr. Scott continued, "has assisted us financially, which has enabled us to inaugurate the various duties of the National Board and the society as a whole is entitled to commendation for its support and whole-hearted co-operation.

"It is apparent, however, that more money is needed to successfully accomplish that which we have started out to do. I would suggest that every state and municipality operating under the A. S. M. E. code get in touch with every manufacturer who builds boilers in their particular territory, requesting that they send in a data report on all their construction work to the secretary of the National Board.

"It is obvious that an annual meeting must be held, at which time all members of the National Board can get together and elaborate on their system and improve any defects that may be apparent. It is also essential that the examining committee, testing appliance committee, etc., get together from time to time, thereby more interest in the various activities of the National Board will be displayed and we would be of considerably more value and assistance to the Boiler Code Committee of the A.S.M.E. and the manufacturers as a whole.

"Revision of the boiler code is now going on and as changes in various paragraphs are being made, interpretations of the changes can be disseminated throughout the country more uniformly through the members of the National Board."

Reminding the boiler manufacturers of the complexity existing in the boiler business throughout the country before the National Board was organized, Mr. Scott declared his firm belief that the National Board is an essential organization that can and will carry out the theory and practice of engineering uniformity under the A. S. M. E. Boiler Code and expressed the hope that some concrete method might be adopted by which the financing of the secretary's office of the National Board will be firmly established for the future.

### Report by C. O. Myers, Secretary-Treasurer, National Board of Boiler and Pressure Vessels

We have in the National Board of Boiler and Pressure Vessel Inspectors the foundation upon which may be built an organization having the power and authority to provide means to secure uniformity in the administration of the Code. To make this a success we must have the confidence and support of all the boiler manufacturers as well as the Boiler Code Committee and the American Uniform Boiler Law Society.

As to the question of the various states accepting the National Board stamp, there is on file at the office of the secretary-treasurer letters of acceptance by all of the states approving of this stamping.

As to the matter of charging a fee for registering data reports upon all boilers bearing the National Board stamp, there is no question but what there should be a permanent office established by the National Board in order to keep all of the states in close contact with one another. Obviously there will be some expense connected with the maintenance of such an office and there must be some concrete means of permanently financing a proposition of this kind. We could think of no better way of equally distributing this expense than by making a charge for all boilers registered.

The fee was fixed at $2 per boiler at the start in view of the fact that it is a much easier matter to reduce it than it would be to raise it should we find it was not sufficient to pay the expenses. There is at this time but one company registering all their boilers, and a few others a small portion of theirs, and the total receipts to date have not been sufficient to balance the expense.

The following states have shown a spirit of co-operation by officially approving of boilers bearing the National Board stamp. By taking such action they have paved the way for the boiler builders to simplify the marking of their product:

Rhode Island, New York, New Jersey, Pennsylvania, Maryland, Ohio, Indiana, Wisconsin, Minnesota, Oklahoma, Oregon, California, Arkansas, Utah, and the cities of Chicago, Ill.; St. Louis, Mo.; Nashville, Tenn.

There are only two states remaining that have not taken action—Michigan and Missouri. With reference to Michigan, we have been advised by the chairman of the Board of Boiler Rules that this matter would be taken up at their next meeting in August or September. We are in communication with the Board of Boiler Rules in the state of Missouri, which has advised that this matter must go to the Governor, and that it is now taking steps to get it to him and we feel that it will be put through as soon as possible. The city of St. Louis has a separate ordinance and is not governed by the state law, and the chief inspector advises that he will approve of boilers bearing the National Board stamp.

We are in receipt of information from the Commissioner of Labor in the state of Arkansas to the effect that the boiler inspection law is inactive, due to the legislature not providing funds for its operation. He further advised us to enter this state as accepting the National Board and that he felt sure when the department was re-established they would go along with us.

There are still some details to be ironed out, which are difficult to clear up by correspondence, and we are in hopes that our finances will be in shape shortly to enable us to hold another convention, when we believe that a clearer understanding of this proposition will be had by the state representatives.

#### Discussion

In discussing the above reports, the members of the association expressed hearty approval of the work of the National Board not only because it provides a means of reducing the number of stamps otherwise required on boilers, especially on those of the portable type, but it vouches, by examination, for the qualifications of its inspectors anywhere in the country and makes for greater uniformity in boiler practice. Ways and means were discussed of aiding the National Board financially, as it started with a deficit and with low production has been unable to break even. It was pointed out that the present filing fee of $2 is prohibitive for the very small boilers and a suggestion that a system be worked out for grading the fees from a minimum of, say 25 cents for the very small boilers up to a maximum according to the horsepower of the boilers met with general approval.

## Standing Committee Reports

H. N. Covell, chairman of the membership committee, reported continued activity in the canvass for new members but with only a slight gain in membership at present. Three new associate members were elected at this meeting.

E. R. Fish, chairman of the A. S. M. E. Code committee, referred to his report submitted earlier in the meeting.

George W. Bach, chairman of the committee on ethics, reported that no direct violations of the code of ethics had been brought to the attention of the committee for action.

W. C. Connelly, chairman of the commercial committee, reported that no suggestions had been offered for additional work for the committee.

A. G. Pratt, chairman of the stoker committee, submitted the following report, the recommendations in which, with slight modifications, were adopted by the association:

### Report of Stoker Committee

"Report was made to the stoker representatives of the action taken by this association on June 21, 1921, on the report of your committee to the American Boiler Manufacturers' Association. In order to clarify the meaning of the recommendations previously adopted it is recommended that sections 6 and 7 be modified so as to read:

"(6) It is recommended that when I-beam or other supports are required to carry front boiler walls, *either vertical or inclined*, these should be furnished by the boiler manufacturer.

"(7) It was recommended that stoker manufacturers should erect and connect all water backs, *including blow-off piping and valves*, regardless of by whom furnished.

"The Stoker Manufacturers' Association representatives advised that boiler manufacturers should assume two limits for excess air—namely, 50 percent and 70 percent—in guaranteeing flue gas temperatures (when boiler manufacturers deem it advisable or necessary to make such guarantees). These limits are subject to confirmation by the Stoker Manufacturers' Association.

"The most troublesome detail in combining boilers and stokers is that of fronts between boilers and stokers. It has been tentatively agreed by the joint committee, subject to the approval of both associations, that stoker manufacturers will in all instances, except for side-feed and chain grate stokers, furnish a lower front to a height of 6 feet from the boiler room floor level and to the full width of the boiler setting; the boiler manufacturers to bring their fronts down to a point 6 feet above the boiler room floor. In the event of the stoker being below the boiler room floor the stoker manufacturer will purchase the necessary panel, to meet the 6 feet height, from the boiler manufacturer. In the event of a side-feed or chain grate stoker being used, which does not necessitate a boiler front to come to a line 6 feet above the floor, a credit may be made for the portion of the front omitted.

"In the joint committee report of June 21, 1921, it was recommended (Recommendation No. 3) that boiler and stoker manufacturers exchange information sheets setting forth contract conditions and details in which the other is interested. Tentative forms have been worked up and submitted to the membership with the statement that these would be discussed at the annual meeting. These forms would be exchanged by the local representatives of boiler and stoker companies interested in a sale. It is recommended that these forms be modified, if necessary, and returned to the joint committee for further conference and report."

G. S. Barnum, chairman of the committee on cost, strongly advised all those who have not adopted a cost system to take up and study the report made by the committee at French Lick Springs in 1920.

G. W. Bach, chairman of a special committee appointed to report on the proper setting heights for hand-fired return tubular boilers, submitted the following report:

### Setting Heights for Hand-Fired Return Tubular Boilers

"It is the opinion of this committee after careful deliberation and tabulation of available data from manufacturers and other sources that the following minimum setting heights should be recommended:

| | | | | | | |
|---|---|---|---|---|---|---|
| Diameter of boiler, inches..... | 54 | 60 | 66 | 72 | 78 | 84 |
| Height of setting for bituminous coal containing more than 35 percent volatile matter, inches | 32 | 36 | 40 | 44 | 48 | 52 |
| Height of setting for bituminous coal containing from 18 to 35 percent volatile matter, inches | 30 | 32 | 36 | 40 | 44 | 48 |
| Height of setting for anthracite and semi-bituminous coal containing less than 18 percent volatile matter, inches...... | 28 | 28 | 32 | 36 | 40 | 44 |

"Where the above dimensions conflict with existing local laws or regulations by smoke departments or others in power, such local laws or regulations should be followed.

"This committee further recommends that a committee be appointed to suggest that a similar committee be appointed by the affiliated smoke prevention bureaus meeting in Cleveland, O., in the near future with a view that co-operative action should be taken jointly to standardize setting heights in the various districts that would meet with the approval of the boiler manufacturers and the local authorities having this matter in charge."

## WEDNESDAY MORNING SESSION

The first speaker at the final session of the convention, which was opened at 9:45 on Wednesday morning, was Dr. Charles Aubrey Eaton, of the American Educational Association, who discussed what he designated as America's greatest need—leadership and education. The power of the world is in the masses of men, he declared, and we are cursed with rotten leadership. The logical leader of the working man is the man who employs him and he urged employers and managers to step in and by giving of their brains and manhood to exert their leadership. We must have leadership first, he declared, and then education. The masses of men are not fitted to discharge the obligations they now have, as shown by the millions of parasites fast developing and the folly we are up against. Investigation has shown that 63 percent of the children have never gone beyond the eighth grade and that 70 percent of the people are not beyond the age of 14 in intelligence. The great task before us, he declared, is to put into the factories, offices and schools a new education that will make men masters of their own powers. It was this task that he gave to the employers and managers as a summons and a challenge.

Following Dr. Eaton's address, S. H. Barnum, of The Bigelow Company, read a preliminary report for the A. B. M. A. representatives on the A. S. M. E. Boiler Code sub-committee on Rules for Inspection of Materials and Boilers, which, with slight modifications, was approved.

The report of the auditing committee was read and approved and the present officers of the association were re-elected for the following year as follows:

## Officers Re-Elected

President—A. G. Pratt, The Babcock and Wilcox Company, New York.

Vice-President—G. S. Barnum, The Bigelow Company, New Haven, Conn.

Secretary and Treasurer—H. N. Covell, The Lidgerwood Manufacturing Company, Brooklyn, N. Y.

Executive Committee—F. C. Burton, Erie City Iron Works, Erie, Pa.; W. S. Cameron, The Frost Manufacturing Company, Galesburg, Ill.; W. C. Connelly, The D. Connelly Boiler Company, Cleveland, O.; F. G. Cox, Edge Moor Iron Company, Edge Moor, Del.; W. A. Drake, The Brownell Company, Dayton, O.; E. C. Fisher, The Wickes Boiler Company, Saginaw, Mich.; A. R. Goldie, Goldie-McCulloch Company, Galt, Ont.; C. V. Kellogg, Kellogg-MacKay Company, Chicago, Ill., and J. S. McKeown, J. O'Brien Boiler Works Company, St. Louis, Mo.

A motion was carried authorizing the president to appoint a conference committee to establish contact with the Department of Commerce.

## Banquet and Entertainment

The annual banquet of the association was held in the main dining room of Buckwood Inn on Tuesday evening, with C. V. Kellogg, of the Kellogg-MacKay Company, as toastmaster.

The entertainment committee, F. G. Cox, of the Edge Moor Iron Company, chairman, arranged golf tournaments for the members and guests on Monday and Tuesday afternoons, the prizes being awarded at the banquet on Tuesday evening.

## Registration at the Convention

The following members and guests attended the convention:

G. E. Andrews, *Power,* Chicago, Ill.

G. W. Bach, Union Iron Works, Erie, Pa.

G. S. Barnum, president, The Bigelow Company, New Haven, Conn.

S. H. Barnum, The Bigelow Company, New Haven, Conn.

B. F. Bart, Standard Seamless Tube Company, New York.

C. R. Barton, Standard Seamless Tube Company, Pittsburgh, Pa.

W. H. S. Bateman, Parkesburg Iron Company, Philadelphia, Pa.

C. S. Blake, Hartford Steam Boiler Inspection and Insurance Company, Hartford, Conn.

G. T. Bliss, Erie City Iron Works, Erie, Pa.

M. Boyd, Boiler Tube Company of America, Pittsburgh, Pa.

C. A. Brandt, The Superheater Company, New York.

H. H. Brown, THE BOILER MAKER, New York.

W. S. Cameron, The Frost Manufacturing Company, Galesburg, Ill.

D. J. Champion, Champion Rivet Company, Cleveland, O.

W. C. Connelly, D. Connelly Boiler Company, Cleveland, O.

H. N. Covell, Lidgerwood Manufacturing Company, Brooklyn, N. Y.

C. Cunningham, The Christopher Cunningham Company, Brooklyn, N. Y.

W. A. Drake, The Brownell Company, Dayton, O.

C. W. Edgerton, Coatesville Boiler Works, Coatesville, Pa.

J. R. Edwards, Pittsburgh Steel Products Company, Pittsburgh, Pa.

J. G. Eury, Henry Vogt Machine Company, Louisville, Ky.

E. R. Fish, Heine Boiler Company, St. Louis, Mo.

E. C. Fisher, The Wickes Boiler Company, Saginaw, Mich.

Michael Fogarty, Michael Fogarty, Inc., New York.

H. C. Fownes, 2nd., Standard Seamless Tube Company, Pittsburgh, Pa.

R. M. Gates, The Superheater Company, New York.

D. W. Glanzer, The Otis Steel Company, Cleveland, O.

A. R. Goldie, Goldie-McCulloch Company, Ltd., Galt, Ont.

C. E. Gorton, American Uniform Boiler Law Society, New York.

Isaac Harter, The Babcock and Wilcox Company, New York.

S. F. Jeter, Hartford Steam Boiler Inspection and Insurance Company, Hartford, Conn.

J. F. Johnston, Johnston Brothers, Ferrysburg, Mich.

C. V. Kellogg, The Kellogg-Mackay Company, Chicago, Ill.

T. L. Kirk, Standard Seamless Tube Company, Pittsburgh, Pa.

F. W. Linaker, The Vulcan Soot Cleaner Company, DuBois, Pa.

Harry Loeb, Lukens Steel Company, Philadelphia, Pa.

F. R. Low, *Power,* New York.

W. S. McAleenan, The C. H. Dutton Company, Kalamazoo, Mich.

J. E. Mason, *Power,* New York.

F. B. Metcalf, International Boiler Works Company, East Stroudsburg, Pa.

M. F. Moore, Kewanee Boiler Company, Kewanee, Ill.

C. O. Myers, National Board of Boiler Inspectors, Columbus, O.

J. J. O'Connor, Oil City Boiler Works, Oil City, Pa.

R. E. Powell, "Blast Furnace and Steel Plant," Pittsburgh, Pa.

R. M. Powers, Kewanee Boiler Company, Kewanee, Ill.

A. G. Pratt, The Babcock and Wilcox Company, New York.

T. S. Reynolds, S. Severance Manufacturing Company, Pittsburgh, Pa.

G. E. Ryder, The Superheater Company, New York.

J. F. Scott, Steam Boiler Inspection Bureau of New Jersey.

N. L. Snow, Diamond Power Specialty Company, Detroit, Mich.

L. S. Thomson, Midvale Steel and Ordnance Company, Philadelphia, Pa.

T. E. Tucker, The Gem City Boiler Company, Dayton, O.

C. E. Tudor, The Tudor Boiler Manufacturing Company, Cincinnati, O.

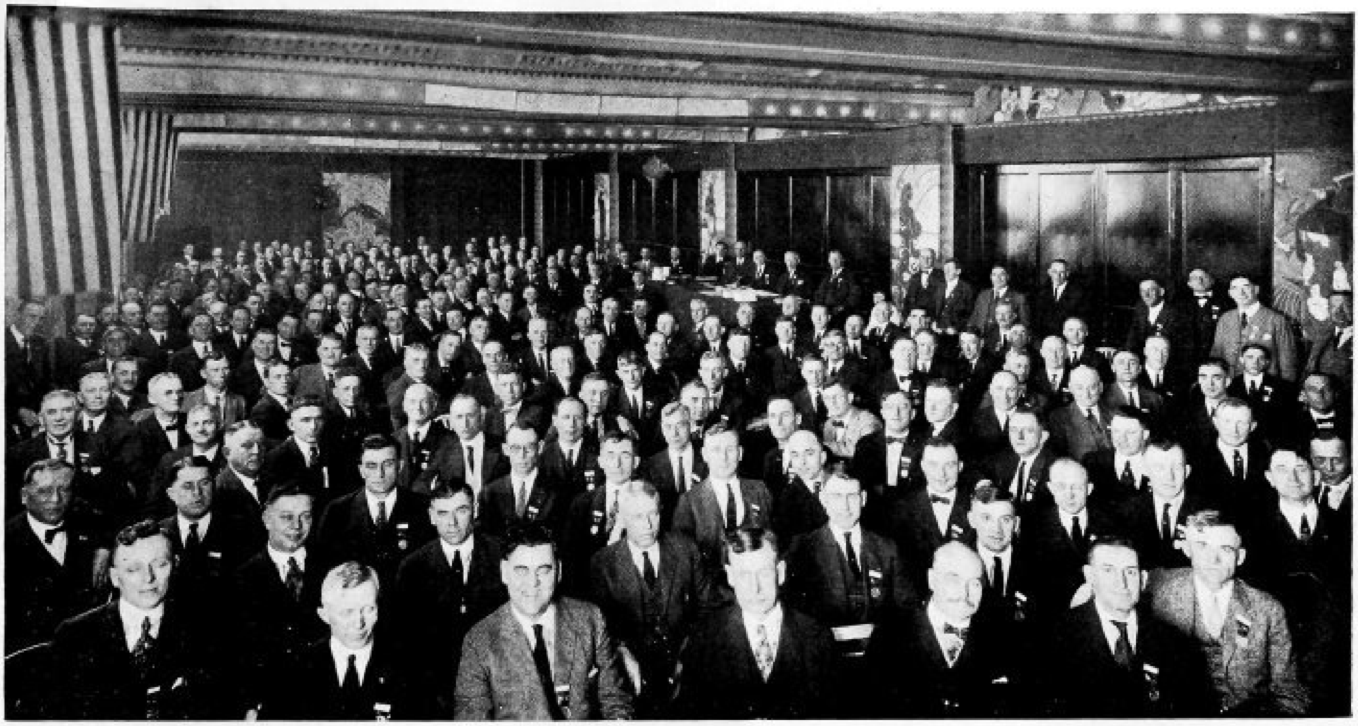
# Work of the Boiler Code Committee

(*Continued from page* 155)

Code, when constructed, tested and operated in accordance with the rules in that section may safely be used and may be stamped A.S.M.E. Standard, for a working pressure not to exceed 15 pounds per square inch steam pressure, or 50 pounds per square inch hot-water pressure. The decision whether such boilers may be used thus necessarily rests with the authorities having jurisdiction.

Part I, Section 2 of the Code is now being revised and this interpretation is subject to the rules for welding of heating boilers which will be incorporated therein.

The thirteenth annual edition (1922) of Hendrick's Commercial Register, published by S. E. Hendricks Company, Inc., 70 Fifth Avenue, New York, contains 2,300 pages and comprises a thoroughly indexed and carefully classified register of producers, manufacturers, dealers and consumers connected with the electrical, engineering, hardware, iron, mechanical, mill, mining, quarrying, chemical, railroad, steel, architectural, contracting and kindred industries. The products are listed from the raw material to the finished article with the concerns handling them from the producer to the consumer.



Members of the Master Boiler Makers' Association Assembled for the Opening of the Thirteenth Annual Convention

# Convention of Master Boiler Makers' Association

## Special Committee Reports on Locomotive Boiler Welding Practice and on the Treating of Boiler Feed Water

IN spite of existing business conditions, the thirteenth annual convention of the Master Boiler Makers' Association which opened May 23 at the Hotel Sherman, Chicago, proved to be an unqualified success. About 275 members of the association registered during the course of the meetings and about 130 representatives of the Supply Men's Association. Charles P. Patrick, president, opened the Tuesday session at 10:15 a. m. The opening invocation was given by past president, John H. Smythe, chaplain of the association.

In the absence of the Honorable William Hale Thompson, Mayor of Chicago, who was to have addressed the association, his representative, W. D. Saltiel, assistant corporation counsel of Chicago, extended official greetings to the association.

H. T. Bentley, superintendent of motive power, Chicago and Northwestern Railroad, talked to the association on mechanical problems that have to be solved by the railroads. This paper appears on page 184 of this issue of the magazine.

### Report of the Secretary

H. D. Vought, secretary of the association submitted the following report covering the period since the last convention met in Minneapolis in 1920.

*To the Officers and Members of the Master Boiler Makers' Association:*

Gentlemen: Your secretary herewith respectfully submits the following report of receipts remitted to the treasurer since the last annual convention at Minneapolis, in May, 1920:

Receipts

1920-1921

| | | |
|---|---|---|
| From dues | $1,003.00 | |
| From initiation fees | 129.00 | |
| From miscellaneous sources | 89.00 | |
| Total | | $1,221.00 |

1921-1922

| | | |
|---|---|---|
| From dues | $443.00 | |
| From initiation fees | 9.00 | |
| From miscellaneous sources | 3.15 | |
| Total | | $ 455.15 |

Membership Record

In Good Standing at Close of Last Fiscal Year

| | | |
|---|---|---|
| Active | 200 | |
| Associate | 11 | |
| Honorary | 5 | |
| Total | | 216 |

The above includes 43 new members enrolled at and since the 1920 convention.

During the same period:

| | | |
|---|---|---|
| Died | 12 | |
| Resigned | 1 | |
| Dropped for want of address | 7 | |
| Total | | 20 |

Delinquents

| | | |
|---|---|---|
| Under suspension for 1920 dues | 4 | |
| Under suspension for 1921 dues | 158 | |
| Under suspension for 1922 dues | 119 | |
| Total | | 281 |

Some of these delinquents have met their obligations in the new fiscal year. Based upon past experience at annual conventions it is anticipated that when the record is made up for this convention it will be found that the total number has been further reduced.

Of course those in arrears for 1920 also owe for the succeeding three years, those of 1921 for also 1922 and 1923, and those for 1922 likewise for 1923. If all paid what they owe the Association would be richer by $1,448, and the membership roll would show a total of 497 in good standing.

Supplementing the above report the secretary stated that during the course of the meeting many delinquents had been reinstated in the association and a substantial increase of funds realized. The total membership of the association is now about 480.

### The Treasurer's Report

The treasurer, W. H. Laughridge gave the following financial statement of the association for the period ending March 13, 1922:

*To the Officers and Members of the Master Boiler Makers' Association:*

GENTLEMEN: I beg leave to submit the following statement of my office as Treasurer for the period ended March 31, 1922.

| | |
|---|---|
| Receipts | $2,836.21 |
| Disbursements | 2,527.99 |
| Balance | 308.22 |

### The President's Address

In his annual address for the good of the association, Charles P. Patrick, president, outlined the present status of the railroads and the part that members of the association must play in re-establishing them on a firm, economic basis. The roads have experienced a period of stress now for several years and it is not to be expected that conditions will become normal immediately. Individuals will probably never go back to the old standards of living and neither should railroads be required to operate on a valuation based on anything other than the amount for which they could be built today.

The foreman boiler makers, as a part of every organized railroad represent 75 percent of the operating end in the form of maintenance. The boiler is the foundation of the entire works and the responsibility for its proper construction and maintenance is entirely in the hands of members of this association.

### Business Session

In the course of the business session which occupied the remainder of the Tuesday session, a telegram from T. P. Madden, second vice-president of the association was read tendering his resignation from this office. Later a letter was received confirming this action.

F. W. Fritchie, master mechanic of the Baltimore & Ohio Railroad who represented the Master Boiler Makers' Association on the Bolt, Nut and Rivet Proportions Committee of the American Society of Mechanical Engineers' Standards Committee reported the progress made at the organization meeting held March 16. The work of the committee has been divided among seven special committees and further reports of the standards developed will be published from time to time.

## Wednesday Morning Session

A paper was read on "Promoting Locomotive Safety," by A. G. Pack, chief inspector, Bureau of Locomotive Inspection.

This paper will be published in an early issue of the magazine.

Next A. R. Ayres, superintendent of motive power of the New York Central and St. Louis Railroad, read a paper on the "Economic Importance of Adequate Locomotive Maintenance," which will appear in a future issue.

## Report on the Autogenous Welding

T. F. Powers as chairman of the Special Report Committee on autogenous welding stated that the purpose of this special committee was different than any committee on welding that has ever handled this subject for the association. The main purpose was to find out if possible, by actual experience and observation, whether autogenous welding is a success or a failure. In the report no attempt has been made to distinguish between the electric arc or the oxy-acetylene process. Members of the committee visited about 25 different railroads and as many as eight or 10 shops on some of them.

As stated in the report, the committee believes sincerely that autogenous welding is a success but should be handled in the right way. Failures have been found but in most cases poor supervision was responsible. Wherever the welding work was properly supervised and the proper kinds of material used, the welding as a general rule, has been a success.

Probably most welding failures are due to an inexperienced operator.

The report was prepared by T. F. POWERS, chairman, J. F. RAPS, H. J. WANDBERG, C. E. ELKINS, W. J. MURPHY and JOHN HARTHILL.

C. P. Patrick, Retiring President — Thomas Lewis, President — E. W. Young, First Vice-President

### Discussion

T. J. Reddy, Danville, Ill., C. & E. I. R.R.: Is it better to weld the flues at the time of application or is it better to apply them by the usual method and then run them for some time, say a month or six weeks, then clean the flues and sheets and weld them, or do you get better results from welding at the time you apply the flues?

Mr. Nichols, Monon Line: I have proven to my own satisfaction that the electric welding of the superheater flues is a success, even in the worst water conditions. I am satisfied that it has increased our flue mileage pretty close to thirty percent.

The welding can be done with good results by filling the boiler with water, sand blasting and then going over the flues with the oxy-acetylene torch, in order to heat them up enough to get any grease out where the welding will take place.

John Harthill, Cleveland, New York Central R.R.: We use absolutely no grease in preparing the back flue sheet; in drilling the flue holes, we use a soda compound. We apply our flues just the same with the copper ferrule and take just as much pains to work the flues as though they were not to be welded.

In setting the flues, we use soft soap for lubrication of all tools. In doing this, when you apply heat to the flue the soap dries and falls off. If oil were used it would run around the flue to the end of the weld, and there is where you later have a leak. After the flue is welded, we use a beading tool and that roughs the flue and brings up the bright metal; then we weld the flue.

I cannot see why you should weld flues in a boiler with water on one side and the extreme welding heat on the other.

J. A. Anderson, Industrial Works, Bay City, Mich.: Our boilers are the vertical type, for the most part, and we are thinking about welding the beads of the tubes at the end. Any information on this work will be very much appreciated.

T. W. Lowe, C. P. R.R., Winnipeg, Man., Can.: We have been working on a plan of our own, and I want to tell you that we weld all our superheater flues with good success. We also have applied a new firebox to one engine with superheater flues and the smaller flues all welded to find out what we can do with them.

We had complete success until the time came that these small flues required to be worked upon. We ran that engine about forty thousand miles before we had to work those small flues and at that time we found it was very difficult to maintain them tight. It was undesirable to have them welded because they cannot be worked as well as when they are applied without welding.

G. W. Bennett, I. C. C., Albany, N. Y.: Several years ago, Mr. Lowe made a statement that he was applying tubes up in Canada in the bad water district without the copper ferrule. I would like to ask him if he is still following that practice.

T. W. Lowe, C. P. R.R.: We have returned to the copper ferrule in the superheater flues. We have always used the copper ferrule in the small flues.

C. A. Nicholson, Southern Railway, Atlanta: Years ago, we never got over nine months from flues. At the end of nine months, it was necessary to remove these flues. Now with welded flues we get four years and, in some cases, on our new engines the federal inspectors have granted us an additional year, and they would grant more, possibly, if we would ask.

We also have bad water conditions, but we have one division where we do not have to weld the flues at all, they will run four or five years. We have divisions going into Florida and Alabama where it is necessary to remove part of the flues in a year, even now with the welding, but during the months that these flues are in the boiler, we have cut the roundhouse forces practically in two.

We have tried several ways of welding flues and after going through them all, I find that the best way of application of the weld is after the engine has been fired up or run a week or even two weeks, but it should be as early as that in order to get good service out of them.

We weld them without water and with water. We clean them with a beading tool, we do not use the sand blast; the better they are cleaned, the better they will hold.

W. P. Harrison, A. T. & S. F. R.R., La Junta, Colo.: Relative to vertical stationary boilers, I would like to say that we have one at Mohanta, Colorado, located on a clam shell. We had a considerable lot of trouble with flues leaking, in fact, we renewed the flues as often as once each six months.

About a year ago, we renewed those flues and beaded them and expanded them on both ends and electric welded them to the sheet on both ends. Since that time, they have never been worked any more. The clam shell is now in the shop for repairs, but there will be nothing done to the flues because they are in first class condition; that trouble was overcome by welding in the flues.

A. N. Lucas: I would like to ask the gentleman who just spoke, if electric welding flues in this vertical boiler stopped the gathering of scale on top of the flue sheets. If it didn't, your flues are going to leak. I have had experience with vertical type boilers, and I never had any trouble with them leaking until the mud got there, then I would pull a few flues and go ahead again. Then we changed our plan and got the mud off, then we got service again, but on vertical type boiler welding the flues will not help unless you keep your flue sheet clean.

W. P. Harrison: I would like to say we worked the boiler before we welded the flues and since, but the flues have not leaked for one year. Up until that time, they were continually leaking. We are using the same water and under the same conditions, therefore, I am bound to say that welding in the flues was what gave us the results which we are now having.

H. B. Stevens, Santa Fe, Topeka: I believe the electric welded flue is a success, and they should be applied in the usual manner of applying flues, and carefully beaded down, before the engine goes into service, it should be fired up and give the flues a chance to set and the grease burned off, then weld with the proper welding fire and not get too much

**Frank Gray, Second Vice-President**

**T. F. Powers, Third Vice-President**

**J. F. Raps, Fourth Vice-President**

metal on. We are running the flues, superheater and small flues, all welded.

The experience we had along those lines in taking care of flues was that welding will reduce roundhouse labor possibly fifty percent. We had one particular place where we ran the flues from eight to nine months and it was necessary to take them out on account of leaks caused by scale accumulations. They have taken care of the water with proper water treatment and we are now increasing the flue mileage better than seventy-five percent.

When the water got bad in the bad water district, it was necessary to look after the flues a little closer in the back flue sheet and expand the flues as much as necessary, in order to keep the scale accumulation away from the sheet.

C. E. Elkins, Missouri Pacific, Little Rock, Ark.: I would like to say a word about the vertical upright boiler. If they are properly welded, they will run about twice as long as they will if not welded. We weld every flue we put in. We do not have half the trouble with the vertical boilers that we used to have.

The ideal plan of welding flues, to my mind, would be to run the engine about two trips. We run the engine out, fire it up, put it up to top pressure and after the engine fire is knocked out, we sand blast the sheet and weld the flues. I might say we do not have any trouble.

John G. Harthill, N. Y. C. R.R., Cleveland, O.: A great many operators just weld around the outer edge of the flue bead, making it similar to a double bead. If they will weld the flue from the center of the bead over to the edge of the sheet, a great deal better success will be obtained than running a layer around the edge. It takes but very little longer to do that, in fact, a 5/32 inch wire will weld one 2-inch flue from the top of the bead down to the edge of the sheet.

T. F. Powers, C. & N. W. R.R., Oak Park, Ill.: On the railroad I am connected with, I have tried to weld flues under all conditions but cannot weld them and run them successfully.

Now, we have had flues that have been welded in our own shop, we have had flues that have been welded in the locomotive works, we have had flues that we have contracted, that is, the engines have been sent to outside railroads for repair, where they were welding flues successfully on that railroad, welded our flues in exactly the same condition, sent them back to our railroad and put them in certain territories and we cut them off in two months. That isn't welding flues successfully.

I think there are two elements that enter into this flue welding question, one is water and the other is coal. Unfortunately, we have some very poor water and we get some bad coal. I am absolutely sincere in my conviction that on the railroad I am connected with, we cannot run electric welded flues successfully. I do not believe where you weld flues and cut the welds off in sixty days to six months, and have to reweld them, have the flues split and bridges crack, that you are running them successfully.

H. H. Service, Santa Fe, Topeka, Kan.: When scale gets on the back end of the sheet or the water side, it has a tendency to overheat the metal, regardless of whether it is a small amount or a large amount, you will have mud burned sheets. The welding isn't responsible for this condition. Remove that scale from the back end, so to have water against the sheet instead of the scale.

J. F. Raps, I. C. R.R., Chicago, Ill.: We have water districts on the Illinois Central where we are running our flues four years and we have other districts where, if we get eight months, we are doing fine. I cannot see the necessity of welding in a district where we get only eight months on flues, on account of scale, where it costs such a small amount of money to replace flues.

Every railroad is making intensive flue drives and everybody has read articles in the technical papers telling how much a sixteenth or an eighteenth of an inch of scale will affect the consumption of fuel and it does not take very much scale to pay for the removal of two or three sets of flues on a coal bill.

We have gone into the welding of flues a little on the Illinois Central and there are certain classes of engines where you can weld flues and weld them successfully, and that is in connection with a small firebox where your flues are covered with coal when the engine is in service and the beads burn off rapidly. We weld flues in those engines and increase our mileage on the flues probably fifty percent.

On the other engines, where we have plenty of fire clearance, we are not welding any flues, we do not need to, because we are saving money by taking the flues out when they get heavily scaled.

As a member of the welding committee, I wish to say that we did quite a bit of work investigating and, as you will notice in the report, we called your attention to the fact that a great deal of welding was being done by incompetent welders.

That sort of thing is giving welding a bad reputation.

The main thing, is to have the work properly prepared, using the proper material and getting a competent welder.

We have welded most everything on the Illinois Central in the form of crown sheet patching, and up to the present time we have never had anything fail.

Professor A. S. Kinsey, of the Stevens' Institute of Technology, next outlined several fundamental principles of the metallurgy of welding, in explanation of trouble experienced with tubes leaking after they had been welded in the sheet. Originally, the tubes are comparatively pure steel, with the grains close together and free of sulphur and phosphorus. After the flues have been in service and repeatedly heated they absorb impurities, especially sulphur from the gases of combustion.

This absorption changes the structure of the steel, enlarges the grains and the inter-granular spaces become coated with a scale of sulphur; cohesion is destroyed and the tensile strength of the metal is decreased. To overcome this in welding and reduce the grain size, it is necessary to bring the tube end up to the welding heat slowly.

W. J. Murphy, Pennsylvania R.R., Allegheny, Pa.: On the Pennsylvania Railroad, in Pittsburgh, we are welding practically all our flues successfully.

E. W. Young, C. M. & St. P. R.R., Dubuque, Ia.: While we have a few engines with the superheater flues welded, we have none with the small flues welded, and I do not think that many members are getting more out of their flues than we are. I do not see where it is necessary to weld flues, especially in good water districts.

A. G. Pack: Speaking of bad water districts, we often hear water east of the Mississippi river spoken of as "bad water." I often tell them they ought to go out west on the Northern Pacific or Santa Fe to find some bad water. I was in sometime ago at the office of a superintendent of motive power, and he told me what horrible water conditions they had. They could not keep the staybolts tight. A few days later they had a crown sheet failure, and the engine had been in service twenty-one years. That is the bad water they have.

We are frequently told about bad water, and when we talk about flue time extension, it is good water. If you want to find bad water, go out on the Milwaukee, the Northern Pacific, come on down through that middle western territory. But when you get east of the Mississippi and complain about bad water, you don't know what bad water is. When they get around the coal mines in Pennsylvania and West Virginia, they find an acid condition, that does eat away the material, but it is not bad water.

Mr. Fairchild, Atlantic Coast Lines: We have tried every method we could learn, read or hear of in welding flues; counterbored the sheets, tried it without working, without copper, and we have finally decided that the most practical way is to put them in and weld them in the usual way, and if you fire up and burn the grease off either one will do. We have welded with and without water.

In following up our autogenous welding, I find that the main trouble is not enough instruction. An official in a supervisory capacity has most of his time taken up in managing, or should be, we will say fifty percent; about twenty-five percent of his time is taken up in supervising, and the other twenty-five percent is left to instructions. If our supervisors or any member of our association is not an experienced autogenous welder, how is it going to be possible for him to instruct a man or get in a firebox and tell whether a man is making a perfect weld?

In order for us to know, we ought to put on a pair of goggles and go in and see if that man is making a weld properly or not. We have very little trouble with autogenous welding, and whenever it is a failure it is due to incompetent welding or poor material.

Mr. Wanamaker, Rock Island, R.R.: I think the Master Boiler Makers and the boiler makers as a whole, are to be given a great deal of credit for the efforts they have put forth in acquiring a knowledge of using a new process such as the autogenous welding process, and I think they have made all the haste probably that is advisable, on account of us doing a lot of bad work; on account of us not knowing how to take care of a good welded job after it was welded; on account of not knowing how to prepare the work, how to buy apparatus, how to buy the proper materials for welding.

I want to say that, personally, I am a pioneer in autogenous welding, going back to the thermit process before we even had gas or electric, and I do not like to see haste made too rapidly.

On the Rock Island, our boiler makers who are directly in touch with the maintenance of our fireboxes, will get up and swear one hundred to one for the success that they have had, but they have been years learning it.

P. S. Hurst, B. R. & P. R.R., Du Bois, Pa.: The flues are put in and worked before we start to weld, then the engine is broken in, that is, it is taken out of the roundhouse or back shop and they are brought back into the roundhouse and dumped. We sand blast the flues and weld them. We have saved five or six men in the roundhouse that we had before, and our flues will average twenty months.

As far as the water is concerned, we think we have bad water in one division, but I have put in a number of years working in St. Paul, and I know our water is not as bad as it was in St. Paul.

H. H. Service, A. T. & S. F. R.R., Topeka, Kans.: I want to illustrate two conditions that we have, we do not have all success. On our coast lines, we used to get twenty thousand miles, that was pretty good service, before the flues were welded. Now they are getting sixty thousand, shopping to shopping, practically. It is a bad water district and I do not believe they are having any failures.

Then we have another condition over our Illinois Division, where we have honeycomb. You can weld the flues or you can let them go without welding. New fireboxes right out of the shop will get a deposit five inches thick, and then do you expect flue beads to hold under the condition? Welding would not hold them, how can a flue bead hold them?

Following this discussion a motion was passed by the association that the General Managers' Association of the railroads be requested to have all master boiler makers and foremen of the various railroads attend the conventions of the Master Boiler Makers' Association.

Another motion proposed which was not passed, was that a boiler maker accompany the Interstate Commerce Commission inspectors on their tours of locomotive inspection. In order to clear up the misunderstanding in the minds of some of the members of the association, as to the methods employed by inspectors of the bureau of locomotive inspection and the way in which they are appointed, A. G. Pack, chief inspector stated that this matter had been very thoroughly discussed in Congress when the Bureau was first organized. No monopoly is given to any craft in inspection work, for all men in the service must pass the required civil service examinations. If a man can pass the examinations on the construction of the locomotive and tender, he is eligible for a position as inspector. Inspectors of the Bureau are about equally divided between boiler makers, mechanics and engineers.

**W. J. Murphy, Fifth Vice-President**

**H. D. Vought, Secretary**

**W. H. Laughridge, Treasurer**

**L. M. Stewart, Chairman Executive Committee**

## Wednesday Afternoon Session

Most of the afternoon session was taken up with the showing of moving pictures showing the production and use of oxygen and acetylene in connection with the oxy-acetylene welding process. Professor A. S. Kinsey of the Stevens Institute of Technology and service engineer of the Air Reduction Sales Company gave an explanation of the pictures wherever necessary. These pictures were shown through the courtesy of the United States Bureau of Mines and the Air Reduction Sales Company, Jersey City, N. J.

## Oxy-Acetylene Welding

We are satisfied that welding done by the oxy-acetylene process can be successfully and substantially done and give perfect satisfaction and service, with great help and saving in repairing and in maintenance and construction of steam boilers.

Care should be taken to see that a competent man is assigned to the welding; a man that is known to understand the nature of welding, and has been tried and tested out before he is put on a job of welding; that is, to stand a constant pressure as in a boiler weld.

We find that successful welding has been done on all stayed portions of the boiler. It is not necessary to enter into details here as this subject has been before the Association several times and all are acquainted with different kinds of welding.

We feel justified in recommending oxy-acetylene welding as one of the best known methods of repairing and building boilers.

This report was prepared by a committee consisting of D. A. LUCAS, chairman; H. J. WANDBERG and THOMAS LEWIS.

DISCUSSION

Thos. Lewis, Lehigh Valley R.R., Sayre, Pa.: For a number of years back, at our different conventions, I have always talked on this subject. We have had quite a number of years now where we have done work with the acetylene welding. Prior to the war, we had some good welders and we did some good work. When the war came on, we lost some of our good welders and it interfered very greatly with the efficiency of the work, and now we are starting or about getting back to where we were prior to the war, and doing welding work in our locomotive fireboxes.

Personally, I think ninety-five percent of the efficiency of that work depends on the operator and the preparation of the job he is going to work on. I believe a good job can be done and a permanent job, notwithstanding all the mistakes and the failures which we have made, I believe this method of repairing fireboxes in locomotives has come to stay, and it is my personal opinion that it is going to get better as we go forward with this work.

In the year 1913, we turned out the first locomotive firebox that was ever turned out in the United States, which was welded throughout, and that firebox never gave us any trouble. We had a competent man to do the work and everybody took an interest in it, and I believe if we continue to take an interest in it and see that we have good men, we will do good work. I do not believe that firebox ever cost us a cent in the matter of repairs, until the engine was dismantled. It was one of our first attempts and we took a small locomotive that was carrying the pressure of one hundred and sixty pounds.

D. A. Lucas: I was one of the first in the acetylene game, and I did it for several years and saw lots of it done, and every time I get a chance, at the present day, I do not lose any time in finding out all I can about acetylene or electric welding.

Now, in my observation, the whole secret is getting the right man on the job. There is one road that takes an interest in it and they pick their men and they do everything they can to get good welding, and they get good results. I know one road that did welding in 1910 and they never have had a bit of trouble with welding. When I say "a bit of trouble," we have had little leaks open up in the welding, not any more than getting in and calking a patch, putting on rivets or patch bolts.

J. J. Keogh, Rock Island R.R., Moline, Ill.: We have been in the game of welding for the past seven or eight years. We have welded sheets of all descriptions; we have eliminated riveting everywhere; we have taken out side sheets, putting the first and second row of staybolts about the fire line, in which the bad sheets were, and successfully welded in sheets. For the past several years we have not had a failure from acetylene welding.

We have been welding in the sheets on the Rock Island for seven years, and we do not know what a failure is with the oxy-acetylene welding or the electric welding, by using this method. I consider it better and more substantial than riveting.

W. H. Evans, Georgia R.R., Augusta, Ga.: I keep a record of every weld that is made and the man's name who does the work, and we have been welding for about seven years, and we have not had a failure of a weld that was done by a good welder. We have had one or two slight failures of welds done by a man who was not really accomplished, but they are only small leaks, no breaks. That man had not reached that stage of perfection that he could do the right kind of work.

Right now I would say that my opinion about welding is simply that the whole matter is with the man who does the job. If you have a man who can weld and make a good weld, there is no danger whatever in welding. I have never had any experience in welding flues; we do not need that on our road, they will run ten or twelve years without welding.

We have about twelve or thirteen fireboxes that are thirty-one years old and they are practically made up of acetylene welds. All boiler makers know how many cracks have developed in that length of time, and all the old patches have been cut out and patches welded in that were put on there years ago, and of all those jobs there has not been one failure. We make the job as good as the original metal.

T. W. Lowe, C. P. R.R., Winnipeg, Man., Can.: I might give you a few words in connection with oxy-acetylene welding, not because we have it in general use at the present time, but because when we were making use of it we got very good results.

We did our first welding in 1908. We put in three-quarter side sheets on an engine about eight staybolts deep from the mud ring up, and those side sheets are still there.

I thought it would be helpful to you to know that the very first one, without a skilled operator, was satisfactory. I am very much in favor of having a skilled operator, but the first operator is not generally your skilled one. We have an expert come and spend some time with us when there is something special going on; and when some particular man has shown a tendency to learn the business, we put him on. We make the best operators from our own apprentice boys.

## Report on Electric Welding

The report on electric welding, outlining in detail the various methods employed for repairing locomotive boilers by the use of the electric arc process, was published in full in the October issue of THE BOILER MAKER. Numerous drawings are included in the report, illustrating the application of the process. Instructions include the welding of complete fireboxes, half side sheets, door sheets, firebox knuckle patch, patches in front and back flue sheets, crown sheet patches and the like. The report was prepared by H. H. Service, chairman, I. J. Poole and I. W. Clark.

DISCUSSION

W. H. Laughridge, Hocking Valley Railroad, Columbus, Ohio: We have heard the subject of autogenous welding discussed here year after year and I think the association should go on record as to rules and regulations governing welding.

I would move that we appoint a committee to draft resolutions of a method of welding, either acetylene or electric, and have that committee report back to the convention before we adjourn, for the ratification by the body.

T. F. Powers: Last year there was a special committee appointed to make an investigation of welding. This committee traveled over a good part of the country, visited a good many railroads in the United States, and I want to draw attention to the last part of the report read here this morning, and that is as follows:

"And we are of the opinion that each railroad or sectional railroads will work out its own method of repairs, based on conditions and experience."

That is the recommendation of your special committee that was appointed last year, and that is our honest belief that each and every one of us on our particular railroads have to work out our own problems.

W. H. Laughridge: It was not my intention that any set of rules would apply to an individual railroad. My idea was that this convention go on record as to what is good practice and what is not good practice.

## Thursday Morning Session

Chairman Patrick called the meeting to order at 9 a. m. o'clock on Thursday.

E. W. Young: I believe every member of this association ought to be interested in Mr. Pack's paper, read here yesterday. We ought to go on record as to what we are trying to do to comply with the law and prevent accidents.

Mr. Pack dealt with some of the things that have always been talked of as being insignificant, but which cause serious injury or death. Take, for instance, the washout plug. We have inserted a paragraph in our boiler maintenance code prohibiting the practice of tightening up a washout plug with pressure on the boiler.

Mr. Pack also dealt with the arch flues. Everybody knows what happens when an arch flue pulls out. When I was in the service, I had occasion to investigate several accidents and I believe in every accident that was investigated, failure was through the fault of the boilermakers. They would cut arch flues short and sooner or later they would pull out and somebody would be seriously injured or killed. That is what you get from arch flue failures.

In order to overcome that, we have issued a certificate; a man who applies an arch flue has to certify: "I have applied right (or left) arch flue, and the same is properly beaded, etc." and he signs it as boiler maker. Just below that is a little statement, "I have examined same and found the statement to be correct." Therefore, you have two men examining those arch flues. Since we have adopted that, we have not had any trouble with arch flues.

Mr. Pack also spoke of autogenous welding. We have issued a circular letter on autogenous welding, just as Mr. Pack recommended. When we put in flue sheets, we rivet them across the top and weld them all the way down.

Mr. Pack also spoke of staybolt accidents. We have issued a circular that anyone caught violating Rule 21 or 22 is going to be held personally responsible for his own action.

## Button Head or Screwed Stays

Up to several years ago, the crown stay generally used on the radial stay fireboxes was of the button head type. The more general use of oil as fuel in fireboxes demonstrated the need of a crown stay without as much bulk and of a smaller head than the button head type.

In most cases when the button head bolt was used in oil burning fireboxes, they could not be maintained. The heads on the bolts crumbled and broke away in pieces, leaving the crown bolt in weakened condition.

The riveted head bolt with a taper was then generally adopted on most oil burning fireboxes and was generally a success. Due to the success of the hammered head bolt in oil burners and the fact that it was much easier to apply and maintain, it was then adopted on some roads as a standard for coal burning locomotives as well as those burning oil.

The only objection that can be raised against the use of the hammered head bolt with taper, used as crown stay, is the fact that it is not as strong as the button head bolt.

In order to reduce the amount of iron in the fire, some roads made it a practice on all oil burning locomotives to drill off one-third to one-half of the head on the button head radials when they were used in the crown sheet. This was not a success as it still left a large amount of iron and like the full button head bolt, crumbled and left the bolt in a weakened condition.

We would recommend for the following reasons the adoption of the stay screwed into the crown sheet with the taper and riveted over.

1. That it is of ample strength.
2. It is easier to apply than the button head on account of being tapered.
3. Less work is needed to replace on account of the rank taper in firebox; can be cut free in roof sheet and in firebox, and driven clear of crown sheet, thereby avoiding a lot of extra work cleaning broken ends off of crown sheet, where, in a great many cases, bodies of bolts become fast between braces and cannot be removed.
4. Easier to get tight and does not strip, can be pulled up tight regardless of the angle of the sheet.
5. Gives little or no trouble in service, while the button head type of bolt leaks very easily, and when it does leak it is hard to calk, and if not calked properly is wedged away from the sheet, making it necessary to renew the bolt.
6. Gives a cleaner crown sheet both on the water and fire sides of the sheet, and does not collect dirt and cinders as does the button head, and gives a more even head surface.
7. Can be manufactured at less cost than the button head stay.
8. Gives a saving in tool bills, both in making of bolts and in reaming and tapping, as the one tap and reamer can be made to do for three or four diameters.
9. Can be carried in stock threaded at both ends ready for use.

In applying the hammered head radial with taper, we would suggest that the first five rows of radials in the center of the crown sheet from the back flue sheet be applied without the taper. This weakens the high point of the crown sheet and, in case of low water, probably would let go by bagging and pulling out these few bolts while the rest of the crown sheet with the taper radial stay would hold.

The report was prepared by LEWIS NICHOLAS, JR., chairman, T. F. POWERS, J. J. MANSFIELD.

### DISCUSSION

Lewis Nicholas, Jr., C. I. & L. R.R., LaFayette, Ind.: I do not believe it is really necessary to read this report, because I think all the boiler makers here are familiar with it. I do not know that there is much more we could add to it in a discussion.

T. J. Reddy, C. & E. I. R.R., Danville, Ill.: We are using 1½-inch taper in 12 inches, as I figured out that 2 inches in 12 was a little bit too much taper. We ran too many chances of not getting the taper on our bolt and the taper on the tap exactly the same. The more taper you get on a bolt, the more possibilities there are in getting your taper a little bit too small or a little bit too big.

T. F. Powers: The Chicago and Northwestern, the road I am connected with, some years ago converted a large number of engines from coal to oil. We had very little experience in burning oil prior to that time, and we decided that on account of the excessive amount of iron in the button head bolts used at that time that we would cut off part of the button head. In that manner we thought we could run the bolt successfully; that is, the button type. After running them for some time, we found we got into all kinds of trouble in the oil burning locomotives. The heads would come off and they would crumble away.

Personally, I was opposed to going to the oil burner type of bolt, the bolt hammered over the same as the straight bolt, due to the fact that I thought on account of certain conditions there was a possibility of the sheet not holding up. So we conducted some tests in the laboratory out at the shops.

We found that under ordinary working conditions, that is, with water over the sheet, that you had ample strength and even under cherry red conditions, I believe that the report shows the sheet will hold 2,900 pounds before it comes down. Of course, it is hard to determine what is the actual heat condition of an engine under low water condition. So we decided to go into taper radial bolts for oil burning locomotives. We followed along this line of reasoning, that if it was a good thing for an oil burning engine, it certainly ought to be a good thing for a coal burning engine.

You gentlemen have had experience with the button head type of bolt. You have to make it fit, and a good many of you use reamers to get a proper fit on the crown sheet. Then if you get leaking on the road, the ordinary boiler maker goes in there and calks it away from the sheet instead of to the sheet, and in a short time you have a doorknob and it is impossible to do anything with it.

We have been using a taper head bolt as a standard installation on our fireboxes, with an inch and a half taper to the foot. There has been some difference of opinion relative to the taper that should be used. There are a good many men in this room who think we ought to stay to the button head type of bolt. My personal opinion is that the inch and a half taper is the proper installation, not only for oil but for coal.

A. N. Lucas: I had considerable experience in boiler work in looking after oil burning engines. I think the Milwaukee road started to burn oil in 1908, and at that time we were running all the radial stays screwed in from the top, and we were applying a nut to the copper gasket.

When we got into the oil, of course the nut was a bad thing, so we took the nut off and cut the radials off and hammered them up, and many of the oil burning engines are still in service with the one inch bolt. We have had a few low water cases out there, but they were not any worse than if the bolt had been tapered.

I always figured that the little taper you get on a three-eighths sheet did not amount to much; but on a test it showed it pulled a little more. I think the taper bolt is the proper bolt to apply.

T. W. Lowe, C. P. R.R., Winnipeg, Man, Can.: In our oil burning district on the Canadian Pacific, which extends through our mountain section, we have had experience with both types of bolt and, unfortunately, we have had a like experience when a crown sheet failed with the button head bolt as we had with the taper bolt. Each of those failures were as destructive as the other; there was not a bit of difference. They went down from the front to the back and ripped through the side sheets and carried around with them and through the crown sheet up by the throat sheet.

Whichever is the strongest bolt in the cold state is the bolt we need. When we come to compare the maintenance service of the taper bolt with the button head bolt, we might tell you this, that it largely depends upon how we accommodate ourselves to the changed conditions of coal burning to oil. For this reason, when we started the oil burning, we had so much trouble with the button head bolts—we had nothing else but button head bolts and nut head bolts—we had to tear them right out and get in taper bolts.

We got in touch with these people who have been using oil for a longer period than we have. In Mexico, I think they have been using oil longer there than anywhere on the continent, and we adopted their taper and we put those in. But with longer experience in the adjustment of our pans and our brick work, we practically can run the button head bolt today just as satisfactorily as we can the taper bolt.

Geo. Austin, Santa Fe, Topeka: I am very much interested in the question of whether the taper head or the button head stay is best. It should be either one or the other. It is unreasonable to expect that it is the best bolt for oil burners and not the best bolt for coal burners. That is the way it looks to me.

In the present construction of locomotives, you have now with the stoker fired locomotives practically the same capacity to generate heat that you have in the oil burner.

I think, too, in considering the relative excellence or the relative performance of the large headed bolt, and the taper headed bolt riveted over, one ought to consider that while the large headed bolt is greater in strength in its cold condition, still that very strength might become a nuisance under other conditions. Of course, we do not care what it will do when cold; we want to know what it is going to do when hot. Is it not a fact that the more surface you present to heat in a firebox, the more heat is going to be taken into that particular place where you have that surface protected?

For example, a flat surface equal to the cross section of the big headed bolt, we will say, will present a couple of square inches of surface that will take the heat, but when you put a big headed bolt there you greatly increase your heating surface of that bolt; your bolt is a little thicker, but the heat goes so fast and goes so rapidly from the fire to the boiler, almost as rapidly as the sunlight will go through a glass, and it will go through there without diminution, so far as the temperature it had on leaving the firebox until it heats the water.

Now if that is a fact, if you have a large headed bolt and it is conducting the heat through the water more rapidly than an equal flat surface, don't you get more evaporation at that point than you do in places where you have not so much heat going through? If you are getting more evaporation at that point, are you not getting more precipitation? Whatever solids there are in the water must be precipitated at certain temperatures in that boiler and the more rapid the precipitation is in any one part of a boiler over another part of the boiler, that part of the boiler will accumulate the most scale and the most cinders. That is a certainty.

I believe that that theory is correct as an explanation of the fillet of scale forming around the necks of your staybolts. I do not think it comes from settling or freezing there; it is because there is an excess of evaporation compared to other parts and, naturally, an excess of precipitation. So then your large headed bolt, while it possessed the element of strength that the taper headed bolt did not, that element of strength under certain conditions, with the fillet of scale around it, may become a source of weakness.

It is my firm belief that the riveted over radial possesses all the elements of strength that are required either in coal or oil burning service, in good water or bad water; that in case of low water, you are more liable to have what I term a slow explosion. That is, with the unusually strong supported crown taking the heat until the whole thing gets hot all over, you will get a quick explosion that is not so liable to happen with a lighter construction; it is not so liable to happen with the taper headed bolt.

W. J. Murphy, Penn. R.R., Allegheny, Pa.: On the Pennsylvania Railroad, from one end to the other, they have a standard button head bolt, and I have never heard of any trouble with those bolts.

At one time, when we put a copper gasket under the bead, that gasket would burn out and they would begin to leak. Since that time we have done away with that gasket and put the bolts iron to iron; they probably apply them in different ways at different places, but at Allegheny and around there, they apply them that way. Put a light taper on the bolt and pull them up tight and we do not have any trouble.

E. W. Young: Our standard has always been the straight bolt with the copper gasket and the nut, 1⅛ inches on top, 1 inch on the bottom. We have had very good luck with that bolt. We have some engines today that are 24 years old with the original crown sheet and original stay. When we got into the oil burning district, we had to remove the nuts and hammer up the head, but the trouble was whenever we had a crown sheet failure the sheet would rip from stem to stern; it was very destructive in loss of life and to the boiler. The nuts were so strong they would hold to the last, and when they let go everything went. You will find that is the same thing with your button head.

In order to get away from that, we are adopting what we call a safety zone. In the front end of the crown sheet we are applying the hammer head bolt. We are now using taper bolts. Our taper is 2 inches in 12 inches. We feel that this is better than the one and a half in twelve.

Mr. Cook: In our shop, I guess less than two years ago, we took up the matter of taper crown bolts. On our road every engine is equipped with button head bolts. We have some engines carrying a heavy pressure, doing hard work. We found that after the button headed bolts ran quite awhile and the threads got a little bit rusted and commenced to leak that the sheet was driven right up over at least one thread.

When the matter of the taper bolt came up, our people examined the condition and they took the matter up with the B. & O. and we finally went into the taper bolt. Now we have adopted a taper bolt for all boiler work. We are putting in nothing else, even when we renew a button head bolt.

A. F. Stiglmeier, B. & O. R.R., Baltimore, Md.: The B. & O. has about as many taper bolts as any road. At Mount Claire we buy on an average of 9,000 taper bolts a month. But we have one rule that has to be lived up to; that is, never apply a taper bolt over 1 5/16 inches in diameter. If you do you will have leaky bolts. If we find a crown sheet that has holes on removing a button head bolt, and we have to apply a bolt larger than 1 5/16 inches, we will remove the crown sheet. That is how we get tight taper bolts.

A. G. Pack, chief inspector, Bureau of Locomotive Inspection: I have had a pretty wide experience in the last ten or twelve years, and some of the lowest water cases we have a record of are with the straight hammered head radial stay.

Now, we have investigated many crown sheets supported by button head radial stays after they had been in service for three, four or five years, when it was difficult to get the line of demarcation on the sheet, they gave away that quick.

The taper oil bolt, in my opinion, is one of the best bolts that can be applied. It will hold up under all ordinary circumstances; you will find ten button head bolts leaking where you will find one hammered head bolt leaking, and we all know what firebox leaks mean in the way of increased fuel consumption and discontent to everybody connected with the operation of locomotives.

There is no question in my mind but what the button head, while it is new, is the strongest bolt you can apply on the crown sheet, but due to constant heating, cooling, contracting and expanding, they become loose in the sheet, the threads wear away and the metal deteriorates to such an extent that it has little holding power.

A paper on this subject was contributed by E. W. Rogers, foreman of the boiler department, American Locomotive Company, Schenectady, N. Y.

The taper radial crown stay from the viewpoint of the manufacturer of boilers is preferable to the button head for various reasons, the most important of which are as follows:

Forging the upset end is a simple operation which can be done in one heat while the button head requires two heats. After forging, the taper can be machined economically on the Landis type of machine. This applies as well to the threading and chasing.

The greatest advantage in favor of the taper radial to my mind lies in the method of application. Tapping of the sheets for both types is the same. In the application of the taper radial, however, we are not obliged to contend with two fits; that is, the fit in the sheet and fitting the flange on the head of the bolt to the sheet. The latter fit is difficult to perform, especially if the line of application is other than normal to the face of the crown sheet. In such cases it is necessary to face the crown sheet to fit the bolt or work the high side of the bolt down with a flat calking tool. This condition invariably occurs on modern radial stay boilers where every six rows of button head bolts are applied through the top center of the crown sheet. Under similar conditions the use of taper radials would permit the application of the entire set of crown sets by merely welding or riveting to insure a tight and serviceable job.

As a step forward I would suggest that this convention, for reasons which are obvious, recommend for adoption a standard taper. Several railway systems require a 1½-inch taper in 12 inches while others specify 2 inches in 12 inches and it would seem as though one should be made standard. The American Locomotive Company standard is 1½ inches in 12 inches. Our engineering department is maintaining that this taper is sufficient to meet all requirements. However, I am sure they would be willing to consider for adoption any taper that this convention should agree upon as standard.

Personally I prefer the 1½-inch taper for the following reasons: Unless the tapers in the sheet coincide exactly with that of the bolt we are apt to have but partial bearing between the bolt and the sheet, which would be more pronounced with a suddenly abrupt taper.

With a suddenly abrupt taper we are obliged to provide unreasonably large holes in the crown sheet affecting thereby the life of the sheet.

With a suddenly abrupt taper we have an abnormally large head exposed to the action of the fire which affects the life of the bolt.

The 1½-inch taper would keep the preceding objections down to a minimum and would meet all requirements of the present day service, such as safety, maintenance, application and renewals.

## Advantages and Disadvantages of Treating Locomotive Feed Water

An abstract of this report prepared by T. P. Madden, chairman of the committee, George Austin, and E. W. Young will appear in an early issue of The Boiler Maker, as well as an outline of the discussion that followed its acceptance.

The discussion on this paper was continued into the afternoon session.

# Thursday Afternoon Session

## Welding Safe Ends on Locomotive Tubes

It seems to be the consensus of opinion of the committee that no difficulty is experienced in welding iron to iron, steel to steel, iron to steel, or vice versa. In this connection I wish to say, however, that where steel is being welded to iron, it is good practice to give the iron somewhat of a lead in the heat, as steel will weld very readily up from 2,500 degrees to 2,600 degrees F., and iron fuses nicely at about 2,800 degrees to 3,000 degrees. This can be very readily done when heating the tube and opening it to receive the safe end; then return to furnace immediately and it will have about the required lead in heat over the steel. If the tube should be placed in the fire with both iron and steel cold, I believe it to be good practice to set the material in the furnace so as to give the iron the benefit of the heat.

A large number of shops are welding safe ends onto tubes without scarfing, with very good results. The committee, however, recommends that the sharp burr be taken off the outer edge of the safe end before inserting it into a tube, otherwise when being rolled down in welding the sharp edge cuts in and thereby weakens the wall of the tube, causing the tube in some cases to break off.

It is the further opinion of the committee that it is not necessary to use flux in welding. In a good many cases dirt and foreign matter become mixed with the flux, and when it is applied to the metal prevents cohesion, and the result is a defective weld.

### Causes for Poor Welds on Safe Ends

Investigating complaints of trouble experienced in the welding of safe ends, we find that this can be attributed mostly to one or two things, or both—improper construction of the furnace and the roller welding machine not being speeded up to the revolutions necessary to make a quick and sound weld. The roller welding machine should have a speed of not less than 450 revolutions at the fly wheel. The burner should be placed so that it will not blow directly upon the material; better at right angles, either top or bottom. In some cases I have found that they mixed heavy crude with kerosene oil; this brought about better combustion and better results were obtained from the furnace.

Welding safe ends by the electrical spot welding machine, in the opinion of the committee, will eventually supersede the present method. Mr. John Doarnberger, a member of this committee, for the benefit of the Association, has made a number of tests, both as to cost, quality of material, and strength of welds. He states that the average consumption of current is about 20 kilowatts. In considering the cost the current is one cent per kilowatt hour delivered to the machine, and would cost about 20 cents per hour for current. Mr. Doarnberger claims that he can turn out about 85 flues per hour, which would make the cost per flue about ¼ cent for current. To operate this machine, however, it is necessary to have available alternating current, 60 cycle, with 110 or 120 volts. They will not operate on direct current.

In connection with the electrical spot welder, I find tubes and safe ends being chamfered to about 30 degrees at the Omaha shop and when the safe end is inserted there is a lap of about 3/16 inch, and this, in my opinion, is the better method; or, I would prefer it over the butt-welded, because if the material carbonized and broke off at the weld, after going into service, it would drop into the boiler. On the other hand, if it is lapped there is less liability of the tube breaking off from the safe end completely, and in this way would cause less damage.

At the Atchison, Topeka & Santa Fe shops I found the most up-to-date electrical spot welding machine, which has a roller attachment on the machine, the tube being heated and rolled down without moving from the machine to the roller, as is the practice in other shops where the spot welder has no roller attachment.

In conclusion, I wish to say that in most large shops—with the present method of furnace, roller and hammer welding—two men are employed in the welding, one piecing up and the other welding. In this way the tube is not allowed to cool off and it takes less time to heat; you might say this brings about continuous welding. I find that in most up-to-date shops they claim to weld about 50 tubes per hour, some places, however, are doing even better than that.

P. J. Conrath, boiler tube expert, National Tube Company, 4414 Michigan Ave., Chicago, Ill., chairman. Members of committee: J. A. Doanberger, Alfred R. Stiglmeier.

### Discussion

P. J. Conrath: The Santa Fe has a good electrical welding apparatus at Topeka and it is the most up-to-date machine of that kind there is.

My observation around the country has been this: There has been a lot of trouble in welding; a lot of men claim that they have as high as twenty-five and thirty percent failures in testing flues; others claim they have a number of tubes breaking off, after they have gone in service, which we find is due to overheating.

I have come to this conclusion after looking into this matter in the different shops; in some places I find that the welding machine, the roller machine is not speeded up high enough. You should have not less than four hundred and fifty to five hundred revolutions at the fly-wheel, which would give about two hundred at the roller.

The next thing I find in a good many cases with the furnace is that it is rather short and the burners are entered from the end, and they play directly on the material. While you have a good clean oil, you have proper combustion and there is no trouble in getting along, but we all know that the finest oil is not furnished for flue welding purposes. We get little specks of oil on the metal and you cannot get a good weld at that spot.

To overcome that, I would say to place your burners below or above or if you cannot do that, at least have not less than thirty-six inches as the length of your furnace. Place your burner back from the end of your furnace, so you give the oil a chance to burn properly.

The analysis shows that the metal is not injured in any way by the electric process and you do away with the dirt and the noise in the shops. It makes a cleaner weld and I believe that it will supersede all of the other methods of welding eventually.

J. A. Doarnberger, N. & W. R.R., Roanoke, Va.: I believe that the first safe end that ever was electrically welded to a flue was done at the Roanoke shops of the Norfolk and Western Railway Company. By chance, I happened to be on the road one time, and I saw some welding being done by the electric system, and I got in communication with the Thomson people at Lynn, Massachusetts, they wrote me back and I gave them an idea of about what a machine really had to be to electrically weld a safe end on a flue. They sent the machine, subject to approval, for thirty days. That was along about 1913.

We started first butt welding and we kept that up until about three years ago.

On account of the safety movement on the Norfolk and Western, we stopped that and started scarf welding. We have several electric welding machines now that take care of our twenty-two hundred miles and we can run off with that machine, not varying from our usual procedure, about fifty-five flues an hour. The weld is clean. We use about one hundred and sixty volts to sixty amperes. We do not use any flux, but use instead a mineral which acts on the flue like borax and sheds all the impurities. We do not test our flues at all.

I know that for purity and a good homogenous weld and security, I do not believe anything will beat an electric weld, as far as safe end welding, whether steel against iron or iron against steel, it makes no difference.

G. W. Bennett: I investigate a good many accidents due to flue failures and I find that one of the principal causes of flue failures is due to the fact that they are using too small a welding mandrel. It leaves the flue at the weld in many cases about twice the thickness of the flue. That gives a stiff joint there. It also puts an offset in the flue at that particular point. After the flue is in service a while it starts to break. I have had many failures due to that, not only on small tubes but on superheater flues.

It was only recently that I was in a shop where they were welding superheater tubes and the welding mandrel was so small that at the weld the metal was just about twice the thickness of the flue. It does not make a good weld, in the first place, and the mandrel ought to be large enough so you can thin down the flue there. I find where the practice is to scarf both flues, the tendency is not to weld so thick; but where they scarf the safe end and build up the body of the flue, I find the weld like this. I daresay I have had, within a year, about twelve accidents just due to the welding mandrel being too small.

I believe everybody who has had any experience with welding with oil and the trouble they have with cleaning the furnace and bricking it up, will agree that the electric welded flue is the coming practice for all railroad shops.

W. H. Laughridge: While we have had no experience with the electric welder so far, we have been investigating the matter for the last two years. I visited a shop where the Thomson machine is used, on the Nashville, Chattanooga & St. Louis, two years ago. At that time, we were getting poor fuel oil and it was a question of getting something that would give us service; afterwards we got a little better oil, and we got along first rate until the present time. We have decided to put in an electric welder.

I spent a day at Portsmouth, in one of Mr. Doarnberger's shops, and I found the work very satisfactory, and the cost of current is less than the cost of oil.

Chairman Patrick: Say you only had about three thousand capacity, would it pay to equip a shop?

J. A. Doarnberger: You are talking about minimum output. I would say it would pay to put up an electric machine no matter what your minimum output, because your machine is ready any time you start. If you have a capacity of one set of flues a week, you do not have to start your oil furnace, but your machine is ready when you turn on the current. It is like an electric rivet heater; you can put the rivet in and in thirty seconds you have the rivet ready for the gang, whereas with the oil furnace, it takes sometime to heat the furnace.

L. M. Stewart: On the Atlantic Coast Line we have used the electric safe end machines for seven years, and until recently we butt welded the flues. Now we scarf them a quarter inch and we think we are getting better results than when butt welding with the electric machine. You understand with an electric machine it is very good practice to keep your anvil up to proper size, so you will not weld your flue too small at that point.

As to the output of electric welding, if you have seen an electric welder in operation and have seen how easy it is for the operator to weld you know that at the end of the day he has a splendid output and you have nice smooth welds. I am very much in favor of electric welding safe ends of flues.

Chairman Patrick: What percentage of failures do you have in the test?

L. M. Stewart: About five percent we did have with the butt welds, but we are getting down to about two percent on the scarf ends.

H. H. Service, Santa Fe: At Topeka, we have a reclaiming device, for reclaiming flues exclusively. We take our flues, cut the back part, about nine feet of the flue or ten feet, whatever part is affected; then it goes to the facing machine, then to the grinder, from the grinder it goes over to the welder, who heats it. We get on an average of thirty to thirty-five flues an hour, but there are two welds to a flue. We clean them out by two, ten foot pieces then and safe end on the end of it.

Fairchild, Atlantic Coast Lines: I just want to ask Mr. Doarnberger to explain a point that has not been explained. I, myself, in preparing the inside of the flue ream it out, using oil for lubricant, which is not satisfactory. I would like to ask how he prepares the inside of his flues; what is the method of cleaning the inside of the flue before applying the safe end? If there is any dirt or anything inside, we do not get a weld; how do you prepare the inside of that flue?

J. A. Doarnberger: If there is any foreign substance inside of a flue that has not been rolled off, understand it will destroy your contact. You can tell that in a minute, as soon as the current comes on, you can tell whether it is fusing right or not. You have to make preparation to clean that out, because you cannot get any contact if there is foreign substance inside.

L. M. Stewart, Atlantic Coast Lines: Those machines we have been discussing are the old types. I notice in the catalogs and also talking to the Thomson people, they have machines that will bring up the heat in five seconds, and they have improved wonderfully on the machines we have been using for six or seven years, and which take care of both small tubes and superheater flues in one machine.

George Bennet: There is an improved flue welding machine on the market at the present time, in fact, it has been used in some railroad shops for about four years, and they make the weld on the inside. It is rolled on the inside, and after the weld is made, the thickness of the flue at the weld is the same as the thickness of the flue. They have a set of jaws that come up and operate with air, then start the roller on the inside and roll the weld. It makes the best weld I ever saw. You can heat it any way, with electricity, coke or oil. But this machine rolls it on the inside, you do not have any welding mandrel on the inside and the trouble many are having, due to the small mandrel, is overcome.

## Elimination of Firebox Deterioration Behind Grate Bars

The most active agent of corrosion behind grate bars is sulphuric acid gas produced from the sulphur in the coal which is converted into sulphuric acid in the presence of moisture in the coal.

The principal reasons for this condition are poorly constructed grate bars and supports and ash pan hanger sheets, together with leaky mud ring rivets and staybolts, side bars and supports being so constructed that they hold the coal and cinders against the side sheet and the moisture from the leaky staybolts or rivets soon causes the sheet to deteriorate.

To prevent this condition, the grate bars should be constructed to fit up tight against the side sheet on top and should also have the top of bar made at an angle of 45 degrees instead of flat on top.

If this practice is carried out and the mud ring rivets and the staybolts are tight, no great amount of trouble will be experienced from deteriorated side sheets. It is also a good plan when the grate bars are removed to have the side sheets thoroughly cleaned and painted with a heavy coat of rust proof paint.

C. E. Elkins, general foreman boiler maker, Missouri Pacific Railroad, 1212 West 11th St., Little Rock, Ark., chairman. Members of committee: John J. Orr, C. F. Petzinger.

### Discussion

C. E. Elkins: If your grate bar is put in there properly and your rivets and staybolts are tight, you will not have any more trouble with side sheets wearing out behind the grate bars than anywhere else. The great trouble I find with side sheets rusting away is due to the fact that the side bars do not fit up close enough to the side sheets and the ash pans hold the cinders and coal up against the side sheets; then if the rivets or staybolts leak, it forms an acid that soon eats up the sheets. But if the side sheets are properly fitted up and made a proper angle at the top, so the cinders and coal will work away from the side sheet, you will not have any trouble with the side sheets rusting out.

Chairman Patrick: I believe that when an engine is stripped for general repairs, it ought to be painted behind the side bar. That is the best repair you can make.

## Boiler Shell Cracks Through Girth Seam Rivet Holes

One member of the committee after 45 or 50 years' experience can recall only 10 boilers which failed when the boiler shell cracked circumferentially. Five were locomotive boilers which cracked through the rivet holes at the external lap, two cracked through the rivet holes at internal lap, and one through the main plate at the abutment of the lap. Two return tubular boilers cracked through the rivet holes of the external lap. These boilers all developed cracks ranging in length from three to four feet, extending about equal distances to each side of bottom center line.

The locomotive boilers had double riveted girth seams and the tubular boilers single riveted girth seams. The girth seams in all boilers which cracked did not become defective because of a low factor of safety as they had factors in excess of that prescribed by both the governments of the United States and Canada. Not one of these cracks resulted in the explosion of the boiler.

The other two members of the committee, after making inquiries and observations from numerous railroads, find very few boiler shells cracked through the girth seam rivet holes and what has come to their attention was due to carelessness in preparing the sheets for riveting.

It is our opinion that the rivet hole should be drilled in the girth seam and sheets properly prepared for riveting, and other improvements, which would quicken circulation such as applications of feed water with top checks located at the top of the boiler and at a distance from the fire; feed water heaters to raise the temperature of the feed water; automatic feed water regulation with regulators which would supply and keep the water as near as possible at a normal working level under all conditions. Also keep the expansion pads that secure the boiler to the frame free. Allowing the boiler to breathe and move freely in the frame will often prolong the rupture.

In our opinion with such improvements in general use on boilers the differential between the expansion of top and bottom of the shell would become more normal, with a reduction in the number of failures and the cracking of rivet holes in the girth seam, and the time of rupture be prolonged.

Andrew S. Greene, general foreman boiler maker, Big Four System, 3209 East 16th St.; Indianapolis, Ind., chairman. Members of committee, William A. McKeown, T. W. Lowe.

Discussion

On this subject, E. W. Rogers, general foreman of the boiler department of the American Locomotive Works, Schenectady, N. Y., prepared a paper which will appear in an early issue of the magazine.

# Friday Session

## Best Type of Side Sheet to Be Applied to Narrow and Wide Fireboxes of Locomotives

This matter was taken up with all members of the committee on July 13, 1920. J. P. Malley has covered the subject thoroughly on every point and in accord with my views and consideration in the following:

Depressed, corrugated, vertical or longitudinal side sheets have been manufactured to overcome short life of sheets, cracks and defective and leaky staybolts without success; therefore, we recommend that straight side sheets be maintained wherever possible and in following this practice, locomotives be equipped with side sheet in the same manner as when received from the mill, free from all strains to which the sheet would be subject in the manufacture of the others referred to above, as well as having a locomotive boiler that can be washed clean.

This report was prepared by a committee consisting of C. R. Bennett, chairman; J. P. Malley and William Fantom.

Discussion

Corrugated side sheets, although giving a certain amount of flexibility wherever tried out, crack very quickly in service. In bad water districts, the scale forms in the corrugations and is difficult to clean, which condition necessitates frequent repairs. Some roads experimented with both horizontal and vertical corrugations, both punching and drilling the holes for staybolts, but have decided that the straight side sheets were better.

The remainder of the closing session was taken up with the reports of standing committees and the election of officers.

Election of Officers

The officers of the Master Boiler Makers' Association elected for the coming year are: President, Thomas Lewis, general boiler inspector, Lehigh Valley Railroad, Sayre, Pa.; first vice-president, E. W. Young, general boiler inspector, Chicago, Milwaukee and St. Paul Railroad, Dubuque, Iowa; second vice-president, Frank Gray, general foreman boiler maker, Chicago and Alton Railroad, Bloomington, Ill.; third vice-president, Thomas F. Powers, assistant general foreman, boiler department, Chicago and Northwestern Railroad, Oak Park, Ill.; fourth vice-president, John F. Raps, general boiler inspector, Illinois Central Railroad, Chicago, Ill.; fifth vice-president, W. J. Murphy, general foreman boiler maker, eastern region, Pennsylvania System, Allegheny, Pa.; secretary, Harry D. Vought, 26 Cortlandt street, New York; treasurer, W. H. Laughridge, general foreman boiler maker, Hocking Valley Railroad, Columbus, O.

Executive Board for one year: Harry F. Weldin, foreman boiler maker, Pennsylvania Railroad, Philadelphia, Pa.; E. J. Reardon, district inspector locomotive boilers, I. C. C., Chicago, Ill.; Captain J. M. Guiry, foreman boiler maker, Great Northern Railroad, St. Paul, Minn. For two years: Henry J. Wandberg, boiler inspector, Chicago, Milwaukee and St. Paul Railroad, Milwaukee, Wis.; George Austin, general boiler inspector, Atchison, Topeka and Santa Fe Railroad, Topeka, Kans.; C. E. Elkins, general foreman boiler maker, Missouri-Pacific Railroad, Little Rock, Ark. For three years: L. M. Stewart, general boiler inspector, Atlantic Coast Lines, Waycross, Ga.; John Harthill, general foreman boiler maker, New York Central Railroad, Cleveland, O.; C. H. Browning, foreman boiler maker, Grand Trunk Railway, Battle Creek, Mich. L. M. Stewart was elected chairman of the executive board and E. J. Reardon, secretary.

## Business Meeting of Supply Men

AT the business session of the Boiler Makers' Supply Men's Association held Thursday, May 25, the Secretary's report showed a total registration of 129 men and 27 ladies.

The following officers were elected for the coming year: President, W. M. Wilson, Flannery Bolt Company, Pittsburgh, Pa. Vice President, George R. Boyce, A. M. Castle Company, Chicago, Ill. Secretary, W. H. Dangel, Lovejoy Tool Works, Chicago, Ill. Executive committee members appointed for three years, J. W. Kelly, National Tube Company, Pittsburgh, Pa., and F. J. O'Brien, Globe Seamless Steel Tubes Company, Milwaukee, Wis.

## List of Exhibitors and Supply Men at Master Boiler Makers' Convention

The following members of the Boiler Makers' Supply Men's Association were represented at the Master Boiler Makers' Convention and held exhibits of equipment and supplies which proved of great interest to the members:

Air Reduction Sales Company, New York.—Represented by G. Van Alstyne, E. L. Fiddyment, and B. N. Law. The exhibit included Airco-Davis-Bournonville welding and cutting outfits for oxy-acetylene welding and cutting, the Radiagraph for straight-line and circle cutting of steel plates and the Camograph for production cutting of hand holes in headers, etc.

American Arch Company, Inc., New York.—Represented by Major W. L. Allison, J. T. Anthony, J. D. Brandon, A. W. Clokey, H. Darby, Thomas F. Kelcoyne, E. T. Mulcahy, John P. Neff, C. T. Pfeiffer, A. M. Success, George W. Wagstaff.

American Locomotive Company, New York.—Represented by W. E. Corrigan, Arthur Haller, G. G. Jones, E. W. Rogers, G. Wilson. The exhibit included Alco flexible and rigid staybolts and parts.

The Bird-Archer Company, New York.—Represented by C. J. McGurn.

The Boiler Maker, New York.—Represented by George Slate, L. S. Blodgett and J. P. O'Hern. The exhibit included sample copies of Simmons-Boardman publications.

Boss Nut Company, Chicago, Illinois.—Represented by J. W. Fogg and A. W. Maclean. The exhibit included Boss lock nuts, bolts and rivets.

Brown & Company, Inc., Pittsburgh, Pa.—Represented by L. E. Hassman and J. Wallace Mitchell.

W. L. Brubaker & Brothers Company, Millersburg, Pa.—Represented by G. Mark Brubaker and W. Searles Rose. Exhibit included standard boiler taps made according to the standards adopted by Railway Tool Foremen in 1920.

The Burden Iron Company, Troy, New York.—Represented by John C. Kuhn.

A. M. Castle & Company, Chicago, Illinois.—Represented by George R. Boyce and Ford S. Clark. Representing Lukens Steel Company, Champion Rivet Company, Rome Iron Mills, Inc., Detroit Seamless Steel Tubes Company, Tyler Tube & Pipe Company.

The Champion Rivet Company, Cleveland, Ohio.—Represented by T. J. Hawless and Frank J. Reynolds. Exhibit included samples of boiler rivets.

Chicago Pneumatic Tool Company, New York.—Represented by D. E. Cooke, John D. Crowley, Edward K. Lynch and J. L. Rowe.

Cleveland Steel Tool Company, Cleveland, Ohio.—Represented by Ralph J. Venning, H. W. Leighton, C. M. Hoppe. Exhibit included punches, dies, chisel blanks, rivet sets, coupling nuts and punch stems.

The Dayton Pneumatic Tool Company, Dayton, Ohio.—Represented by A. B. Clausen. Exhibit included cut out sections of Champion riveter and new Dayton chipper, riveters, shippers, scaling hammers, hose couplings and other accessories.

Dearborn Chemical Company, Chicago, Illinois.—Represented by George R. Carr, Ira L. Beebee, N. F. Dunn, I. H. Bowen, H. Rehmeyer, C. T. Bowen and H. P. Ross.

Detroit Seamless Steel Tubes Company, Detroit, Mich.—Represented by C. C. Rosser.

Duntley-King Pneumatic Tool Company, Chicago, Illinois.—Represented by Henry P. Arnold, H. G. Torson, C. E. Walker, W. H. S. Bateman and J. M. Butler. Exhibit included King sleeve valves for riveting hammers, King molybdenum riveting hammers, King molybdenum chipping hammers, King molybdenum rivet cutter, King rivet sets and King pneumatic tool accessories.

Ewald Iron Company, Louisville, Kentucky.—Represented by S. F. Sullivan and R. F. Kilpatrick.

J. Faessler Mfg. Company, Moberly, Missouri.—Represented by J. W. Faessler and G. R. Maupin. Exhibit included perfect superheater tube cutter, plain, ball bearing, built-up-cage type roller expanders, sectional expanders, flue cutters for hand or motor drive.

Flannery Bolt Company, Pittsburgh, Pa.—Represented by J. Rogers Flannery, E. S. Fitzsimmons, W. M. Wilson and R. W. Benson. Exhibit included Tate flexible staybolts, F. B. C. welded flexible staybolts, Flannery rigid water space stays, Flannery taper head crown stays and Flannery button head stays.

Garratt-Callahan Company, Chicago, Illinois.—Represented by J. G. Barclay, W. F. Caspers and A. H. Hawkinson. Exhibit included samples of metal treated with "Magic" boiler preservative.

Gary Screw and Bolt Company, Chicago, Illinois.—Represented by Philip Robinson, Robert W. Dierker and Gerald J. Garvey. Exhibit included bolts, nuts, rivets and rods.

Globe Seamless Steel Tubes Company, Milwaukee, Wisconsin.—Represented by F. J. O'Brien, T. F. Clifford and L. T. Wilson. Exhibit included boiler tubes, arch tubes, superheater pipes and safe ends.

Independent Pneumatic Tool Company, Chicago, Illinois.—Represented by T. T. Cruice, John G. Cowell, G. H. Du Sell and O. H. Dallman.

Ingersoll-Rand Company, New York.—Represented by T. E. Forbes and L. W. Schnitzer. Exhibit included "Little David" catalogues and air tools.

Keller Pneumatic Tool Company, Grand Haven, Michigan.—Represented by J. C. Campbell, C. A. Bremmer, George M. Kenyon, J. N. Stebbins and L. H. Olsen. Exhibit included complete line "Master" pneumatic riveting, chipping and calking hammers, staybolt rivets, drills, etc.

The Liberty Manufacturing Company, Pittsburgh, Pa., and the Lagonda Manufacturing Company, Springfield, Ohio.—Represented by Henry A. Pastre and E. L. Davis. Exhibit included steam, air and water operated turbine cleaners for locomotive arch and stationary boiler tubes.

Locomotive Firebox Company, Chicago, Illinois.—Represented by John S. Hawley and B. E. Larson. Exhibit included working model of Nicholson Thermic Syphon equipped boiler. Sections of syphons.

Lovejoy Tool Works, Chicago, Illinois.—Represented by W. H. Dangel. Exhibit included all steel roller expanders, frictionless roller expanders, Universal roller expanders, ball bearing roller expanders, Dixon multiple roller expanders (new), arch roller expanders, superheater expanders, sectional spring expanders, perfection staybolt chuck, Lovejoy flue-hole cutter, railroad flue cutter, beading tools, Bush rubber stop, Lovejoy electric drill.

McCabe Manufacturing Company, Lawrence, Mass.—Represented by Fred H. McCabe. Exhibit included working model of pneumatic flanging machine, flanging flue sheets, flanged car parts.

Midvale Steel & Ordnance Company and Cambria Steel Company, Philadelphia, Pa.—Represented by George Bangart, C. E. Keenan, F. E. Rogers, Fred Sager, N. Miller, R. C. Jordan and I. C. Shumacher. Exhibit included charcoal iron boiler tubes, lap welded steel tubes, boiler plates and firebox plates.

National Boiler Washing Company, Chicago, Illinois.—Represented by B. H. Willis, T. G. Dalton and F. W. Gala. Exhibit included stereopticon machine showing boiler washing plant.

National Tube Company, Pittsburgh, Pa.—Represented by George N. Rily, P. J. Conrath, J. T. Goodwin, J. W. Kelly.

The Oxweld Railroad Service Company, Chicago, Ill.—Represented by William A. Champieux, H. V. Gigandet, William A. Hogan, O. F. Ladtkow, William Leighton, A. N. Lucas, Richard Rivett and H. W. Schulze. Exhibit included Oxweld cutting and welding equipment, materials for oxy-acetylene welding. Special entertainment feature.—R. W. Harvey of the Oxweld Railroad Service Company demonstrating the latest radio equipment. Received market reports and up to the minute news during each day. Special concert each evening—Batteries furnished by the Prest-o-lite & National Carbon Company.

Parkesburg Iron Company, Parkesburg, Pa.—Represented by George Thomas, 3rd, W. H. S. Bateman, L. P. Mercer, J. Frederic Wiese and Robert W. Porteous. Exhibit included six inch diameter charcoal iron tube—made of Parkesburg Iron that had been in service 42 years. Flange tests—Master Mechanic Crushing and Expanding tests demonstrated.

Penn Iron and Steel Company, Creighton, Pa.—Represented by Henry F. Gilg and J. C. Campbell. Exhibit included Lewis special hollow drilled staybolts.

Pittsburgh Forge & Iron Company, Pittsburgh, Pa.—Represented by R. A. Dugan, C. E. Miller and W. Schuettler.

Pittsburgh Steel Products Company, Pittsburgh, Pa.—Represented by Charles F. Palmer and Charles W. Van Allen.

Pratt & Whitney Company, Chicago, Ill.—Represented by F. A. Armstrong, L. T. Bohnet and J. J. Nuttall. Exhibit included staybolt taps, boiler taps, taper bridge reamers, locomotive taper reamers, ratchet drills, punches and dies and washout taps.

The Prime Manufacturing Company, Milwaukee, Wis.—Represented by C. A. Dunn.

Railway Journal, Chicago, Illinois.—Represented by Walter H. Bentley, Mrs. H. M. McCandless and E. C. Cook.

Railway Purchases and Stores, Chicago, Ill.—Represented by H. B. Kirkland.

Rome Iron Mills, Inc., New York.—Represented by C. C. Osterhout. Exhibit included samples of staybolt iron.

Joseph T. Ryerson & Son, Chicago, Illinois.—Represented by H. A. Gray, J. P. Moses, C. F. Barton, L. D. Hiner, I. H. Jones, Edward Kavanagh, D. S. Mair, E. S. Pike and A. W. Willcuts. Exhibit included hollow staybolt iron, flue shop machinery. A typical model layout of a locomotive flue shop was a special feature of this exhibit.

Scully Steel & Iron Company, Chicago, Illinois.—Represented by J. W. Patterson, R. Siewert, Walter Schuett and C. E. Lingenfelter. Exhibit included tube expanders and tube cutters, boiler-maker tools such as staybolt chucks, staybolt taps, reamers, blow-off valves and special flat plug valves and models of machinery.

The Superheater Company, New York.—Represented by George L. Dolan and George Fogg.

The Talmage Manufacturing Company, Cleveland, Ohio.—Represented by Frank M. Roby and H. B. Thurston. Exhibit included Talmage system ash-pan cleaner, Talmage blow-off valves, Cleveland low water alarm, Talmage system steam chest and cylinder lubricating drifting valves, Talmage grease cups.

Thompson Electric Welding Company, Lynn, Mass.—Represented by F. H. Leslie and R. M. Taylor. Exhibit included about two dozen samples of electrically safe ended boiler tubes by butt welding, together with miscellaneous butt and spot welded samples.

Torchweld Equipment Company, Chicago, Ill.—Represented by A. T. Dillon and W. A. Slack. Exhibit included oxy-acetylene welding and cutting equipment, lead burning equipment, decarbonizing equipment and acetylene generators.

The W. S. Tyler Company, Cleveland, Ohio.—Represented by J. H. Jackson and R. T. Massett. Exhibit included samples of locomotive front end netting, draftac spark arrester.

U. S. Light and Heat Corporation, Niagara Falls, N. Y.—Represented by A. A. Morrison and Ed. C. Wilson.

## Registration at Master Boiler Makers' Convention

Aiken, C. H., The Bourne-Fuller Co., 12121 Saywell Ave., Cleveland, O.
Albert, Jacob, Asst. B. F., C. & W. I. R. R., 6721 S. Peoria St., Chicago, Ill.
Anderson, J. A., Gen. F. B. M., Industrial Wks., 216 N. Madison Ave., Bay City, Mich.
Austin, George, G. B. I., A. T. & S. F. Ry., 6 Devon Apts., Topeka, Kans.
Badger, R. L., Supv. Boilers, Erie R. R., 514 Term. Bldg., Youngstown, O.
Batchman, F. A., F. B. M., N. Y. C. R. R. Co., 1421 Krau St., Elkhart, Ind.
Baumann, C. J., F. B. M., N. Y. N. H. & H. R. R., 188 Hallock Ave., New Haven, Conn.
Beck, John F., F. B. M., G. R. & I. R. R., 426 Thomas St., Grand Rapids, Mich.
Bell, H. A., G. B. F., C. B. & Q. R. R., 316 So. 11th St., Havelock, Neb.
Bennett, G. W., Dist. Insp., I. C. C., 15 Kent St., Albany, N. Y.
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(*Continued on page* 182)

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Gradually improved business conditions and renewed confidence in the prospects for considerably better business in the boiler making industry next year are among the hopeful signs brought out at the annual convention of the American Boiler Manufacturers' Association this month. A. G. Pratt, president of the association, in his annual address did not hesitate to predict that the volume of business in the boiler shops for each quarter of this year will surpass that of the corresponding quarter of last year and that this will be followed by a marked improvement next year. Many projects are already well advanced and orders will be forthcoming just as soon as general business conditions warrant placing them.

One of the most far-reaching actions ever taken by the Master Boiler Makers' Association occurred at the recent convention in Chicago in the formation of the recommended practice and the standard practice committees. The association as was stated during the meetings is young in years, but is a firmly established and representative body of master boiler makers well qualified to determine the most practical and advantageous methods of constructing and maintaining locomotive boilers. Such special committee reports as that on the use of electric welding for locomotive repairs, resulting from the exhaustive investigation of the process on all the principal roads of the country, are certainly of sufficient value to receive the approval of the association and to be given to the industry as recommendations of the association.

The procedure to be followed, in order that the value and standing of the recommendations made might not be misused, should be similar to that of other railway organizations such as the Master Mechanics' Association, the Master Car Builders and others. Only subjects that have been thoroughly investigated by competent committees and which when discussed on the floor of the convention are shown to represent the practice of the greater majority of the members should be considered for future action by the recommended practice committee. Once a report has reached this committee the details should be carefully checked for possible revisions and then, for a period of years, the methods proposed should be exhaustively tested in actual practice. After the points which have proved to be good in practically all the operating districts throughout the country, the practice should be again revised by the standards committee and established as the standard of the association.

No better means exist for giving the association a high standing in the railroad field than to take positive action on matters dealing with locomotive boiler construction and maintenance on which the members are the best qualified individuals to pass.

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An especially favorable indication of the increasing prestige of the Master Boiler Makers' Association occurred at the convention in the request from one of the prominent members of the American Railway Engineering Association that the boiler makers cooperate with the railroad chemists in determining the causes of boiler pitting. This invitation opens a line of investigation for every member of the association which will materially aid in solving the pitting problem. The specific request made on the floor of the convention was that members of the Master Boiler Makers' Association maintain a record of the location and kind of pitting in the boilers under their charge; that is, whether pitting occurs on flues near the front tube sheet, whether it is distributed uniformly over the entire flue or acts locally on the top or on the bottom, and whether or not it affects the shell. With records of this action from representative roads operating under all kinds of conditions, with all kinds of water, the chemists will be able to accomplish real progress in eliminating this costly item of locomotive maintenance.

This subject is not on the report program for the next convention, but the work of a well qualified committee would be invaluable in collecting and preparing the data on boiler pitting compiled by the members in the course of the year.

# Engineering Specialties for Boiler Making

**New Tools, Machinery, Appliances and Supplies for the Boiler Shop and Improved Fittings for Boilers**

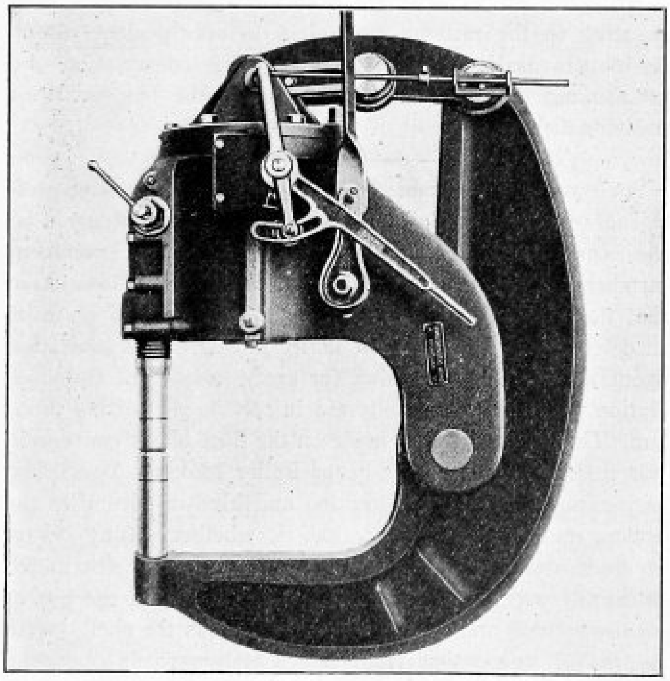
## Pinch Bug Riveter

Unusually wide range is one of the features of the new Shepard pinch bug riveter recently developed by the Hanna Engineering Works, Chicago. This riveter has a reach of 20 inches and the gap is 11½ inches or 18 inches depending on whether the short (channel jaw) or long (girder jaw) is used. The capacity of the riveter is 50 tons on the dies at 100 pounds air pressure and its weight is 1490 pounds.

The angular movement is small due to the small radius from the hinge pin to the die axis. This allows greater variation in the length of the lower die. The die stroke of the Shepard riveter is 3⅝ inches. The machine is equipped with a removable valve plate and an extra plate and valve allow maintenance of the valve without shut down.

In the Shepard pinch bug riveter, the upper die does not move as the rivet is driven when the machine is suspended with the die vertical. Rivets are placed from the top and driven from below and may be inserted far in advance of the machine itself. It is thus possible for the "rivet sticker" to devote some of his time to drift pins and stitching bolts without interrupting the continuous operation of the machine.

The suspension pin about which the machine is free to revolve is so located with relation to the center of gravity of the machine that the riveter when suspended naturally assumes a position resulting in the upper die screw being



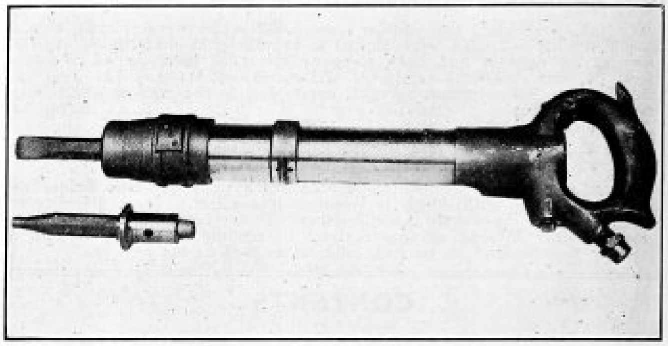
Shepard Pinch Bug Riveting Machine

exactly vertical. The upper die screw remains vertical whether the unit is open or closed as the center of gravity shifts but lightly during movements.

The proper working suspension is easily obtained by merely hoisting the machine to the point where the upper die just rests on the work.

## Pneumatic Tool for Removing Rivets

A pneumatic tool for removing rivets, known as the Thor No. 90-S rivet buster, has just been placed on the market by the Independent Pneumatic Tool Company, Chicago. This is a substantial tool, as shown in the illustration, being similar in design to the Thor riveting hammer. It can be



Easily-Operated Thor Pneumatic Rivet Buster

operated by one man instead of three and used in close quarters. The tool is well adapted for cutting off and backing out rivets of all sizes, its greatest value to railroad men being in the dismantling of steel cars.

The operation of this tool by one man instead of three results in a considerable labor saving. Rivets can also be cut in more difficult corners and there is less possibility of damaging the steel plates.

On account of the blows being rapid but not so severe the plates do not buckle at rivet holes, thus wasting expensive material as is often the case with the old style heavy three man buster. The Thor machine is designed to cut the rivet off smoothly at the surface of the sheet without disfiguring or spoiling the material.

The chisels and backing out punches are provided with individual safety retainers and can be quickly changed in the hammer from cutting off to backing out without disassembling the small retainer from the shank.

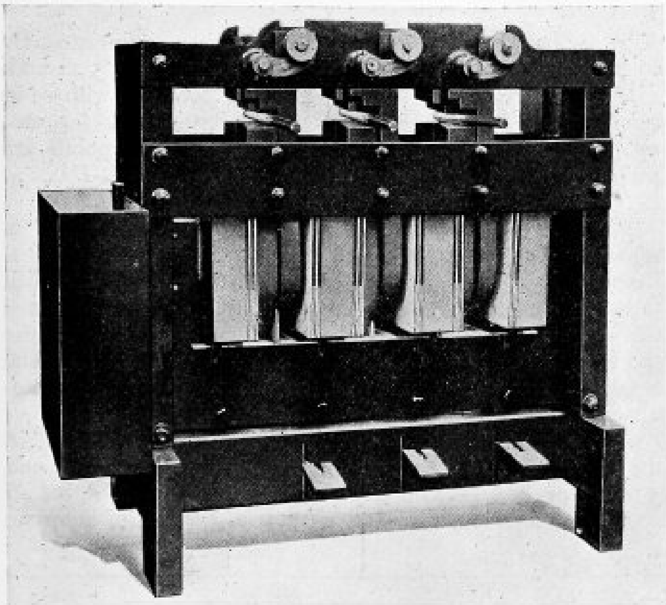
## Two Path Electric Heater

A Berwick electric heater for heating the ends of stock to be used in forging operations has been developed by the American Car and Foundry Company, New York. The heating is accomplished without burning or melting the metal and so that an even heat is distributed through the metal at all times.

The heaters are built with one, two, three and if desired with four or five electrodes. The range of heat runs from 1 inch to 8 inches or from 3 inches to 11 inches, with the possibility of increasing the length by slight changes in the standard heater to 16 inches or 18 inches. Stock ⅜ inch to ⅞ inch in diameter may be heated to best advantage on the type machine illustrated, while for larger stock a type 4 machine should be used.

The operation of the heater is along the lines of the Berwick rivet heater. The lower or left hand electrodes are stationary while the upper or right hand electrode is arranged with a vertical adjustment by depression of the foot treadle, which raises the electrode sufficiently to insert or remove the material. Horizontal motion is provided by sliding the electrode clamping device along the shaft provided for the purpose, while as indicated the vertical motion is imparted to the electrode by the depression of the pedal, thus causing the rotation of the shaft, which in turn through cams raises the shaft carrying the electrode.

The material to be heated is inserted between the top and bottom electrodes and due to the double path the time of

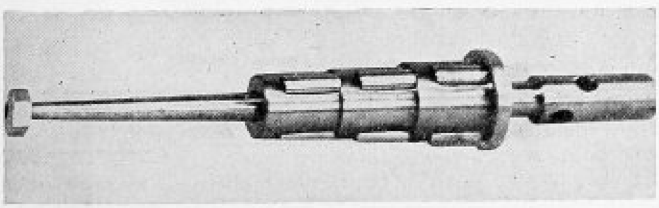


Berwick Electric Heater for Bar Stock

heating is reduced and the possibility of pitting is not so great. Flexibility of the rear portion of the bottom electrode is provided by the spring shown in the illustration on the rear of the heater, the top face of the electrode being set on an incline so that when the top electrode is dropped in position contact is assured at four points on the material.

## Multiple Tube Expander

A tube expander designed to expand flues of three or more sizes and developed by a practical boiler maker is being produced by the Lovejoy Tool Works, Chicago, is made in various combinations, the smallest size covering tubes 1¼ inches, 1⅜ inches and 1½ inches in diameter, and the larg-



Three-Step Flue Expander

est taking flues 4 inches, 4½ inches and 5 inches in diameter. Other sizes accommodate tubes within this range.

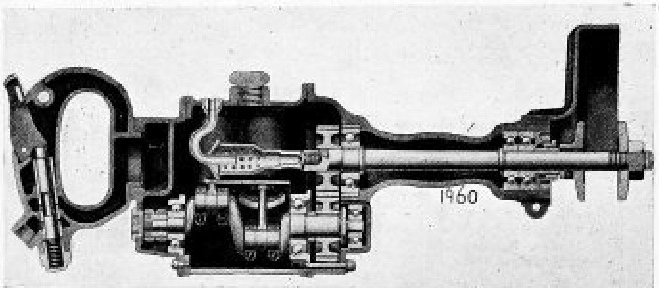
The tool is designed so that when a smaller stage of the expander is rolled to its full diameter the mandrel may be withdrawn and the work continued if necessary on the next larger size, making it practically a universal expander from its minimum to its maximum capacity. It is useful in railroad work where ferrules have been enlarged through constant rolling, as well as for rolling copper ferrules in enlarged holes. In stationary work it can be used to advantage on a job where the actual size of the tubes is not definitely known beforehand.

The tool is made of a steel casting and tool steel and without keys or screws to work loose. The collar is furnished for the largest size and can be removed if necessary. The tool is a little heavier than a single size roller expander and the cost is only slightly higher.

## Oil Separator for Air Grinders

To permit air grinders to operate for long periods without replenishing the supply of lubricant, the Chicago Pneumatic Tool Company, Chicago, Illinois, has designed an oil separator which is applicable to "Little Giant" air grinders.

The oil separator consists of a hollow perforated cylindrical




Oil Separator Applied to "Little Giant" Air Grinder

steel shell attached at one end to the grinder spindle while the other encircles and revolves around the vent tube.

As the oil laden air enters the holes in the oil separator, the centrifugal action of the oil separator revolving at spindle speed instantly separates the oil from the air permitting the air to escape oil free, through the vent tube preventing oil leakage. It is claimed that a great quantity of lubricant is saved annually with this device, for it makes oiling necessary only once in a week instead of daily as has heretofore been the practice among users of air grinders.

## BUSINESS NOTES

Norman R. Seidle has resigned as assistant general manager of the Jas. G. Heggie Company of Joliet, Illinois, to become works manager of the General Boilers Company, Waukegan, Illinois. The General Boilers Company manufactures steel welded boilers (Pacific Type) for all general heating purposes.

O. H. Dallman, formerly of the Vanadium Alloy Steel Company, Latrobe, Pa. and mechanical department, Pennsylvania Ry. Company, 55th Street Shops, Chicago, has joined the sales force of the Independent Pneumatic Tool Company, 600 West Jackson Boulevard, Chicago, manufacturers of Thor Pneumatic Tools and Thor Electric Drills and Grinders.

At a meeting of the Board of Directors of the Air Reduction Company, Incorporated, held May 24, A. R. Ludlow, formerly vice president in charge of sales, was elected first vice president. M. W. Randall, formerly secretary, was elected vice president and secretary; Herman Van Fleet, formerly chief engineer, was elected vice president and operating manager; Dr. F. J. Metzger was elected vice president in charge of research and development.

# Questions and Answers for Boiler Makers

## Information for Those Who Design, Construct, Erect, Inspect and Repair Boilers—Practical Boiler Shop Problems

**Conducted by C. B. Lindstrom**

*This department is open to subscribers of* THE BOILER MAKER *for the purpose of helping those who desire assistance on practical boiler shop problems. All questions should be definitely stated and clearly written in ink, or typewritten, on one side of the paper, and sketches furnished if necessary. 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 permission to do so.*

## Development of Tapering Sections Intersecting a Frustum of a Cone

Q.—I am writing to ask if you will please give me an explanation of the method to be used in the development of patterns for the uptake *A-B*, as per Fig. 1. This is made up of ⅜-inch sheet steel to fit a cone according to the dimensions stated.—F. C. C.

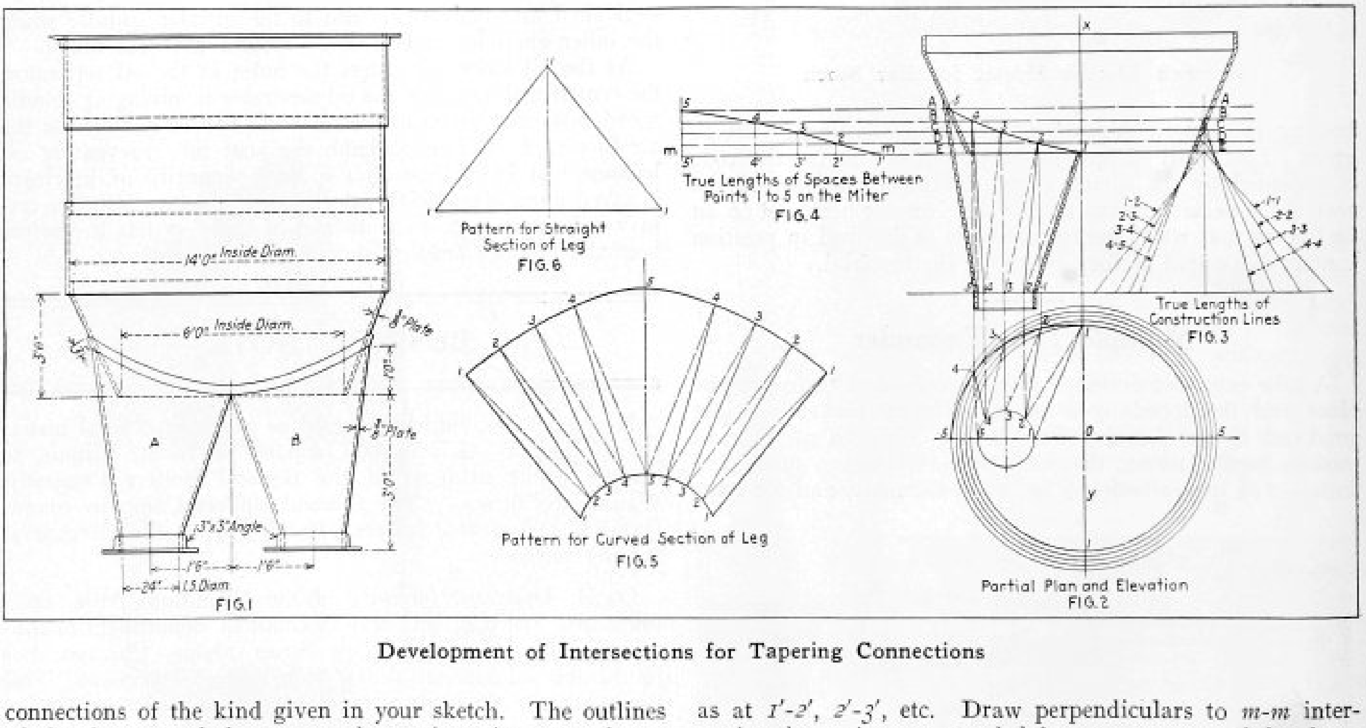
A.—The sketches, Figs. 2 to 6, inclusive, show a method of developing intersections and the patterns for tapering connections of the kind given in your sketch. The outlines of the frustum of the cone and tapering pieces are drawn to the given dimensions in the plan and elevation. Divide the distance *A-E* of the elevation into a number of equal parts and through points so located draw the cutting planes *B-B*, *C-C* and *D-D* perpendicular to *X-Y*.

Show the circular sections of the frustum as taken on these planes in the plan view. The circles are drawn from the point *O*. The circle for the small end is also indicated in the plan in its relative position. Divide the small circle so that one-half of it, as shown, is spaced into four equal parts. Also divide the quadrant of the larger inner circle into four equal divisions; thus locating points *1-2-3-4* and *5* in both cases. Connect the points *1-1*, *2-2* and *3-3*, etc., with solid lines; where these lines intersect the circles as at *2-3-4*, etc., establishes the points lying on the miter. These points are projected to intersect the planes *B-B*, *C-C* and *D-D* as at *2-3* and *4* in the elevation.

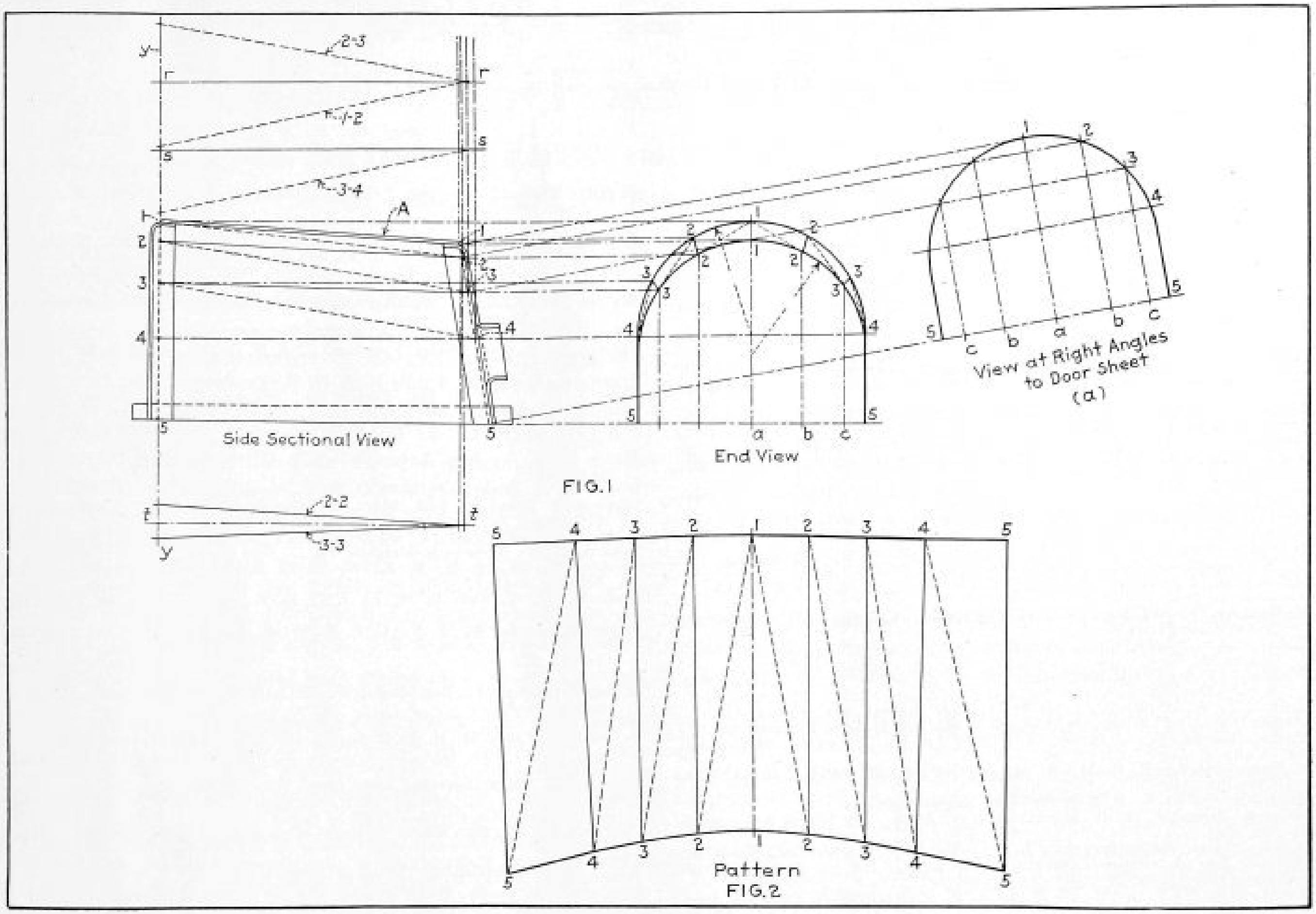
The line of intersection is drawn through these points as represented. The construction lines as the solid and dotted lines *1-1*, *2-2* and *1-2*, *2-3*, etc., are now drawn in. With these data established construct right angle triangles indicated to the right of the elevation. For their respective bases use the lengths of the construction lines shown in the plan. The heights are projected as shown in the elevation; the hypotenuses are the required true lengths.

Before the pattern can be laid off, it is necessary to obtain the true lengths of the spaces between the points *1-2-3-4* and *5* on the miter. This development is given in Fig. 4. Set off on the line *m-m* the arc lengths *1-2*, *2-3*, *3-4*, *4-5* of the plan, as at *1'-2'*, *2'-3'*, etc. Draw perpendiculars to *m-m* intersecting the projectors extended from *1-2*, *3*, etc., of the elevation; thus the lengths *1-2*, *2-3*, *3-4*, *4-5* are the true lengths.

The pattern layouts are given in Figs. 5 and 6. It will be noted that the back of each leg is formed with a triangular-shaped piece *1-1-1*, Fig. 6. Other means could be employed for closing in this part. As all lines in the pattern developments are numbered to correspond with those in the triangles no further explanation seems necessary. The allowances for laps and joints must be made to the outlines of the patterns, Figs. 5 and 6.




Development of Intersections for Tapering Connections




Tapering Firebox with Sloping Crown Sheet

## Layout of Firebox Side Sheet

Q.—Will you please show me how to lay out a furnace for a locomotive boiler to get the slant on the back head? I understand this is somewhat different from the square firebox.—C. Le B.

A.—To illustrate this laying out problem, I have shown in Fig. 1 a tapering firebox with a sloping crown sheet *A*. The sides of the firebox are straight and parallel with each other. The crown sheet is semi-circular in section except at the door sheet end, where the section runs into an elliptical form as illustrated in view (*a*) taken at right angles to the door sheet.

The first step in the layout is to show a sectional side and an end view drawn to the neutral or center of the plate section. These views are laid off to the overall dimensions of the firebox or furnace. The profile view (*a*) is developed from the end view.

Divide the semi-circular portions of the end view into a number of equal divisions and project these points as *1-2-3* to the small and large ends of the firebox side view. Connect the points *1-1*, *2-2*, etc., with full lines and *1-2*, *2-3*, etc., with dotted lines which assist in the development work. In practice, more lines of construction would be employed than given in this layout which is necessary to obtain accurate results. Transfer distance *a-b*, *b-c*, *c-5* to the view (*a*) and from the points *1-2-3*, etc., of the side view draw projectors, as shown to intersect those drawn from *a-b* and *c*. Draw in the outline of the elliptical section and the straight sides *4-5*, thus completing view (*a*). From the side and end view develop the true lengths of the solid and dotted construction lines, as follows: At right angles to the line *4-4* draw projectors through the points *1-2-3* and *4* of the door sheet end; also a straight line at the tube sheet end, as *y-y*. At right angles to *y-y* draw the lines *r-r*, *s-s* and *t-t*. From these lines and on the base line *y-y* set off the dotted distances *1* to *2*, *2* to *3*, *3* to *4* and the solid lengths *2-2* and *3-3*, as shown in the diagrams for finding these true lengths. The diagonal lengths connecting the base and height of the respective triangles are the true lengths of the construction lines.

### Construction of Patterns

Lay off a straight line as *1-1* equal to *1-1* of the side view. Use the arc lengths of the semi-circle showing the section at the tube sheet end for the large end of the pattern and those of profile (*a*) for the smaller or door sheet end. With the true lengths of the triangles the respective camber lines are then developed. In this case the layout is made directly to the outside edge of the plate but in problems of this kind it would be better to make the construction to the rivet line and then allow for the required laps.

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## Patent Rights on Boilers

Q.—In conversing with an insurance company boiler inspector, naturally the conversation drifted to boilers and the question arose as to the difference between the Heine boiler and the watertube boiler manufactured by the Murray Iron Works. In answering the question, I said there is no difference between the Heine and the Murray watertube boiler, and in fact anyone can build a Heine type boiler or an Edge Moor boiler. I would be very pleased to have your opinion in this matter, because the only basis I had for my argument was that the boilers were old and that the patents had expired years ago.—J. T. C., Jr.

A.—The basic principle of the watertube boiler types comprises in construction, water drums, tube headers, steam and water drums and water tubes. Features in the construction of these have been patented and in any case where a patent has expired, *unless improvements are made on the patent,* the old patent can be used by anyone, without infringing. The general arrangement in the details of the boilers you mention are similar, but you will find that they are not all alike in the construction and proportions of the different parts.

## Registration at Boiler Makers' Convention

(*Continued from page* 176)

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(*Continued on page* 184)

# Letters from Practical Boiler Makers

**This Department Is Open to All Readers of the Magazine —All Letters Published Are Paid for at Regular Rates**

## Examples of Boiler Patching

Only under ideal operating conditions should a patch be placed on the second course at the middle girth seam of a boiler. Of course a repair at this point is seldom required, but it has occasionally been found necessary to repair a second course sheet which has been grooved by corrosion caused by prolonged leakage of the girth seam. A patch placed at this point must, of course, be located outside so that it can be scarfed into the girth seam and in this position it forms a convenient pocket for oil or sediment, which will invariably cause leakage within a short time. Such a patch has been used with success on very lightly fired boilers and on some boilers equipped with down draft furnaces, where that portion of the boiler is not in the direct path of the products of combustion.

Leaking fire cracks extending from the edge of the first course at the girth seam to the rivet holes have often caused patching or renewal of the sheet. As has been said before, if the condition can be traced to scale deposits, unfavorable furnace construction or unreasonable forcing, the boiler maker should consider well before deciding to use a patch. However, such a defect is sometimes the result of offset rivet holes, failure to remove burrs after reaming or some such poor workmanship. If this is found to be the case, the operating conditions being favorable, a patch might be tried.

### Leaking Fire Cracks in Girth Seam

I recall a defect of this sort in a boiler in Iowa, where operating conditions were very unfavorable from every standpoint. The inspector who preceded me had recommended a three-quarter sheet and I followed suit, but the owners would have none of it. The sheet had been notched out widely in front of each of the sixteen or eighteen rivets to which the cracks extended to provide a new and additional calking edge, much on the same principle as the sawtooth butt-strap joint. Although this had held for a time, repeated calking soon made it worse than ever. It was in this condition that I found it on my second trip there. Something had to be done promptly and at little expense, for the owners still objected strenuously to a three-quarter sheet.

Finally some expert boiler welders were called in. About twenty-five rivets were cut out, the sheet wedged apart and the notches and rivet holes welded up solid. The welded portion was then annealed, the calking edges chipped off nicely and the sheet laid up properly after drawing the wedges. Rivet holes were drilled in line with those of the second course, new rivets driven and the seam carefully calked. After the boiler had run until the next washout period, an expert would hardly have noticed the repair and the inspector now covering that territory recently stated that the seam has never leaked since. It might be of interest to state that the rivet holes in this seam were found to be offset and pulled out of round by heavy pinning; in fact, the entire boiler, which was new at that time, was an excellent example of poor workmanship, it having been found necessary to calk nearly half of the rivet heads in the butt strap joint during the first six months it was used.

### Oil Mill Boiler Repairs

A recent allusion to a cotton oil mill in The Boiler Maker reminds me of my experience in Oklahoma, Texas and Louisiana among the cotton gins and oil mills. There I soon learned that the word patch meant a piece of boiler or even tank steel of almost any shape, placed anywhere on any boiler in any conceivable manner. I have seen more than one square patch on the first course directly over the fire, single riveted to the outside and measuring 36 inches by 36 inches center to center of rivets, the boiler carrying the safe limit for an 87 percent longitudinal seam and a crack in the patch in front of practically every rivet.

A patch repair is pretty much of a gamble at best; therefore boiler makers who are relied upon in isolated districts to specify proper boiler repairs should familiarize themselves with proper methods of installing patches, so that the safe working pressure of the boiler will not be reduced by reason of the patch design. Much has been written about designing patches, but most of the explanations contain so much trigonometry that few workmen will ever attempt to comprehend them. One of the best things published on patch design, from the standpoint of simplicity and practical common sense, is a little pamphlet put out by the Industrial Accident Commission of California. It is commonly called the California method of patching, and I am sure the commission will be pleased to furnish a copy to anyone upon request. The calculations are in simple arithmetic and the sketches are easily understood.

San Francisco, Cal. A. J. Lamie,

## We Are Placing Your Letter on File

During the past seventeen years, ever since leaving college, I have sought to better myself—to find a better position. I have gradually improved, I believe. At least I have been paid more and more and now I have a so-called "business of my own."

In my search for better positions I wrote many letters—hundreds of them. To be sure some of them were answered, but according to my way of thinking it would have been better had they remained unanswered. The standard reply was:

> "We are sorry to state that we have no position for you at present. However, we are placing your letter on file and if we need a man of your qualifications you will hear from us."

I have never yet heard from a single one of these concerns. Placing letters on file seems to be meaningless. It seems that most of the writers of such letters feel that some sort of reply is due the applicant "just to be courteous." I think that to be perfectly fair to the applicant, if the prospective employer wants to reply at all, he should tell the truth straight from the shoulder. When an inexperienced or young applicant receives a number of fairly encouraging placing-your-letter-on-file letters he is liable to stop in his search for employment thinking that at least ONE of these letters should soon bring him something. However, after a long wait nothing happens. He may write them all again and they, again, will probably reply that they are "placing his letter on file." Some may flatly reject him this time and if so, all the better. Most of the prospective employers, if they reply, will reply as though they had never before received a letter from the applicant, all of which tends to open the eyes of the inexperienced applicant.

After these seventeen years of seeking for employment, therefore, my advice to those who are new at it is this: Don't pay any attention to letters that end with the words, "We are placing your letter on file." Or, change the last two words to these, "——— in the waste basket." Keep everlastingly at it until you land the position you want.

Newark, N. J. N. G. NEAR.

## Necessity of Heating Feed Water

I am submitting an experience which I had during the year 1921 and that I know will interest the readers of THE BOILER MAKER.

I was making an inspection of watertube boilers located in a steel mill. The boilers consisted of three drums above and three drums below connected vertically by long tubes and horizontally by three short tubes which were bent slightly to allow for expansion and contraction. I had taken the necessary precaution to see that the boilers were ready to inspect and had inspected five of the drums internally and had found nothing that I considered dangerous or not permissible to run.

Upon entering the rear drum, however, I found that it was considerably pitted or honey-combed and corroded to a depth of from 3/8 to 1/4 inch. Upon investigating the reason that this rear drum was so damaged and not the others I discovered that the feed water entered the rear drum and that this was the contributing cause.

If feed water is not heated to a temperature of at least 165 degrees, there is a certain amount of carbon dioxide liberated from the water on account of the free oxygen that already exists in the water and it has a strong affinity to boiler plates and very often causes pitting. Now by raising the temperature of the feed water I have no doubt that the trouble would be eliminated.

Olean, N. Y. CHARLES W. CARTER, JR.

## Mechanical Problems to Be Solved*

### By H. T. Bentley†

The question of water treatment and purification for boiler feeding has not had the attention it should have although one or two roads report having done considerable work in this direction during the past few years, and are now reaping the benefits from their investment.

It seems strange that year in and year out some of us go through the same performance in the way of tying engines up with poor flues and fireboxes that have only made small mileage, whereas by providing good water we could have increased their life tremendously.

With the difficulty in getting young men to follow the boiler makers trade, we certainly are very short sighted when we do not attempt to do everything possible to offset the coming shortage by providing a good quality of water that we know will be equal to many boilermakers in the amount of work it will save.

It may be difficult to improve water conditions in a territory where flues pit and corrode and the question arises, would it not be better to use iron flues, if such things are now made, as we all know that iron is less susceptible to pitting than steel. It would be interesting to know if iron flues are used to any extent, and if so, with what results?

At one time we rather thought we were saving a lot of money by using solid staybolts and drilling tell-tales in place, but with the increased cost of labor, drills, motors, air hose, etc., I doubt if it pays us to do this work when we can purchase hollow bolts that dispenses with some of it. The use of a hollow bolt throughout the firebox now appears to be justified.

*Abstract of address delivered at annual meeting of Master Boiler Makers' Association, Chicago, Ill., May, 1922.

†Superintendent of Motive Power, Chicago and North Western Railroad.

Radial staybolts at one time were generally of the button head type but with oil burning locomotives and others in heavy hard service, it was a difficult thing to keep them tight and I presume now that nearly everyone is working towards installing the taper and radial stays, which are easier to apply, and when in place, give far less trouble in service.

In years gone by the fitting up of boilers carrying comparatively low pressures and with light sheets was not a very serious problem and the way holes were punched and drifted, if they didn't match up would now be considered criminal and not tolerated with the thick plates used and the higher steam pressures carried. Modern conditions require all holes in a boiler to be drilled and sheets carefully fitted up and even when this is done we sometimes find boiler shells cracking and so far we have not been able to definitely say what is the cause.

The ordinary sheet steel ash pans are a constant bill of expense and it has taken us a long time to learn that the cast steel pan can be installed and maintained at a much lower cost than the sheet steel pan, which was always getting warped out of shape, causing fire risk by dropping hot cinders.

The use of flexible staybolts should now be beyond the experimental stage and no doubt you can tell us what effect flexible bolts have on the life of firebox sheets and whether it is a more economical proposition to equip engines complete and remove caps every two years or to put in hollow bolts and inspect them every thirty days.

I have just been reading a very interesting article on accidents, and note that during the year 1921, notwithstanding the volume of business, there were less train accidents than any year of which we have any record, which is a wonderful showing.

With such a record before us we should make special efforts to bring about a reduction in industrial and other non-train accidents and I am sure we will have the assistance of the locomotive inspection department which has done so much to bring about safer operation, due to its requiring a high standard of maintenance which means less accidents, and for some of this reduction, I am going to look to you men.

Accidents due to grates, grate shaking apparatus, and other similar things, can be greatly reduced by a little care on the part of the foremen in checking up to see that the work given employes to do has been done properly.

The fuel saving problem can be materially improved by careful attention of your men to check up the flue cleaners, see that boilers are properly washed out, air leaks in front end and around outside steam pipes are taken care of.

The question as to how deterioration of firebox sheets behind grate bars and supports can be eliminated is raised and believe that a suitable cement between sheet and side bar that excludes air and moisture will overcome this trouble.

In regard to hot water washout plants or hot wells, I think we all appreciate the good results obtained by using hot water to wash out and fill up locomotives; this, however, is one of the things that, when short of money, as at present, we can get along without, but in doing so are hurting our engines and wasting coal and will have to pay for it later. In our coal conservation efforts, the use of hot water for washing out and filling up is a valuable help and advantage should be taken of it whenever practical to do so.

## Registration at M. B. M. Convention

*(Continued from page 182)*

Larason, Ralph W., B. M., Hocking Valley R. R., 1070 N. Lexington Ave., Columbus, O.
Logan, G. H., Gen. F., N. W. R. R., Chicago, Ill.
Lutman, H. S., Am. Tank Car Corp., Hammond, Ind.
Nelson, C. B., M. M., I. H. B. R. R., Gibson, Ind.
Reid, F. C., E. H. F., I. H. B. R. R, Gibson, Ind
Shea, W. A., N. Y. C. R. R., Elkhart, Ind.
Shirley, John A., Washington, D. C.

Smith, George A., Gen. F., C. W. I. R. R., Chicago, Ill.
Smythe, Howard, H., C. & O. R. R., Bloomington, Ill.
Whitsel, N. B., M. M., C. W. I. R. R., Chicago, Ill.
Zeeder, M. L., Gen. E. H. F., Blue Island, Ill.

## Ladies

Bennett, Mrs. G. W., 15 Kent St., Albany, N. Y.
Besant, Mrs, W. F., 1426 E. 65th St., Chicago, Ill.
Borneman, Mrs. L., St. Paul, Minn.
Borneman, Miss La Verne, St. Paul, Minn.
Bower, Mrs. Wm. G., 4206 Washington Blvd., Chicago, Ill.
Browning, Mrs. C. H., 53 Cherry St., Battle Creek, Mich.
Campbell, Mrs. John C., 40 E. Jackson Blvd., Chicago, Ill.
Clare, Mrs. J. E., 541 N. Grove Ave., Oak Park, Ill.
Conrath, Mrs. P. J., 4511 S. Michigan Ave., Chicago, Ill.
Cook, Mrs. E. C., 6935 Stewart Ave., Chicago, Ill.
Cook, Miss Beatrice, 6935 Stewart Ave., Chicago, Ill.
Cook, Miss Genevieve, 6935 Stewart Ave., Chicago, Ill.
Cooper, Mrs. J. H., Owasso, Mich.
Cooke, Mrs. J. E., 360 S. Main St., Greenville, Pa.
Cravens, Mrs. Guy., Big Spring, Tex.
Cravens, Miss Gladys, Big Spring, Tex.
Creger, Mrs. R. A., S. Brainerd, Minn.
Cunningham, Mrs. A. J., 539 S. 6th St., Muskogee, Okla.
Davey, Mrs. J. J., St. Paul, Minn.
Davey, Miss Helen, St. Paul, Minn.
Du Mars, Mrs. L. B., 234 Clinton St., Greenville, Pa.
Evans, Mrs. W. H., Augusta, Ga.
Fairchild, Mrs. E. B., Waycross, Ga.
Fantom, Mrs. Wm., 7721 Eggleston Ave., Chicago, Ill.
Fennelly, Mrs. M. J., Jersey City, N. J.
Fisher, Mrs. George G., 8711 Peoria St., Chicago, Ill.
Fitzgerald, Mrs, J. J., Beverley Hills, Ind.
Frazier, Mrs. A. F., Etowah, Tenn.
Frazier, Miss Zelina, Etowah, Tenn.
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Goodwin, Mrs. J. T., Plainfield, N. J.
Garlock, Miss May V., South Chicago, Ill.
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Greene, Mrs.Andrew S., 3209 E. 16th St., Indianapolis, Ind.
Guiry, Mrs. M. J., 684 Grand Ave., St. Paul, Minn.
Hagan, Mrs. G. N., Marion, O.
Hartford, Mrs. D. J., 5104 Throop St., Chicago, Ill.
Harthill, Mrs. John, 14708 Cost Road, Cleveland, O.
Hasse, Mrs. F. C., La Grange, Ill.
Hatz. Mrs. G. J., Omaha, Neb.
Howard, Mrs. H., 206 W. Baltimore St., Jackson, Tenn.
Howard, Miss Nina Lee, 206 W. Baltimore St., Jackson, Tenn.
Hempel, Mrs. C. L., 2545 Davenport St., Omaha, Neb.
Hohenstein, Mrs. E. H., 2530 7th Ave., Rock Island, Ill.
Holt, Mrs. John, 4045 W. Park, Chicago, Ill.
Hopp, Mrs. W. H., 313 22nd St., Dubuque, Ia.
Hursh, Mrs. P. S., 17 Linden Ave., Du Bois, Pa.
Johnston, Mrs. Jas. T., 1315 W. 41st St., Los Angeles, Cal.
Kelly, Mrs. J. W., 515 N. Grove Ave., Oak Park, Ill.
Krahl, Mrs. J. P., 2606 Quincy St., N. E., Minneapolis, Minn.
Kremer, Mrs. John, 4014 Wash. Blvd., Chicago, Ill.
Ladtkow, Mrs. O. F., 1311 Fredericka Place, Milwaukee, Wis.
Larason, Mrs. W. S., 1070 Lexington Ave., Columbus, O.
Laughridge, Mrs. W. H., Columbus, O.
Le Flare, Mrs. M. C., Chicago, Ill.
Lewis, Mrs. Thomas, Sayre, Pa.
Libera, Mrs. J. R., Milwaukee, Wis.
Lowe, Mrs. T. W., 760 Westminister Ave., Winnipeg, Man.
Lucas, Mrs. A. N., 170 22nd St., Milwaukee, Wis.
Lutman, Mrs. W. S., Hammond, Ind.
Lux, Mrs. Peter, Maywood, Ill.
McAndrews, C. C., 5417 Cottage Grove Ave., Chicago, Ill.
McCune, Mrs. T. E., Chicago, Ill.
McDermott, Mrs. John, 104 S. Court St., Water Valley, Miss.
McGarrigal, Mrs. J., Paducah, Ky.
McKenna, Mrs. John F., E. Providence, R. I.
Marshall, Mrs. R. L., 407 S. State St., Du Bois, Pa.
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Minehan, Mrs. J. H., Scranton, Pa.
Mitchell, Mrs. L. A., E. St. Louis, Ill.
Moore, Mrs. W. N., 1929 N. Crawford Ave., Chicago, Ill.
Moore, Miss, 1929 N. Crawford Ave., Chicago, Ill.
Morton, Miss, Indianapolis, Ind.
Nau, Mrs. C. N., 23 Elizabeth St., Hammond, Ind.
Nicholson, Mrs. C. A., Atlanta, Ga.
Nicholas, Mrs. Lewis, Jr., La Fayette, Ind.
Nicholas, Miss Anna May, La Fayette, Ind.
Norton, Mrs. W. A., Indianapolis, Ind.
O'Laughlin, Mrs. Thos. J., St. Paul, Minn.
Orr, Mrs. J. J., Scranton, Pa.
Patrick, Mrs. Charles P., Meadville, Pa.
Petty, Mrs. George M., 211 N. Louise St., Shawnee, Okla.
Petzinger, Mrs. C. F., 742 Courtland Ave., Macon, Ga.
Pool, Mrs. I. J., Baltimore, Md.
Porter, Mrs. Louis R., Minneapolis, Ind.
Powers, Mrs. John F., 726 Ellis Blvd., Cedar Rapids, Ia.
Powers, Mrs. John P., 905 1st St., Escanaba, Mich.
Powers, Mrs. T. F., 1129 S. Clarence Ave., Oak Park, Ill.
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Rearick, Mrs. G. M., 85 Germania St., Galeton, Pa.
Riley, Mrs. George N., 1917 Frick Bldg., Pittsburgh, Pa.
Ritter, Mrs. E. H., Newark, O.
Royss, Mrs. H. J., Chicago, Ill.
Russel, Mrs. Robert, Battle Creek, Mich.
Service, Mrs. H. H., 308 Jefferson St., Topeka, Kans.
Shea, Mrs. J. F., Sedalia, Mo.
Simms, Miss, Chicago, Ill.
Smythe, Mrs. Howard, 505 S. Vale, Bloomington, Ill.
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Sullivan, Mrs. F. J., 537 Empire St., Freeport, Ill.
Thomson, Mrs. D. A., 37 35th St., Milwaukee, Wis.
Todtz, Mrs. Fred, 543 W. Midwest Ave., Casper, Wyo.
Troy, Mrs. John, Saginaw, Mich.
Umlauf, Mrs., 215 Willow Ave., Susquehanna, Pa.
Voss, Mrs. Otto C., Milwaukee, Wis.
Walla, Mrs. Frank, Sioux City, Ia.
Wagner, Mrs. G. A., Green Bay, Wis.
Warfel, Miss P., Scranton, Pa.
Warner, Mrs. Victor, 9226 Clyde Ave., Chicago, Ill.
Washburn, Mrs. L. E., 209 Erie Ave., Susquehanna, Pa.
Whitman, Mrs. C. L., Milwaukee, Wis.
Wilson, Mrs. George M., 117 Glenwood Blvd., Schenectady, N. Y.
Yochem, Mrs. F., Ft. Scott, Kans.
Young, Mrs. E. W., 787 Caledonia Pl., Dubuque, Ia.
Ziegenbein, Mrs. E., Jackson, Mich.
Zigler, Mrs. Wanda, 2530 7th Ave., Rock Island, Ill.

# TRADE PUBLICATIONS

EVAPORATORS FOR BOILER FEED WATER.—The application of evaporators to the purification of boiler feed water by distillation is covered in a general and non-technical manner in bulletin No. 360 recently issued by the Griscom-Russell Company, New York. This booklet is so written that the application of Reilly self-scaling evaporators to the power plant may be readily understood by executives.

WELDING RODS AND ELECTRODES.—A handbook for welders, giving complete instructions for the use of "Page-Armco" welding rods for oxy-acetylene welding and electrodes for arc welding has been issued by the Page Steel and Wire Company, Bridgeport, Conn. An outline of the manufacturing processes for making the Page products chemically pure is given as well as many useful tables for welders.

WELDED FLEXIBLE STAYBOLTS.—A pamphlet outlining the reasons why locomotive users should change from the threaded to the welded flexible staybolt sleeve in their boilers has been sent out by the Flannery Bolt Company, Pittsburgh, Pa. The answer given in the booklet is that the latter is stronger, will not leak, does not require the care in application, will not crystalize and can be used to replace threaded sleeves or rigid bolts.

BOILER TUBE CLEANERS.—The problem of eliminating the heat waste due to the formation of scale in boilers is dealt with at length in a catalogue sent out by the Liberty Manufacturing Company, Pittsburgh, Pa. Water turbine cleaners of various types, equipped with different style heads are described with the special uses for which they are best adapted. Pneumatic cleaners of high power in which steam can also be used are also illustrated and described. Mention is made of pneumatic cleaners for fire tube and return tubular boilers, arch tube cleaners and special cutting heads.

POWDERED FUEL EQUIPMENT.—A catalogue having as its object the explanation to prospective users of the advantages, construction and operation of the Grindle powdered fuel system has been published by the Grindle Fuel Equipment Company, Harvey, Ill. The complete system of stowing, drying, pulverizing, conveying and burning coal eliminates all handling of fuel by hand, shovels, wheelbarrows, or industrial coal cars, also firing tools, grate bars, etc. The catalogue contains specifications and illustrations of standard equipment, but special types can be furnished to meet any particular condition.

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Assistant Chief Inspector—J. M. Hall, Washington, D. C.

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### International Brotherhood of Boiler Makers, Iron Ship Builders and Helpers of America

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William Atkinson, Assistant International President, suite 522, Brotherhood Block, Kansas City, Kansas.

Joseph Flynn, International Secretary-Treasurer, suite 504, Brotherhood Block, Kansas City, Kansas.

James B. Casey, Editor-Manager of Journal, suite 524, Brotherhood Block, Kansas City, Kansas.

H. J. Norton, International Vice-President, Alcazar Hotel, San Francisco, Calif.

International Vice-Presidents—Thomas Nolan, 700 Court St., Portsmouth, Va.; John Coots, 344 North Spring St., St. Louis, Mo.; M. A. Maher, 2001-20th St., Portsmouth, Ohio; E. J. Sheehan, 7826 South Shore Drive, Chicago, Ill.; John J. Dowd, 953 Avenue C, Bayonne, N. J.; R. C. McCutcheon, 15 La Salle Block, Winnipeg, Man., Can.; Joseph P. Ryan, 7533 Vernon Ave., Chicago, Ill.; John F. Schmitt, 605 East 11th Ave., Columbus, Ohio.

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Executive Board—L. M. Stewart, G. B. I., Atlantic Coast Lines, Waycross, Ga., Chairman.

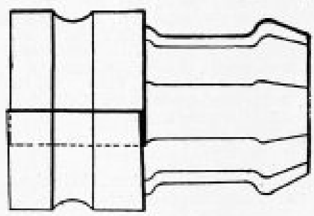
## SELECTED BOILER PATENTS

Compiled by
GEORGE A. HUTCHINSON, Patent Attorney,
Washington Loan and Trust Building,
Washington, D. C.

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

1,408,546. SPRING RETAINER AND SAFETY COVER FOR SECTIONAL TUBE EXPANDERS. EDWARD J. SWEENEY, OF HAMMOND, INDIANA.

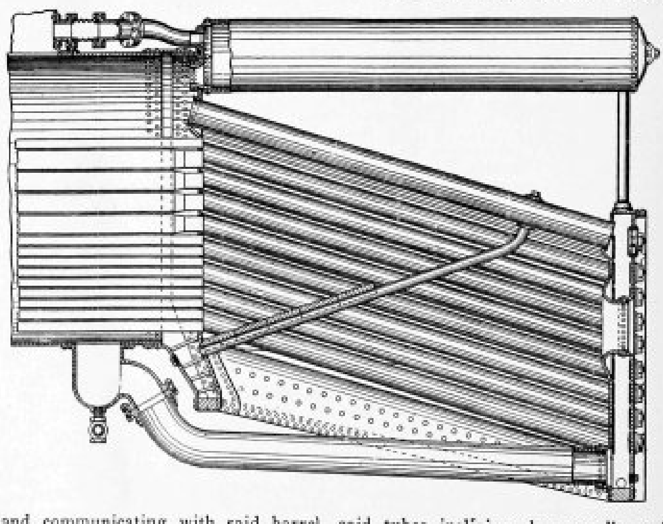
*Claim* 1.—In combination with a sectional expander, a circular cover adapted to be positioned over one end of the expander, and having a flange



portion contacting with one end of the expander, said circular cover having overlapping ends to permit the cover to expand and contract, and said cover adapted to hold the sections of the expander in an assembled position. Two claims.

1,341,475. BOILER. JAMES M. McCLELLON, OF EVERETT, MASSACHUSETTS.

*Claim* 1.—The combination of a barrel with a firebox comprising side and crown tubes connected to close the sides and crown of the firebox



and communicating with said barrel, said tubes inclining downwardly and rearwardly therefrom, and steam drums located above the firebox and communicating with said barrel and with the water spaces of the firebox. 3 Claims.

THE BOILER MAKER

JULY, 1922

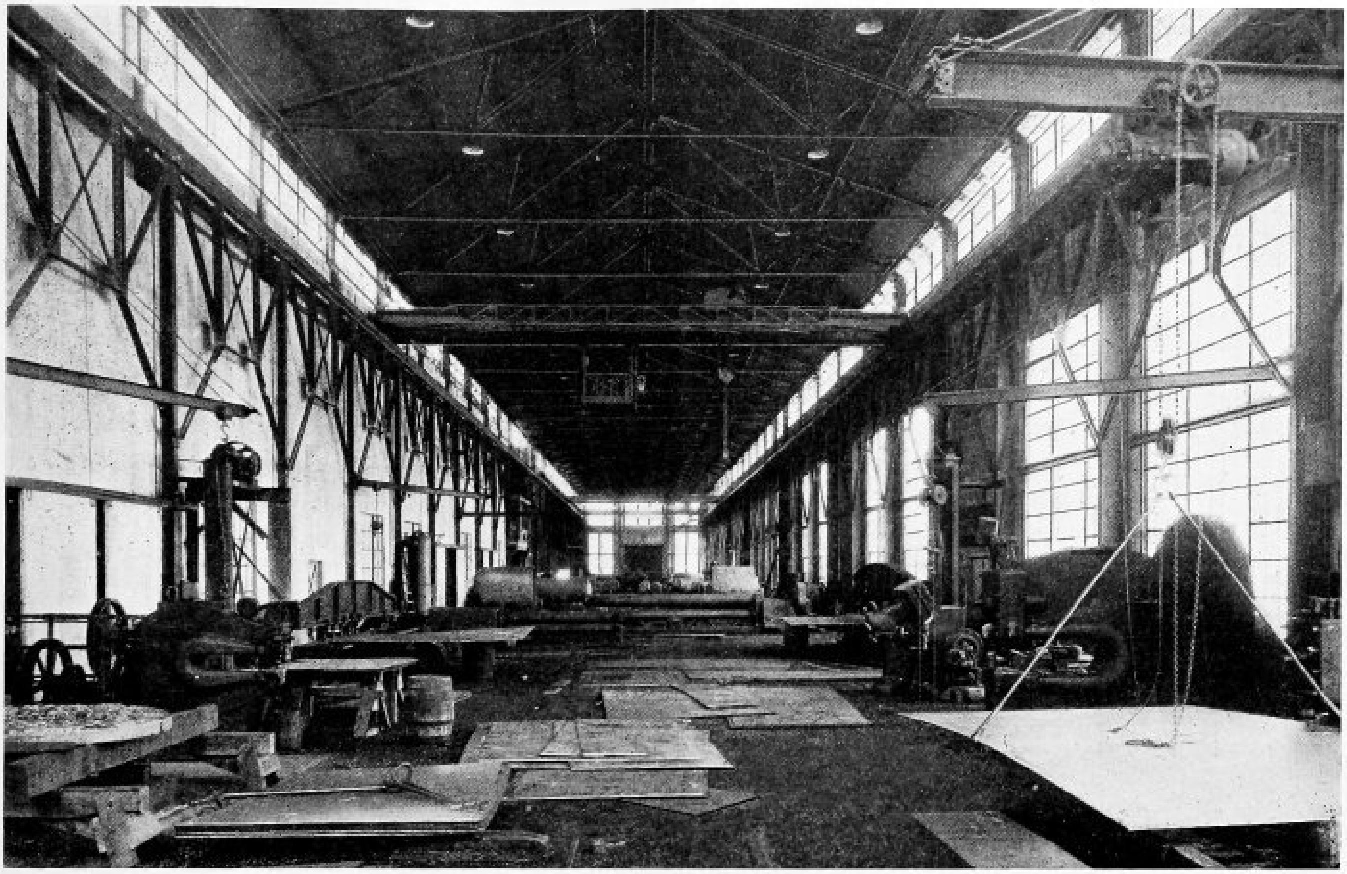


Fig. 1.—View of Main Shop, Plate Fabricating Department Is in the Foreground

# New Shop of the International Boiler Works Company

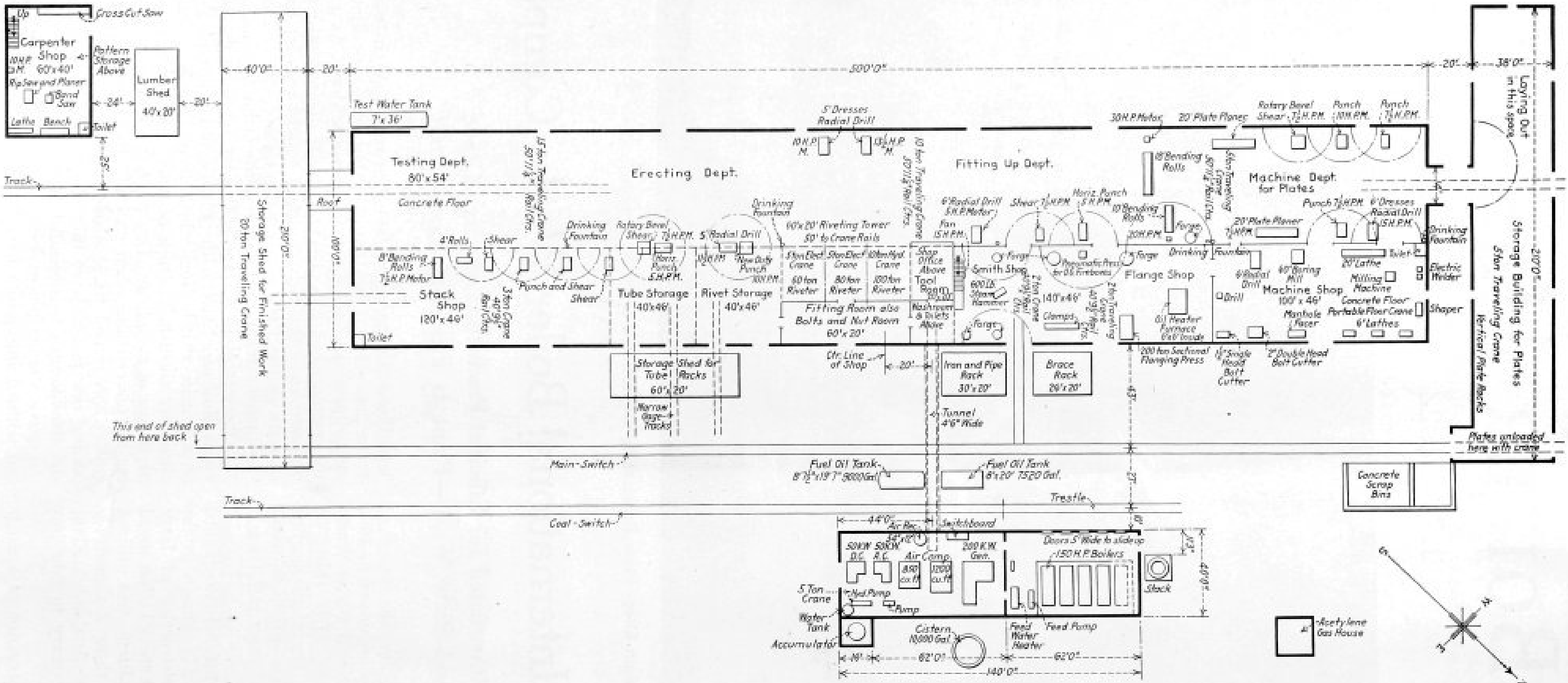
## Designed and Constructed for Efficient Production of High Grade Boilers, Tank and Plate Work—Plant Is Fireproof Throughout

ESTABLISHED in July, 1886, under the name of Weiser, Seiders and Company and reorganized in 1900 under its present name, the International Boiler Works Company of East Stroudsburg, Pa., has, after thirty-six years of progressive development, become one of the leading boiler manufacturers in the East, whose products, comprising a general line of boiler, tank and sheet metal work, are in use in all parts of the world.

From 1900 until 1919 the company operated two plants, both in East Stroudsburg. Shop No. 1, known as the Minnisink Plant, was used for the construction of large marine and horizontal tubular boilers and special sheet metal work; while shop No. 2, the Analomink Plant, was utilized for building vertical boilers (especially those designed for hoisting engines), tanks, etc. In 1919 the Analomink Plant was destroyed by fire and it became necessary to take immediate steps to provide new facilities.

The plan adopted provided for the construction of a much larger and thoroughly modern fireproof plant in which the entire business of the company could be consolidated and ample provision made for future expansion. As a result, the company now has in operation one of the most efficiently designed and completely equipped boiler shops for this class of work in the East.

Situated along the main line of the Delaware, Lackawanna and Western Railroad and with easy access to the Pennsylvania Railroad System, the plant's rail connection consists of a private switch from which three branches, comprising altogether about half a mile of track, lead to the various departments of the plant. One track leads to a trestle adjoining the power house where coal and fuel oil are unloaded by gravity. A second track is used almost exclusively for incoming raw materials so that plates, tubes, rivets, bar iron and the like can be unloaded from the cars direct to their respective storage places without any unnecessary handling and without interfering with production in the shop or the




## Equipment

### Cranes

1—20 ton Niles 3 motor traveling crane
1—15 ton Niles 3 motor traveling crane
1—10 ton Niles 3 motor traveling crane
1— 5 ton Patterson-Kelley 3 motor traveling crane
1— 5 ton Niles 3 motor traveling crane
1—10 ton hydraulic crane (R. D. Wood) floor control
2— 5 ton Shepard crane—floor control
1— 3 ton box 3 motor traveling crane—floor control
1— 2 ton 2 motor traveling crane—International Boiler Wks. Co.
1— 5 ton hand crane—International Boiler Wks. Co.
1—2 ton hand crane—International Boiler Wks. Co.
18— 2 ton jib cranes

### Machine Tools

1—6' Dreses Radial Drill
3—5' Dreses radial drill
1—6' Cincinnati Bickford radial drill
1—6' radial drill
4—Small spindle drills
3—6' Lathes
1—20' Lathe
1—1½" single head Acme bolt cutter
1—2" double head Acme bolt cutter
1—60" Boring mill
1—Milling machine
1—Shaper
1—Manhole facer
1—Tool grinder
1—No. 5 Hilles & Jones Punch
1—No. 17 G—New Doty punch
1—No. 2, Hilles & Jones horizontal punch
1—Wais Bros. horizontal punch
2—Vertical punches
2—No. 2 Lennox rotary bevel shears
1—No. 1 Hilles & Jones universal shear
1—Shear for light plates
1—Combination punch and plate, bar and angle shear
2—Combination punch and shears
1—Size "A" pneumatic staybolt clipper
1—100 R. D. wood hydraulic riveter, 102" reach
1—80 ton Hanna riveter, 102" reach
1—60 ton I. B. W. riveter, 84" reach
1—200 ton R. D. Wood sectional flanging press
1—Press for O. G. fire boxes—International Boiler Wks. Co.
1—18' horizontal bending rolls—Wickes Bros.—motor driven
1—10' horizontal bending rolls—Wickes Bros.—motor driven
1—8' horizontal bending rolls—Wickes Bros.—motor driven
1—4' horizontal bending rolls line shaft drive
1—3' horizontal bending rolls hand power
1—Pair of No. 6 Hilles & Jones flanging clamps
1—No. 3 Two electrode Berwick elec. rivet heater
3—No. 3 Four electrode Berwick elec. rivet heater
1—75/300 amperes Lincoln arc welder
1—600-pound Niles steam hammer
1—20' Cleveland plate planer
1—20' Hilles & Jones plate planer
1—American Saw Mill Machinery Co. combination planer and rip saw
1—American Saw Mill Machinery Co. band saw
1—American Saw Mill Machinery Co. cross cut saw

**Fig. 2.—Plan of the International Boiler Works**

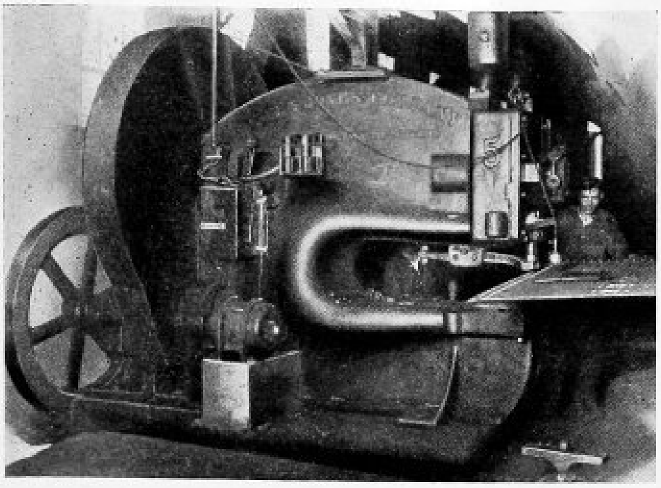


Fig. 3.—Hilles and Jones No. 5 Punch

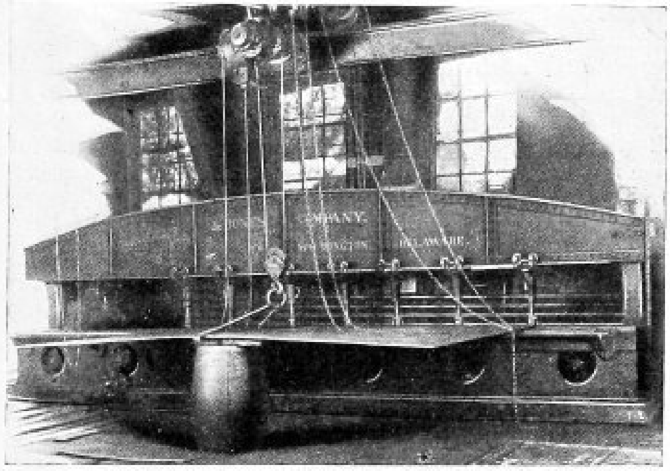


Fig. 5.—20-Foot Hilles and Jones Plate Planer

shipping of finished products. The third track leads to the testing floor and storage building for finished products and is used solely for shipping out the completed work.

### Construction of the Plant

The general plan of the plant, as shown by Fig. 2, resembles an I-beam section, the web of which is formed by the main shop, over 500 feet long and over 100 feet wide, and the flanges of which are represented by two buildings, each 210 feet long by 40 feet wide, placed at the ends of the main shop and at right angles to it. The building at the northwest end of the main shop contains the plate storage and laying out floors while the building at the other end of the main shop is used as storage space for finished work. Along one side of the main shop is a side bay, 46 feet wide, in which are located the machine shop, flange shop, smith shop, tool and fitting rooms, riveting department and stack shop. At one side of the main shop and about 100 feet from it in a separate building, 140 feet long by 40 feet wide, is the power plant, which supplies all the electric and hydraulic power and compressed air required to serve the entire plant.

The plant is absolutely fireproof throughout, as it is constructed of steel, concrete and tile. Heavy steel columns, spaced 20 feet between centers and reinforced for the crane runway, support the steel roof trusses, which are of special design and also the roof, which is of concrete. At each column on both sides of the shop are one or more connections

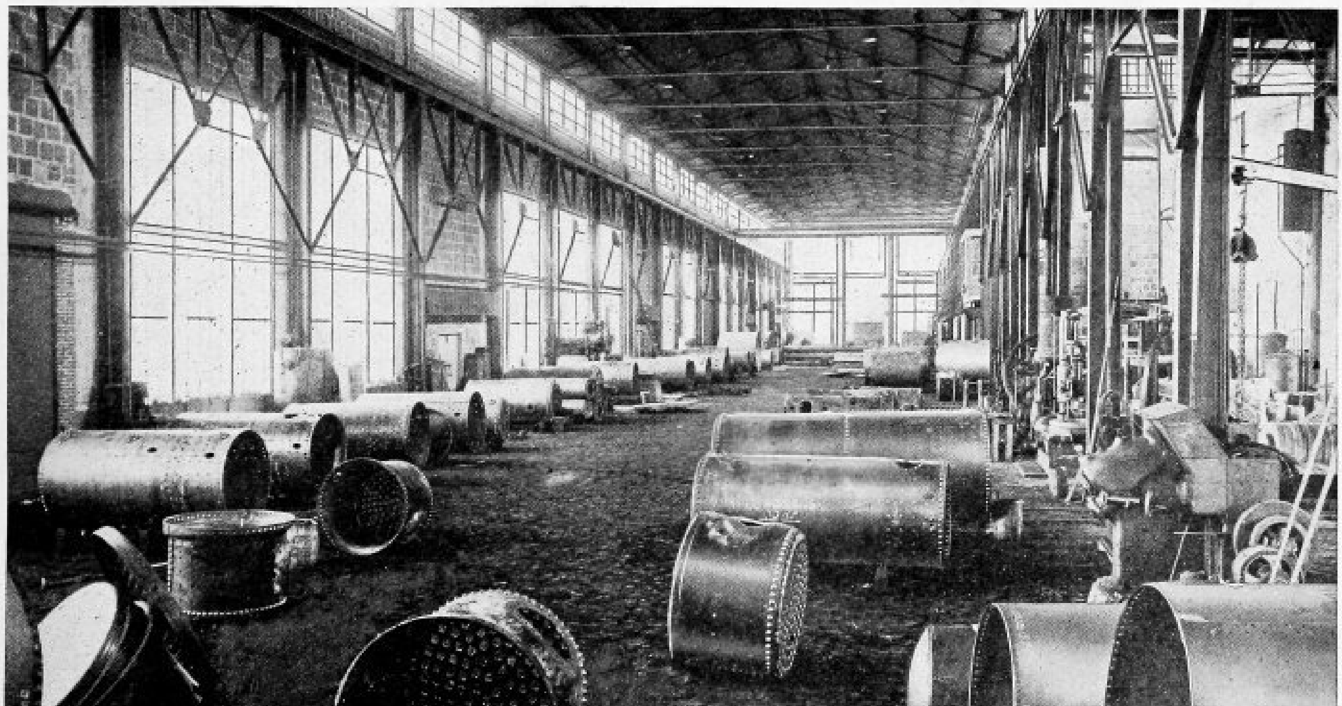


Fig. 4.—View of Main Shop, Showing Erecting Department in Foreground

for electric lamps and portable electrical machinery. On each column is also a 2-inch compressed air feed line which supplies the auxiliary air receivers and manifolds in which are air hose connections.

The total effective floor area is 82,678 square feet. About 70 percent of the wall area consists of glass surfaces for lighting the shop by daylight. Artificial light is furnished by 500-watt reflecting lamps.

Exhaust steam from the power plant is used to heat the shop by direct radiation in cold weather. Pure artesian well water is continuously flowing at various points in the shop

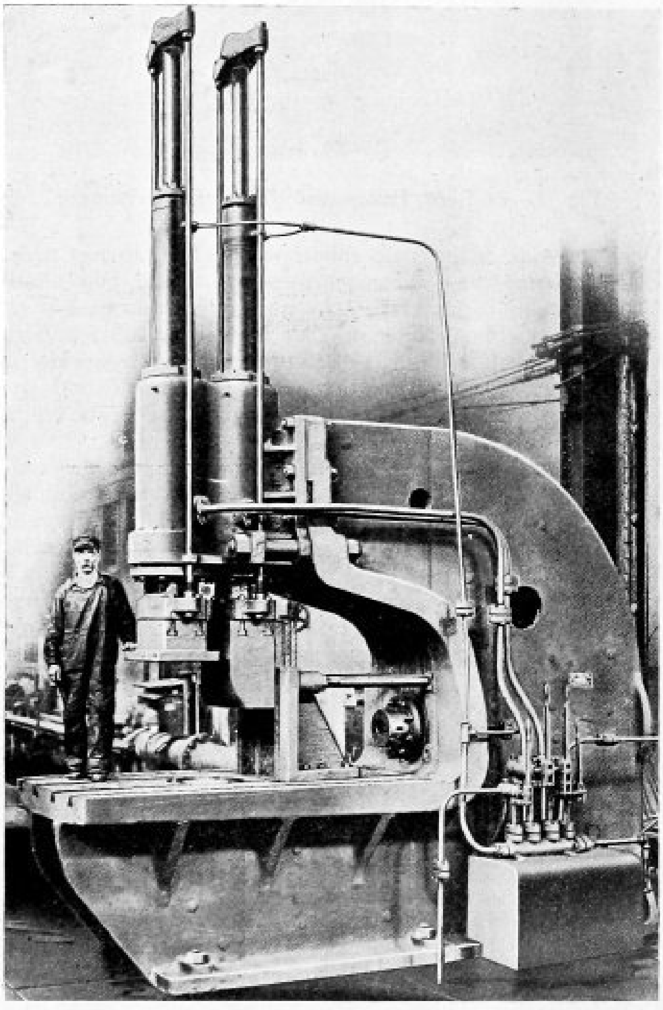


Fig. 6.—200-Ton R. D. Wood Sectional Flanging Press

for the workmen. A special wash room with hot and cold water, toilets, individual lockers, etc., is also provided.

Two submerged fuel oil storage tanks of 16,500 capacity lie between the main shop and power plant. A 15,000 gallon concrete well stores water derived from private sources and used for boiler feeding, etc.

With the exception of the necessary supply of fuel the operation of the plant is entirely independent of all outside influence.

### Straight-Line Progression of Work Through the Shop

The primary object in the layout of the entire plant when it was designed was to have the raw material enter at one end and go out the other end as a finished product without any crossing or reverse movement. This object has been carried out with unusual success, which is shown to the best advantage by the remarkable decrease in labor cost.

The plates and heads which form the bulk of the raw material in boilers and tanks do not leave the main bay of

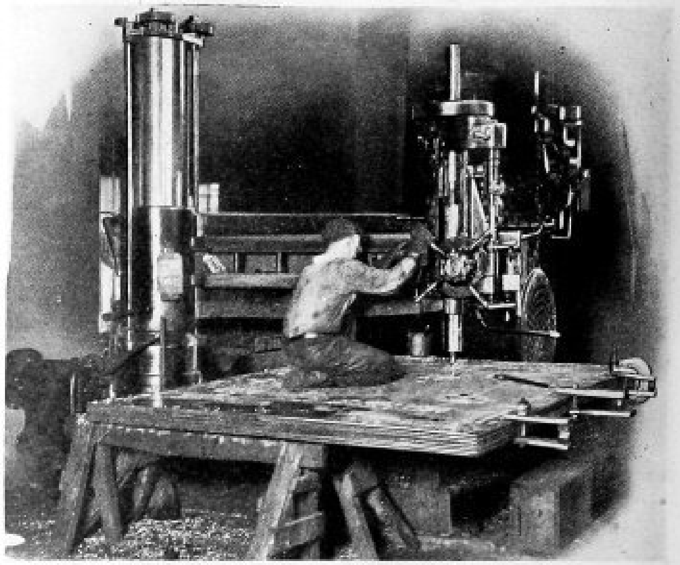


Fig. 7.—Drilling Eight Plates Simultaneously on Radial Drill

the shop during the course of construction, consequently the overhead traveling cranes are accessible throughout the route.

The material is handled throughout the shop by overhead electrically operated traveling cranes, electric hoists or by jib cranes at individual machines. All cranes in the main shop have a 30-foot lift with the exception of those at the riveting department, which have a clear lift of 50 feet.

Each machine has its individual jib crane with either hand or electric hoist, so that the traveling cranes need not be detained but are ready to move the work from one machine

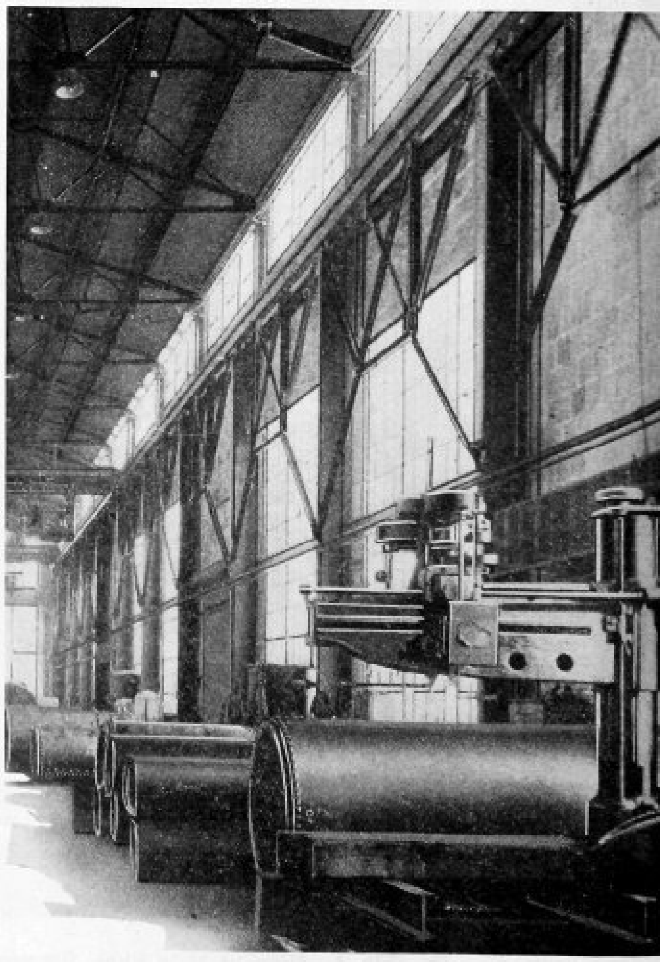


Fig. 8.—Radial Drill in Erecting Department

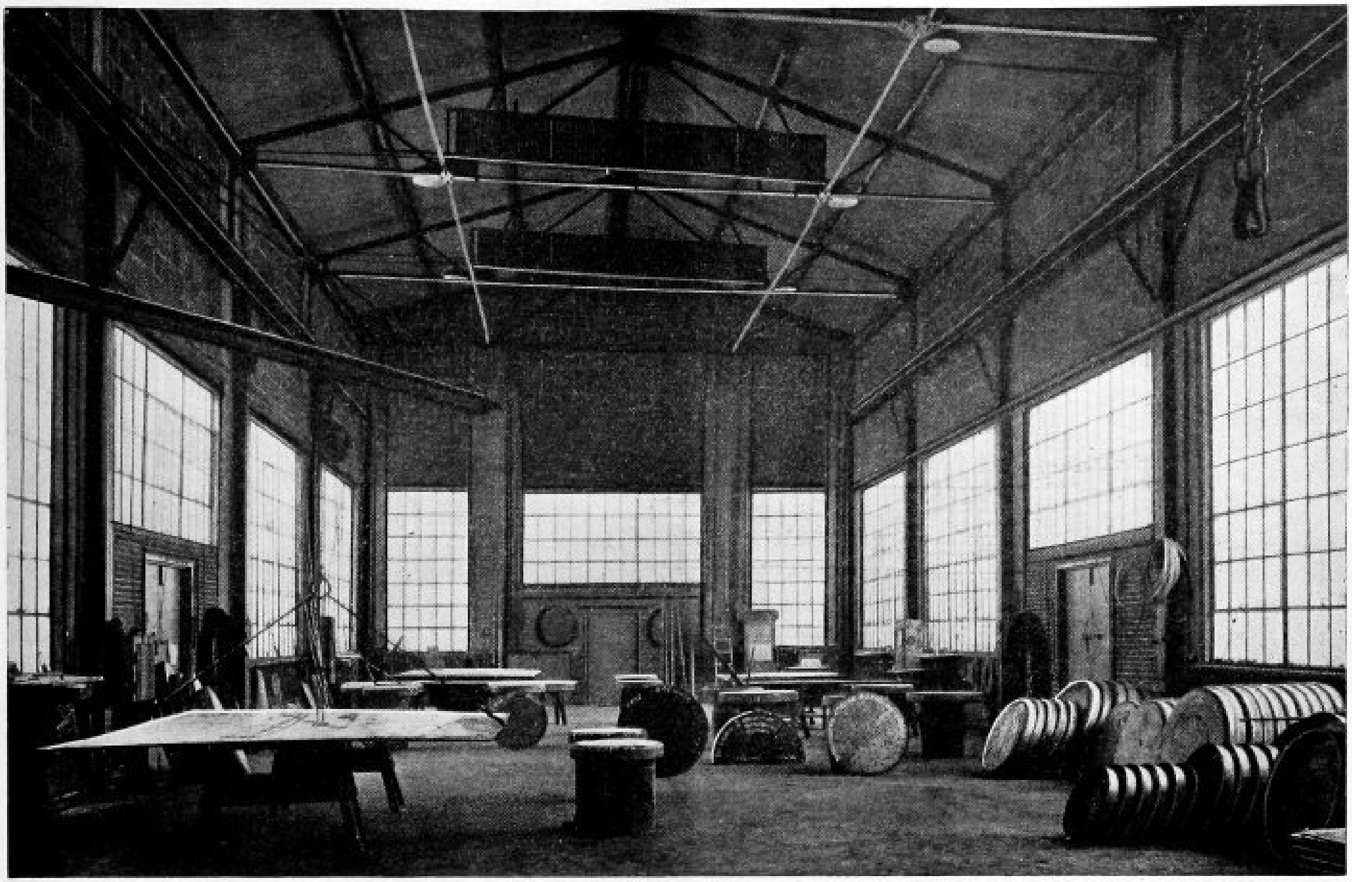


Fig. 9.—Laying Out Department

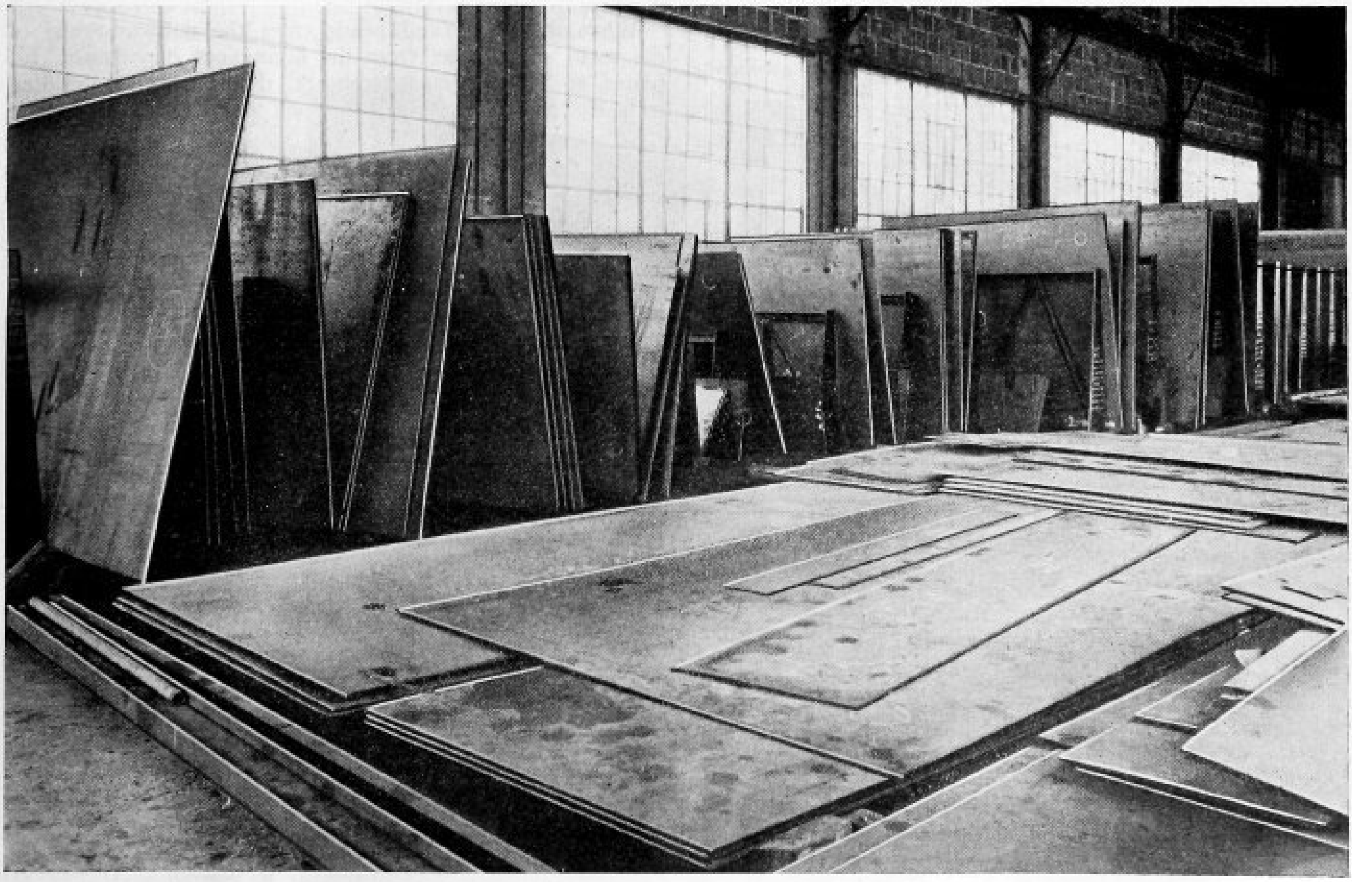


Fig. 10.—Plate Storage

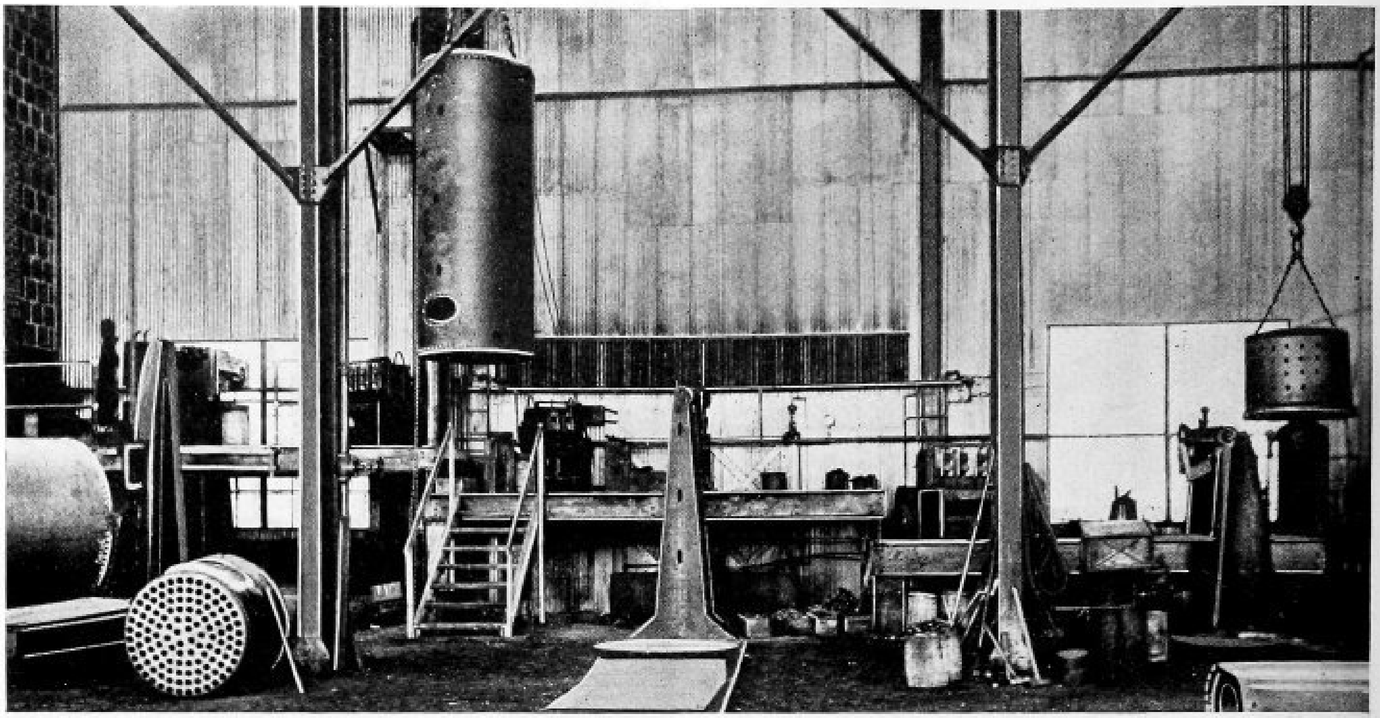


Fig. 11.—Riveting Department in Side Bay

to the other. Another advantage in having all of this machinery under the traveling crane is felt when repairs are necessary.

### Plate Storage and Laying Out Department

Raw material in the form of plates is shipped into the plant from the railroad over the spur track leading into the end of the storage building at the northwest end of the main shop; from the cars, the plates are picked up by a 5-ton traveling crane and either stacked vertically in steel racks according to size or laid flat, if of special nature, as shown in Fig. 10, at the north end of the storage building. At the other end of this building is the laying out department (Fig. 9) with concrete floor. This is equipped with the necessary steel templates, gages and laying out tables and is served by the 5-ton overhead traveling crane and also by jib cranes with hoists.

### The Main Shop

When the plates and heads enter the northwest end of the main shop direct from the laying out department, the plates go to the punches, shears, drills, planers, bending rolls, etc., and then are passed along to the fitting up depart-

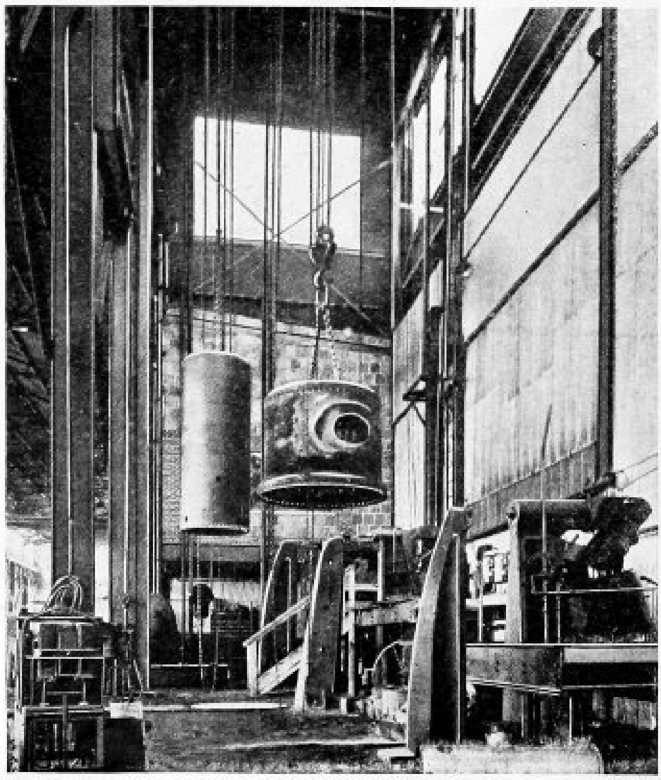


Fig. 12.—Riveting Tower. Cranes Have 50-Foot Clear Lift

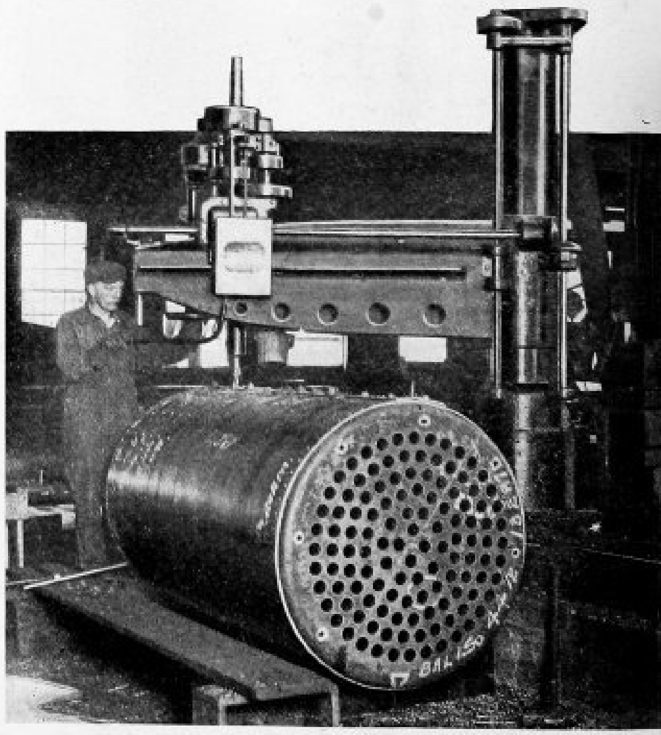


Fig. 13.—Reaming Rivet Holes in Assembled Boiler

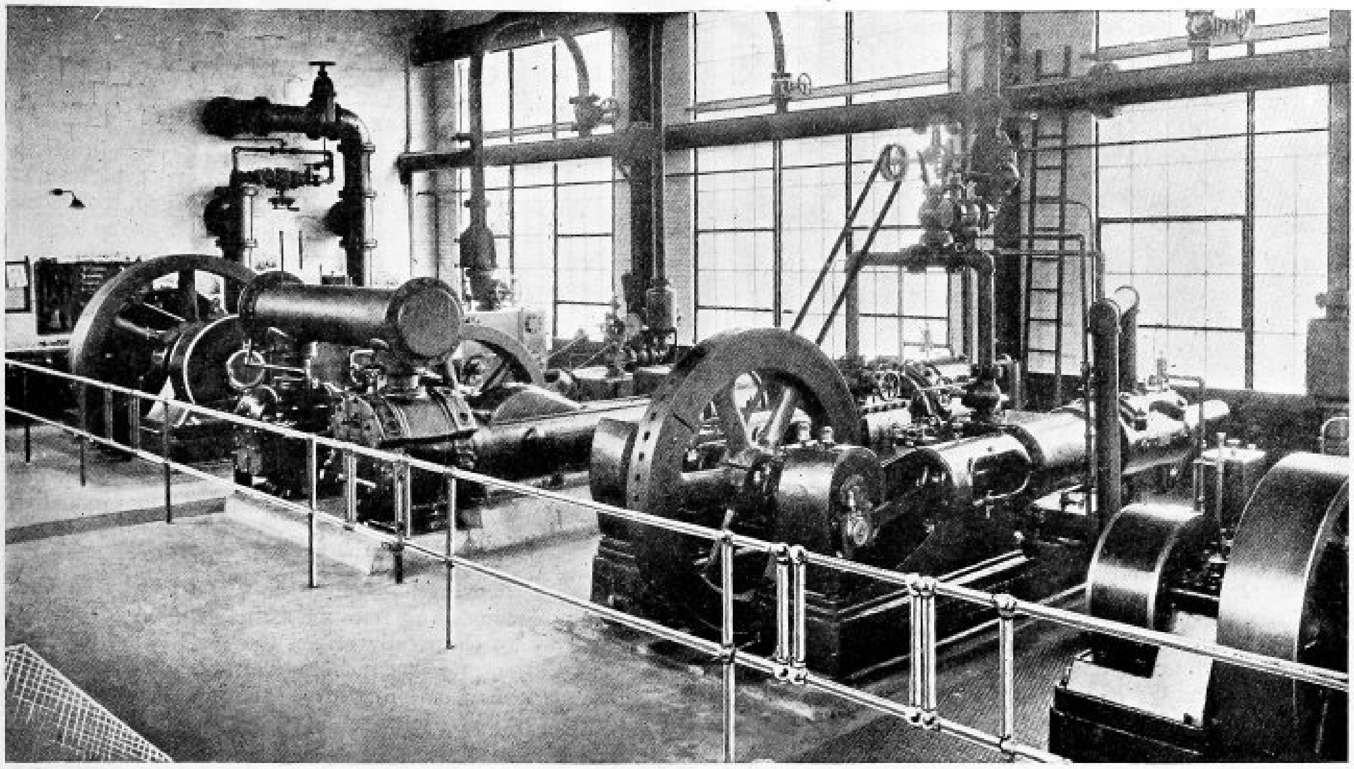


Fig. 14.—Engine Room, Showing Air Compressors in Foreground and 200-Kilowatt Generator in Background

ment; meanwhile, the heads have advanced toward the southeast end of the main shop at a location on the side of the erecting floor where they are drilled and stored ready for installation when the shells arrive.

The location and capacity of the machine tools in the plate fabricating department are clearly shown in the plan, Fig. 2. Each machine has an individual electric motor drive and is served by a jib crane with either electric or hand hoist. Over all is a 5-ton high speed electric traveling crane with a 50-foot 11¼-inch span.

In the intervening space of approximately 250 feet by 51 feet between the plate shop and the testing floor are the assembling floors where the boilers are fitted and assembled both preparatory and finally. A 10-ton high speed electric traveling crane and jib cranes serve this section.

After the boilers and tanks have been fitted up, the holes reamed and burrs removed, they are taken to the riveting tower in the side bay at the center of the shop and machine

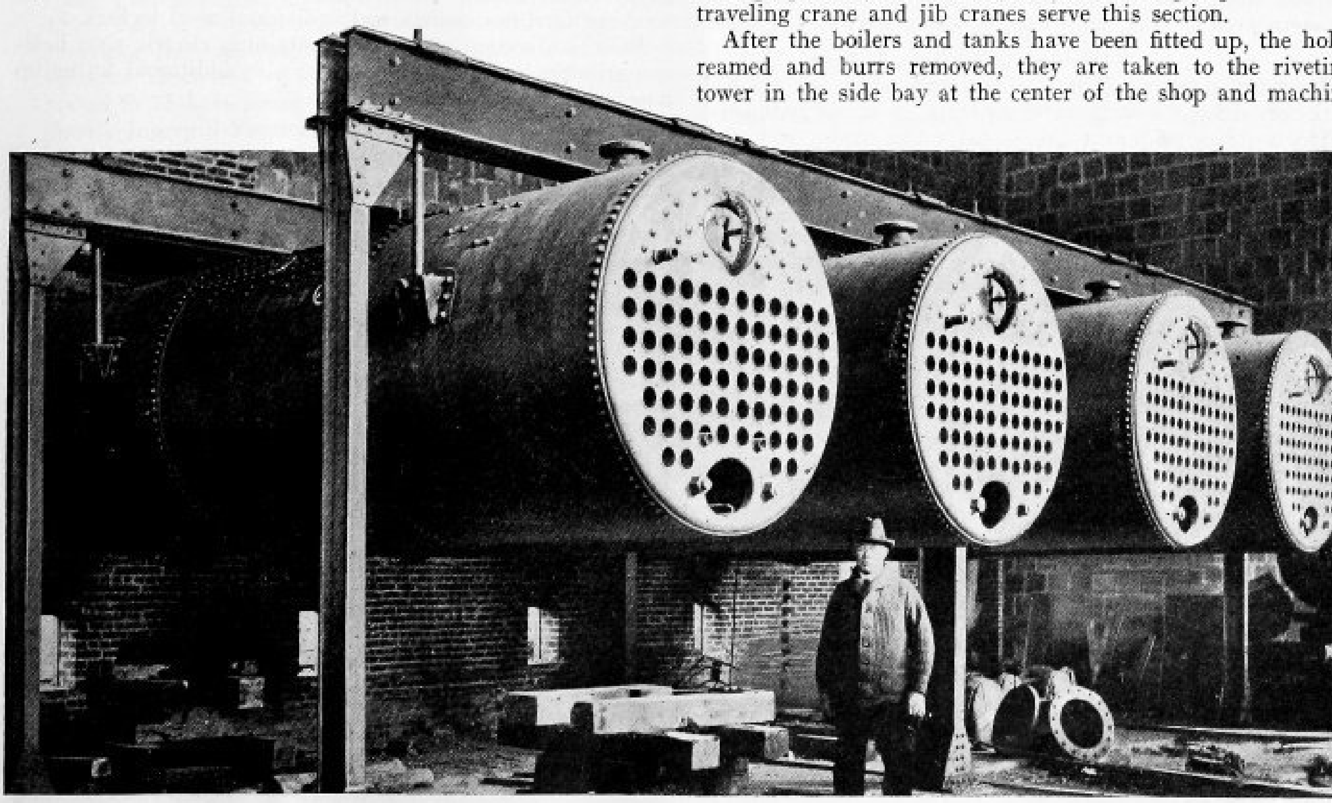


Fig. 15.—Main Battery of International Horizontal Tubular Boilers in Boiler Room, Showing Improved Type Suspension Before Completion of Brick Work

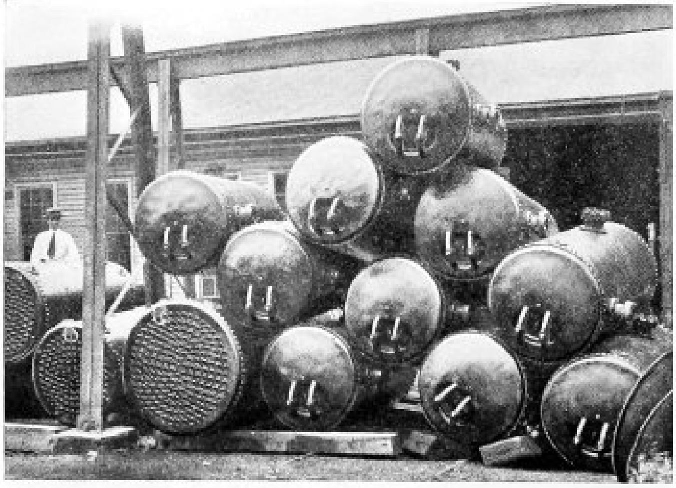


Fig. 16.—Completed Work, Ready for Shipment

riveted. The riveting tower is easily accessible to the main traveling cranes and has reinforced concrete platforms on steel structures. The riveting equipment comprises a 100-ton hydraulic riveter and two pneumatic riveters, one of 80 tons and one of 60 tons. The riveting machines are served by one 10-ton hydraulic crane and two 5-ton electric cranes, all with a clear lift of 50 feet.

### Testing

On the assembling floors, between the riveting tower and the testing floor, all boiler tubes are installed, calking done and the boilers completely finished preparatory to testing. When the work is completed on the erecting floor it is advanced to the testing department.

The testing takes place on a self-draining special concrete floor over a submerged tank of 20,000 gallons capacity which stores the testing water for repeated use. A 15-ton high speed electric traveling crane serves this floor from which finished work may be shipped directly on an extension of the spur track serving the storage building for finished work.

### Storage Section

Beyond the testing floor is the storage shed for finished work served by a 20-ton traveling crane in which completed boilers pending shipment are stored under cover and protected from the elements.

From the foregoing it is seen that the plant's general construction allows all work to move in straight-line progression from the raw material to the finished product with no unnecessary handling and, consequently, with minimum production cost.

### Auxiliary Departments

The 46-foot side bay, which extends the full length of the main shop, is taken up entirely by auxiliary departments, such as the machine shop, flange shop, smith shop, tool room, fitting room and stack department, all of which are so located as to feed the work as it progresses through the main shop at the proper time and place.

### Machine Shop

At the northwest end of the side bay, nearest the plate storage, is a completely equipped modern machine shop, 100 feet long by 46 feet wide, in which special machinery is installed for the plant's upkeep, the making of staybolts, etc. It has a concrete floor on which portable floor cranes are used to serve various machines, some of which have jib cranes. Air and electric connections also aid in productive efficiency.

### Flanging and Smith Shop

Next is the flanging and smith shop, 140 feet by 46 feet, completely partitioned off from the main shop and adequately ventilated by an electrically driven fan installation to eliminate gases. Its equipment includes hydraulic and pneumatic flanging machinery, smithing fires, a large gas heated flanging furnace, two electric traveling cranes and jib cranes with hoists. Conveniently located outside are fire proof buildings for the storage of bar iron, pipe, boiler braces, rivets and tubes.

### Tool Room and Fittings Room

At the center of the shop in the side bay are the tool room and fittings room. The first contains a supply of gages, hand tools and other appliances while the second contains bolts, nuts, piping, gage glasses, pipe fittings, valves, etc. Above these rooms is the superintendent's office slightly projecting into the main shop to provide a clear view throughout the shop. Above also is the workmen's welfare room containing washing facilities, toilets and individual steel lockers.

Next is a section of the bay containing electric rivet heaters, grinders and other equipment; also additional fitting up floor space all served by cranes.

### Stack Shop

At the extreme southeast end of the side bay and extending for a length of 120 feet is the stack shop used for build-

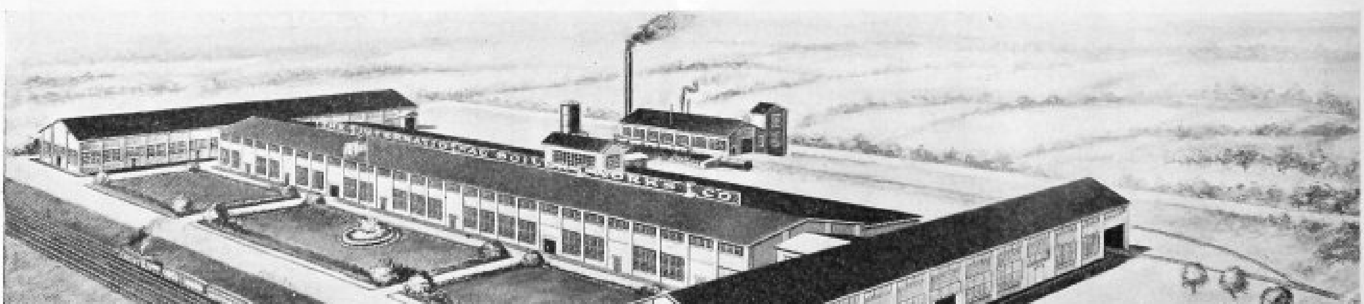


Fig. 17.—Sketch of New Plant of International Boiler Works Company

ing stacks, small tanks and light plate work, thereby relieving the main boiler shop of work that would tend to retard the heavy work. The stack shop is a small boiler shop in itself, complete in every detail, having punches, shears, bending rolls, riveting stakes, traveling cranes, etc. The plates for this class of work are stored in racks at one end of the shop.

### CARPENTER SHOP

In a separate building, 60 feet by 40 feet, situated near the storage building for finished work, is the carpenter shop, used for making crates and patterns. This shop is equipped with power-driven wood-working tools.

### POWER PLANT

As previously stated, the power plant, which supplies all the electric and hydraulic power and compressed air required for the operation of the entire plant, is situated in a separate building about 100 feet distant from the main shop. This building is also of fire-proof construction, being made of steel, concrete, tile and glass. The boiler room is 62 feet by 40 feet and contains four horizontal tubular boilers, each 72 inches diameter by 18 feet long of 150 horsepower, built by the International Boiler Works Company and supported by an improved steel suspension setting entirely independent of the brick work. The products of combustion are led to a self-supporting steel stack 6 feet in diameter by 100 feet high.

The coal and fuel oil are unloaded by gravity from the elevated track alongside the power house. An automatic feed water regulator controls the feed water supply to the boilers which are fitted with an automatic draft regulator. A 600-horsepower Linton combined feed water heater, purifier and oil extractor and an outside packed feed water pump of 70 gallons per minute capacity are also in the boiler room.

The engine room, which is 62 feet by 40 feet, is served by a 10-ton traveling crane. Its equipment includes the following units: One 200-kilowatt General Electric direct current generator, direct connected to a 300-horsepower medium speed Corliss engine supplied by the Ball Engine Company, Erie, Pa.; a 50-kilowatt Westinghouse alternating current generator for supplying the rivet heaters and a 50-kilowatt General Electric direct current generator both direct connected to 75-horsepower Ball high speed engines; one steam-driven Ingersoll-Rand air compressor of 850 cubic feet capacity; one steam-driven Ingersoll-Rand air compressor of 1,190 cubic feet capacity and one hydraulic accumulator, 10 inches by 12 feet, supplying a hydraulic pressure of 1,500 pounds per square inch. The engine room also contains a modern switchboard fully equipped, oil filters and other necessary auxiliaries.

The air compressors deliver to a 54-inch by 12-foot vertical air receiver in the engine room; an 8-inch supply line runs to the main shop, branching into two 6-inch lines rising on each side of the shop to supply headers running the full length of the shop on each side. These headers gradually decrease to 3-inch diameter at the ends. Auxiliary air receivers are located at several points in the main shop, where the demand for compressed air is greatest.

The exhaust steam from the engines enters a 16-inch header and then passes through the feed water heater. It is used for heating the shop by direct radiation in winter and is returned by a vacuum pumping system to the heater and in summertime goes directly to the atmosphere.

A special and unique feature connecting the power plant and main shop is a concrete tunnel, 100 feet long by 6 feet 6 inches high by 4 feet 6 inches wide, lighted and ventilated, through which are carried on one side the heating lines, compressed air lines, high pressure steam lines and water supply lines, and on the other side all electric wires arranged in conduits supported on racks.

### PERSONNEL

At this plant labor dissensions and disturbances are said to be unknown. Many workmen have spent their lives in the employment of the company and, in several cases, have their sons and grandsons working beside them in the shop, giving the plant the unusual distinction of having available three generations of inherent skill and ability in the fabrication of its products.

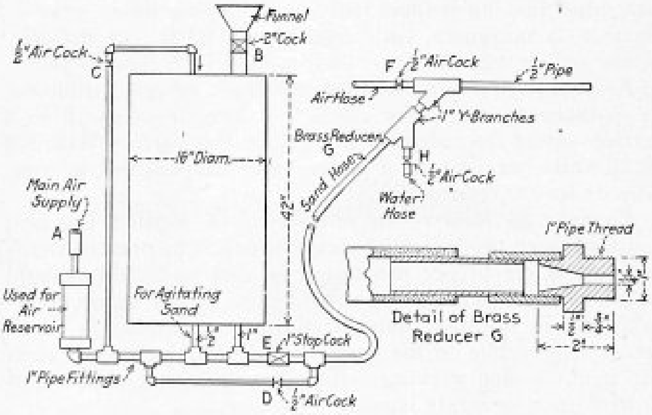
Charles S. Hebard is president of the company; James W. Booth and Frank D. Metcalf, formerly with the Baldwin Locomotive Works, are vice-presidents; Charles R. Turn, who has been associated with the company since 1895, is treasurer and general manager and A. Mitchell Palmer, formerly United States attorney-general, is secretary and solicitor.

## Scaling Boilers with Sand Blast

THROUGH the courtesy of George McCormick, general superintendent motive power of the Southern Pacific at San Francisco, the following description and drawing of an hydro-pneumatic sand blast for cleaning boilers is published.

As shown in the drawing the device consists of a 16-in. by 42-in. tank which can be mounted on a four-wheel truck for easy movement about the shop. Suitable hose connections are provided to the air supply and water supply, the latter being used to keep down the dust. Air is furnished from the shop mains through flexible hose *A* to the line of 1-in. pipe and fittings beneath the tank. An auxiliary ½-in pipe is connected to the top of the tank and admits air through valve *C* on top of the sand. The tank can be filled with sand through the funnel and valve *B*. Valves *D* and *E* are located in the lower pipe lines as shown and a ½-in. pipe to the bottom of the tank facilitates keeping the sand in agitation so that it will readily fall through the 1-in. pipe to the moving air column. Air and sand are delivered through the flexible hose, brass reducer *G* and two Y branches to the ½-in. pipe which the operator uses in directing the final flow of air, sand and water. The blast is given force by means of air through valve *F* and water is admitted through valve *H*.

In operation the tank is filled with dry screened sand and valve *B* closed. With main air pressure on the tank




**Tank and Apparatus Used in Sand Blasting**

sand falls on the rapidly moving stream of air which carries it to the blast nozzle. The reducer *G* has a tapered hole (¼ in. at the smallest diameter) which automatically controls the amount of sand. The sand is moistened with water through valve *H* to keep down the dust and is finally ejected by the independent air hose connection at valve *F*. The strength of the blast and the amount of moisture are regulated by suitable adjustments of the respective valves.

# Feed Water Heaters for Locomotives

*The following report read at the Atlantic City Convention of the American Railway Association—Division V—Mechanical, in June, states that there are at present 58 feed water heaters in service and 139 on order for locomotives on the railroads of the United States and Canada. Test data obtained from the operation of these devices show a feed water temperature rise ranging from 145 degrees to 175 degrees F., and fuel savings from 10.5 percent to 16.5 percent.*

THAT considerable interest in the use of feed water heaters has developed during the last two years is evident from the number that have been applied. The committee's report for the year 1920 showed that there were 16 locomotives equipped at that time. There are now 186 feed water heaters in service or on order; 15 open type in service and 110 on order; 43 closed type in service and 29 on order.*

All new applications reported to the committee have been exhaust steam heaters, either of the open type, manufactured by the Worthington Company, or of the closed type, manufactured by the Superheater Company, with the exception of one, a Foster-Thompson exhaust gas heater.

### Maintenance Cost

The cost of upkeep of either the open or closed type heaters as reported by the different roads varies from $1.00 to $9.00 per 1,000 locomotive miles. Such a range is to be expected, as development work is still in progress and we cannot expect close agreement of the cost figures until a large number of heaters are in service and the supervision and repairs follow the general practice accorded other devices.

### Tests at Inspection Pits

No railroad reports any systematic daily inspection of feed water heaters. The usual practice is to depend upon the engineer's report, and to supplement it by having the engine house inspector run the pump and note its action and any leaks in the pump or piping. Some roads report that at boiler wash periods they make a systematic inspection which includes special examinations of valves, tubes and other parts.

*Piping*—Some trouble has been experienced in maintaining the joints, but some of the roads advise that, by using iron pipe, bracing it thoroughly, and keeping the number of joints to a minimum, little trouble will occur. A majority of the replies report the use of iron pipe with flanged joints.

*Boiler Check*—A number of the roads reported difficulty in maintaining the boiler check, but have overcome it to a certain extent by reducing the lift of the valve. Where a small valve was in use, a larger valve was applied to compensate for the reduced lift.

*Freezing of Heater*—In ordinary cold weather the heat radiated from the boiler has been sufficient to prevent freezing and where proper precaution is used no trouble should result. All roads are using suitable drain cocks where necessary and in addition some of them have applied a small steam supply line to the suction pipe, which is used when the pump is not working. Both the open and closed type heaters are thoroughly lagged.

*Oil Separator*—The use of oil separators with heaters seems to be general. Only two roads report having found traces of oil in the boiler, and both state that it has not resulted in any damage to the boiler. One of these roads, which is located in bad water districts, attributes an increased amount of foaming to the presence of oil in the boiler.

The other road, which is located in a good water district, reports that they have had heaters in service for several years and that frequently chemical analyses of the boiler scale have never shown more than a trace of oil, although one heater was in service for one year with the oil drain from the separator closed.

### Economy Tests

A number of the roads have made economy tests of the heater in comparison with the injector, and some very excellent results have been obtained. The committee has no information as to how these tests were run and cannot vouch for the accuracy of the results reported, but give them as information.

| | |
|---|---|
| **Road No. 1—Closed Type** | |
| Increased evaporation per pound of coal | 14.3 per cent |
| Coal saving per 1,000 gross ton miles | 12.3 per cent |
| Increase in over-all boiler, furnace and grate efficiency | 14.3 per cent |
| Type of locomotive tested (cylinders 27 in. by 30 in., drivers 69 in., 200 lb. boiler pressure) | 4-8-2 |
| **Road No. 2—Open Type** | |
| Coal saving | 12 per cent |
| **Road No. 3—Closed Type** | |
| Increased evaporation per pound of coal | 24.1 per cent |
| Decrease in fuel consumption | 10.5 per cent |
| Decrease in superheat | 3.6 per cent |
| **Road No. 4—Open Type** | |
| Saving in coal per 1,000 ton miles | 14.0 per cent |
| Increased boiler efficiency | 16.1 per cent |
| Exhaust steam recovered from the cylinders, condensed and returned to the boiler | 8.6 per cent |
| Decrease in superheat, deg. F. | 21.7 |
| **Road No. 5—Closed Type** | |
| Saving in coal per 1,000 ton miles | 8.9 per cent |
| **Road No. 6—Open Type** | |
| Saving in fuel oil | 12.5 per cent |
| **Road No. 7—Closed Type** | |
| Saving in coal per trip | 12.5 per cent |
| Increased evaporation per pound of coal fired | 16.0 per cent |
| **Road No. 8—Closed Type** | |
| Saving in fuel | 13.0 per cent |
| **Road No. 9—Closed Type** | |
| Saving in fuel | 16.5 per cent |
| **Road No. 10—Closed Type** | |
| Saving in fuel | 14.0 per cent |

### Temperature of Feed Water

The rise in temperature of the feed water is a very definite indication of the economy which is gained by the use of feed water heaters, and accordingly in the questionnaire temperatures obtained, with the locomotive working at or near maximum power and also with a light train, of the delivery water, section water and exhaust steam, were requested in order to more fully bring out this feature. A digest of the replies shows that the rise in temperature for heavy trains ranged from 135 degrees to 185 degrees F., with an average of 156 degrees F. For light trains the rise ranged from 92 degrees F. to 175 degrees F., with an average of 144 degrees. Many of the roads reported but small differences in the temperatures obtained for heavy trains and for light trains.

### Cleaning of the Heaters

In good water districts no trouble has been experienced with the collection of mud or scale in the heaters, but in bad water districts such has been the case and consequently it has been necessary to clean them.

With the open type the usual method has been to scrape the scale and mud loose and then wash it out with a hose.

*A table accompanying the report shows that 106 of the open type heaters on the order are for the Southern Pacific and 24 of the closed heaters on order are for the New York, New Haven and Hartford.

With the closed type the inside of the tubes are usually cleaned by pumping through them a solution of muriatic acid and the outside of the tubes are cleaned by boiling them in a solution of washing soda for about twenty minutes and then washing them with hot water.

### Exhaust Nozzle

There was no agreement as to the necessity or the advisability of changing the size of the exhaust nozzle. Four roads found it necessary to decrease the size of the nozzle and ten have made no change at all.

### Indicating Device for Pump

Pressure gages of various types have been the only device used to indicate the action of the pump. The opinion is general that there should be some device which will tell the enginemen that the pump is running, but the results so far obtained with the gages have not been entirely satisfactory, due to their inability to stand the severe service.

### Use of Heater When Locomotive Is Standing or Drifting

When the locomotive is standing or drifting the use of the heater is not recommended. Objection has been made to the application of feed water heaters on the ground that it would be impossible to prevent their use when there was no exhaust steam to heat the water and then cold water introduced into the boiler would have a bad effect on the flues and firebox.

The replies to the questionnaire indicate that there is no evidence that the use of the feed water heater has resulted in any damage to the boiler.

The use of exhaust steam from the auxiliaries, such as air pump, headlight generator and stoker may be advisable in order to maintain the temperature of the feed water when the locomotive is not working. Several roads express the opinion that any damage from the introduction of cold water to the boiler would be reduced by the use of a top head check.

### Capacity of Heater

The question with reference to the capacity of the heater developed the fact that a few of the roads were of the opinion that the capacity of the heater should be equivalent to that of one injector, while the majority desire an increased capacity ranging from 10 per cent to 100 per cent, with an average of about 33 per cent. Some additional capacity no doubt should be provided to compensate for the reduction in the capacity of the feed water heater due to worn packing, worn cylinders or leaky valves.

It is recommended that the work of this committee be continued and that additions be made to the rules covering locomotive tests, whereby standard methods may be introduced for testing the two types of heaters so that the results of heater tests made on different roads may be comparable.

The report is signed by F. M. Waring (chairman), Pennsylvania System; A. Kearney, N. & W.; W. Kelly, Great Northern; G. W. Rink, C. R. of N. Y.; L. P. Michael, C. & N. W.; G. S. Edmonds, D. & H., and H. C. Oviatt, N. Y., N. H. & H.

### Discussion

F. M. Waring (Pennsylvania): Your committee can only report progress and submit a short summary of replies that it has received to its inquiries made to the members regarding their experience with feed water heaters.

It is interesting and encouraging to note that the table giving the number of heaters in use is already out of date, before the report is presented. We have unofficial information that the number of open heaters should be increased by about 19 and the committee will endeavor to bring that table up to date before the report is printed.

J. Snowden Bell: Inasmuch as this report shows a fuel saving from 8 and 9 to 14 per cent and averaging 12.6 on nine reported cases, there can be no question but that the feed water heater is a fuel saving device. It comes directly within the suggestion of the chairman for full and careful consideration and I earnestly hope that it will be discussed. The subject is by no means a new one. Feed water heaters were introduced in this country and put in service (I saw them in 1883) as early as 1836 and from time to time since that year various designs have been experimented with and used to some extent. The Pennsylvania has about ten. There were a very large number on the Reading, but for some reason they were discontinued and it is only recently that they have been revived.

We have before us two types in the open and closed heaters. They are not half-baked experiments, or any sort of theoretical scheme, but they are well developed, actual constructions which have stood the test of use. I do not think, Mr. Chairman, that the last word has been said as to either type, nor do I think that these will be the only types. These, however, come before us with well-reported success and it seems to me that they certainly ought to have a very full and careful consideration and discussion.

In preparing the paper which I presented at the 1918 meeting on feed water heaters and their development, I sent inquiries to members and there were 51 favorable to feed water heaters and 11 who either expressed doubt or were unfavorable. The very material increase in favorable sentiment since then is evidenced by the fact that now 197 heaters are in service or on order.

I recently saw a design of smokebox jacket heater which impressed me very favorably for its simplicity. I have never approved of the smokebox heater and it has failed for the reason that we have got too many things in the smokebox now. We do not want anything more in there and if we take out a few of the present parts it will be of advantage. It always seemed to me that a smokebox jacket heater would get the benefit of the heat if it could be made in a simple manner. That was the design presented. I do not know how far it has been carried out, but if Mr. Giles is here he probably can tell us because it emanated from his department. It was constructed very much on the style I described in the 1918 report, regarding which the superintendent of motive power on the road that was using it said: "This heater was in use for about two years, but, on account of the application of a superheater it was taken out. The arrangement showed a good saving in coal and repairs to the boiler and the water entered the boiler at a temperature of 250 degrees. I am of the opinion that the device has merit both in economy in fuel and in repairs, as the boiler has a more even temperature than when supplied by an injector."

## Fees for Stamping Boilers

Since the National Board of Boiler and Pressure Vessel Inspectors has been functioning, the question of fees for stamping boilers with the National Board stamp has arisen. No single rate could be established which would be fair to manufacturers of all types of boilers since small, low priced boilers would have to carry the same item of expense as higher priced equipment.

To overcome this difficulty, a sliding scale of rates has been established by the executive committee of the National Board which became effective July 1. This scale follows:

(A. H. P. being based upon 10 square feet of heating surface.)

| | |
|---|---|
| From 1 to 5 horsepower | 0.25 |
| From 6 to 50 horsepower | 0.50 |
| From 51 to 200 horsepower | 1.00 |
| From 201 to 500 horsepower | 2.00 |
| From 501 horsepower up | 3.00 |

In view of this new schedule it will be necessary that all of the manufacturers place the heating surface of the boiler on the bottom of the data report.

# Calculating Thickness of Plates and Size of Stays for Rectangular Tanks

**By John S. Watts**

THE design of rectangular tanks, especially the thickness of plates used and the staying, is too often done by rule of thumb and, in consequence, the tanks so made are insufficiently strong for the strains imposed upon them. This does not mean, however, that a tank will burst when filled, or even that it will show signs of distress when tested to a pressure exceeding the working pressure by 50 percent. My experience has been that a tank may be absolutely tight under test when new, but if the plates are too light, or insufficiently stayed, it will soon begin to leak at the corners and also to corrode rapidly at the places where the stress is highest.

Once a leak is opened in a tank, it is practically impossible, owing to the thinness of the plates, to stop it by calking and, even if it could be stopped, the movement of the plates that caused the leak to start will inevitably reopen it and ultimately cause the tank to be discarded. Even if the tank remains watertight, the plates will, if the staying is insufficient, deflect and start the form of corrosion known as grooving along the edges of the plates. In either case, the life of a tank that is weak in design is very short in comparison with a tank which has been thoroughly well designed.

### Corrosion Increased by Breathing Action

As is well known, a steel plate under high stress and, especially so when this stress causes a bending of the plate, will corrode rapidly and hence in any kind of a tank, the more stiffly the plates are stayed the longer will they resist corrosion. Unfortunately the stress imposed upon flat plates under pressure has not yet been accurately determined and this no doubt explains why so little data have been published bearing on this subject. At the same time formulae have been developed which while not theoretically correct, experience proves are quite sufficiently accurate for the purpose of the subject under discussion.

The one most applicable to square or rectangular tanks is that derived by Unwin, which is

$$L = 2\,t\,\sqrt{\frac{S}{P}}$$

Where: $L$ = Length of square plate between stays in inches,
$S$ = Working stress in pounds per square inch,
$P$ = Working pressure in pounds per square inch,
$t$ = Thickness of plate in inches.

This formula is for square plates firmly fixed around all four sides and uniformly loaded over the whole surface. In practice the plate is held by rivets which are spaced more or less closely, depending upon whether they are in a seam which has to be calked or in a stay fastened to the plate. In the first case, the rivets are usually spaced sufficiently close to enable us to consider the plate as firmly fixed all along the riveted edge. In the second case, it is general practice to space the rivets quite far apart, too much so to really fix the plate as called for by the conditions under which this formula was derived.

It is impossible to say exactly how much the stress on the plate is increased by a wide spacing of the rivets, but experience seems to show that the pitch of the rivets should never exceed six times their diameter and that little or nothing is gained by making the pitch less than four times the diameter of the rivet.

### Trial and Error Method of Solving Problem

It will be noticed that in the above formula we have two variables namely $t$, the thickness of the plate, and $L$, the pitch of the stays. To calculate these involves assuming one, and working out the other from the formula. If this gives an undesirable size, another combination must be tried. In order to eliminate this amount of labor, I have made up the chart accompanying this article, from which, knowing the pressure, we can see at a glance all the combinations of thickness of plate and pitch of stays which will carry this pressure. It is then possible to choose a combination which will suit the conditions best. This chart is based upon the above formula, using a safe stress $S$ of 10,000 pounds, which gives a factor of safety of about five. This will be found to give good results in practice and ensure a reasonable life to tanks made to these dimensions.

### Working Details of Chart

To increase the convenience of the chart, I have marked off along the bottom line the equivalent of the pressures in feet of head of water, so that we can use it with equal facility given either the head of water or the pressure, without having to convert either one into the other. To illustrate the method of using the chart, I will take the concrete example to determine the required thickness of plate and pitch of stays for the plate in the bottom of a tank ten feet deep.

Following up vertically from the point on the bottom line marked for a ten foot head, as indicated on the chart by the dotted line, we read at the points where this line crosses the horizontal lines for the various thicknesses of plates, the pitch of stays that is required for each thickness. We find that we have the choice of any of the combinations in the following table.

| Thickness of Plate | Pitch of Stays Inches |
|---|---|
| 12 gage | 10 |
| 11 gage | 11 |
| 1/8 inch | 12 |
| 10 gage | 13 |
| 9 gage | 15 |
| 8 gage | 16 |
| 7 gage | 17 |
| 3/16 inch | 18 |
| 6 gage | 19½ |
| 5 gage | 21 |
| ¼ inch | 24 |

The pitch of stays is read off from the diagonal line at or next below the intersection of the vertical line drawn from the head of the water point with the respective thickness of plate line. Bear in mind that the pitch of stays is, more correctly speaking, the maximum length of the side of a square plate which will safely carry the pressure in question and that this square plate must be firmly fixed all along each edge; that is, the plate will not be safe for the pressure if merely supported by a stay at each corner of the square as is done in the staying of flat surfaces of boilers.

### Choosing the Plate Thickness

The thickness of plate to be used will be chosen to suit the dimensions of the tank, as for example, in the above case, if the tank were 24 inches wide by 48 inches long, it would be most economical to use the ¼-inch plate, because this thickness is good for the required pressure on a plate 24 inches square.

Having chosen the thickness of plate, the next point is to work out the scantlings of the stays, and to facilitate this calculation, I have added at the right hand side of the chart a scale showing the total pressure on the square plate; that is, the pressure per square inch multiplied by the area of the square. This is found by drawing a horizontal line from the intersection of the head or pressure line with the pitch of stays diagonal line to the scale at the right and reading off there the total pressure, which in our example of ten feet head imposed on a 24 inch square plate we find to be 2,500 pounds.

If the tank is for a ship it will be necessary to fit what are called wash plates to prevent the water from surging around in the tank and so unduly straining the sides and these wash plates will be amply strong to serve also as stays. Otherwise these stays must be provided either in the shape of angle bar stiffeners, or stay plates, or a combination of both. Using the same example as before, the base of the tank will be 24 inches by 48 inches and referring to Fig. 2, this base will require a stay across the center. This stay will have to carry the load due to the pressure on the shaded area, the remainder being carried by the sides of the tank. The total load on the stay is obviously one half of the total load on the 24-inch square plate as given by the chart; that is, one-half of 2,500 pounds or 1,250 pounds.

The simplest and cheapest method of providing the support is to fit an angle across the bottom supported at each end by the sides of the tank, either externally or internally, as may be most convenient. This angle will carry the load which increases uniformly to the center as a beam supported at each end. The formula for such a beam is:

$$z = \frac{W \times L}{6 \times S}$$

Where: $z$ = modulus of section of the angle,
$W$ = total load on the angle,
$L$ = length of angle between supports in inches,
$S$ = safe stress = 10,000 pounds.

Substituting we get:

$$z = \frac{1{,}250 \times 24}{6 \times 10{,}000} = \tfrac{1}{2}$$

This is the modulus of a section of a 3-inch by 2-inch by ¼-inch angle, the 3-inch leg of course being vertical.

### Staying the Tank Bottom

Most manufacturers leave the bottom of a tank unstayed, as they claim that the tank will be resting upon a floor or other foundation which will support the bottom plate and that therefore stays are superfluous. Experience proves that when a tank stands flat upon a floor, whether this floor be wood or concrete, dampness will be generated, and the plate will corrode rapidly. This arrangement also prevents painting and inspection of the tank, with the result that it is impossible to know that the plate is rusting, until it actually starts to leak.

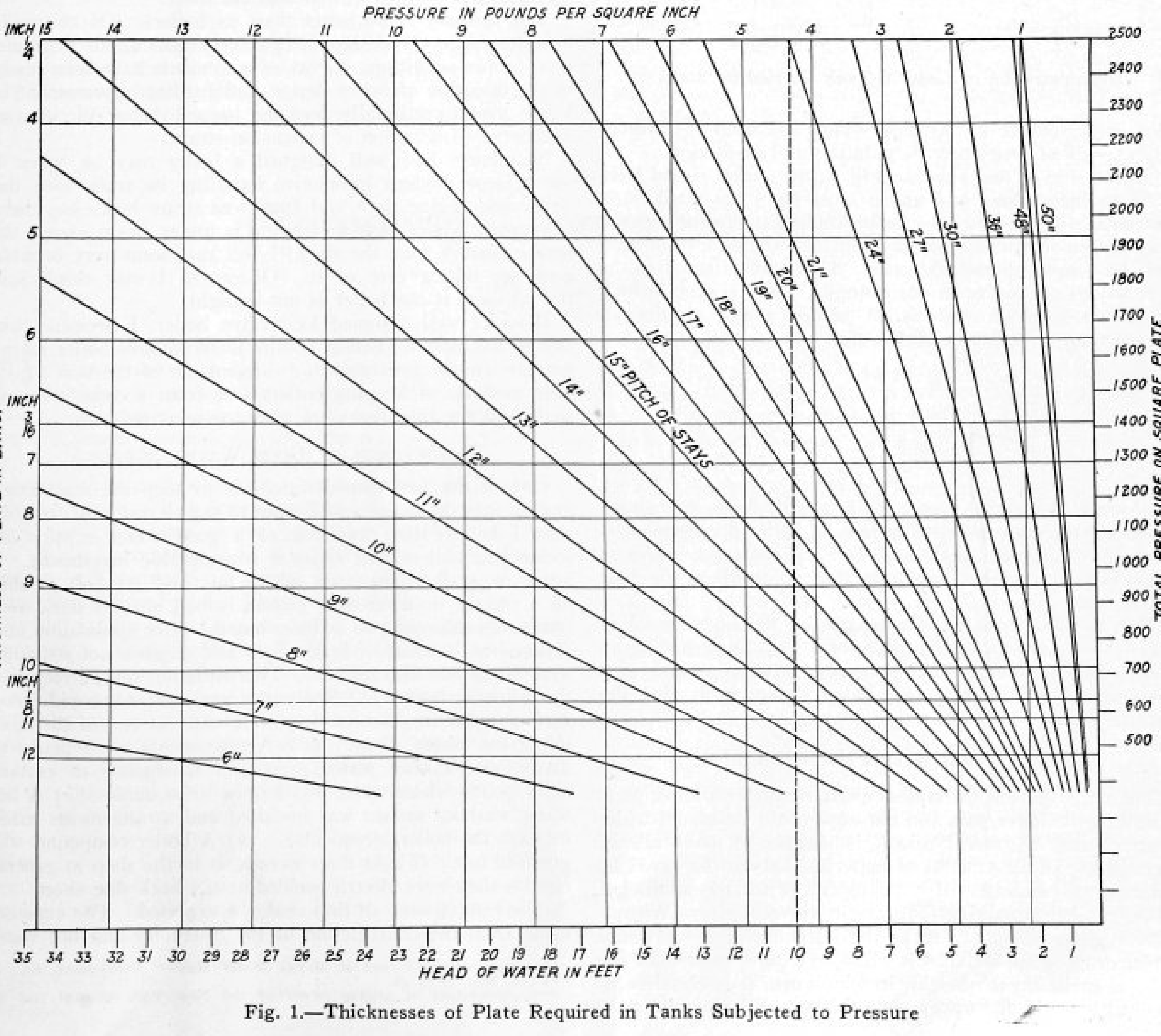



**Fig. 1.—Thicknesses of Plate Required in Tanks Subjected to Pressure**

The probability that the tank will give way without warning, and subject its owner to loss and delay until a new one can be ordered, made and installed is sufficient to warrant incurring the extra expense necessary to make the tank so that it can be supported on legs or other means that will

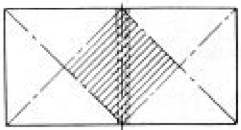


FIG.2

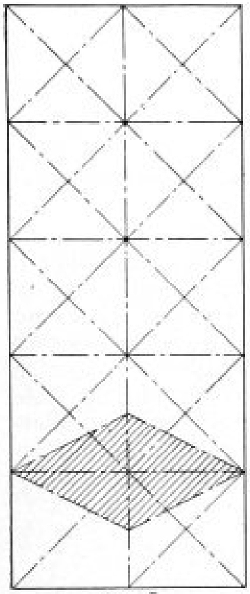


FIG.3

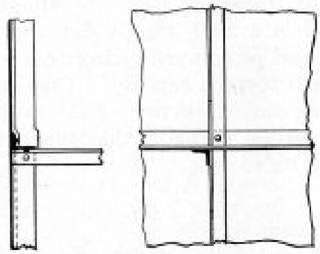


FIG.4

**Demonstration of Load in Tank Carried by Stays**

allow a current of air to pass under and keep the bottom dry, as well as permitting its painting and inspection.

On the side of the tank, see Fig. 3, the angles would have to be 48 inches long and unless cross stays are fitted, each horizontal angle acting as a beam would have to support the shaded area shown, the vertical angles of course transmitting their load to the horizontal ones. This load is equal to the load on one square, or in our example, 2,500 pounds, which as the unsupported span is 48 inches, would require an angle having a section modulus of:

$$z = \frac{W \times L}{6 \times S} = \frac{2{,}500 \times 48}{6 \times 10{,}000} = 2.$$

This would demand a 4-inch by 3-inch by 9/16-inch angle, which is rather a cumbersome size. A better arrangement is to use the same size angle as before and fit cross braces to support these angles at each junction point where the four angles meet.

This can be very simply arranged, on the lines shown in Fig. 4, the cross brace being made of a light angle having an area sufficient to carry the 2,500 pound load in tension, at a stress of not over 10,000 pounds per square inch, after deducting the rivet holes.

### Pressure on the Upper Part

The upper part of the tank is of course under a lower pressure than the lower part and the stays could be spaced wider apart, but as a general rule it is cheaper to make all the stays alike, as the amount of material that can be saved by reducing the staying will not compensate for the additional labor entailed in making the stays in different sizes. When a tank is deep enough to make the lessening of the pressure sufficient to be appreciable, it will also require more than one plate to make up the height, in which case it is clearly economical to make the upper plate thinner. Keeping the stays the same pitch, the allowable thickness can be quickly determined by reference to the chart.

In certain cases it is not possible to divide the plate into squares and the problem becomes that of calculating the thickness of plate required to support a given pressure, when the plate is rectangular in shape. It will require more staying to support a given number of square feet when the area is rectangular, but if unavoidable to have it this way the thickness can be determined by the following formula:

$$t = 0.62\sqrt{\frac{P \times L^2 \times l^2}{S\ (L^2 - l^2)}}$$

Where $L$ and $l$ are the lengths of the sides of the rectangle in inches.

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# Economic Importance of Adequate Locomotive Maintenance*

**By A. R. Ayres†**

RAILROADING is becoming more and more an exact science in which a locomotive represents a certain investment which is calculated to perform certain service. In other words, if steam locomotives are properly maintained there should not be a great deal of difference in power and operating efficiency between locomotives just out of the shop and locomotives ready to go into the shop.

The railroad is no better than its boilers. Of course if a boiler is poorly designed, it is very difficult to maintain it in proper condition. Great advancements have been made in the direction of better design and further improvement is being made continually looking toward better circulation and better distribution of expansion strains.

No matter how well designed a boiler may be, when I see a large modern locomotive handling its train with the boiler and engine tight and free from steam leaks and there is scarcely a sign that the engine is under steam except the smoke issuing from the stack, I feel that some very capable men are taking care of it. Of course I may think just the opposite if the boiler is not so tight.

Given a well designed locomotive boiler, I presume that two of the most important factors in locomotive boiler maintenance are the provision and diligent use of the best available methods of keeping boilers free from accumulation of scale and the intelligent use of autogenous welding.

### Importance of Good Water Supply

One of the first considerations is to keep the scale from getting into the boiler and I want to say to you most forcibly that I believe the provision of a good water supply for locomotive boilers will repay a considerable investment. I know of at least one case where flue and staybolt trouble on a certain division were extremely bad so that flues were sometimes changed two or three months after application and failures on account of leaky flues and engines not steaming were altogether too common. This situation was corrected in the following way: (1) Reservoirs were built to provide good surface water in place of deep well water at two of the most important water stops. (2) Arrangements were made to discontinue taking water except in emergency at certain other points where water was known to be hard. (3) A hot water washout system was installed and arrangements made to wash the boilers frequently. (4) A boiler compound was put into use. (5) As flues were reset in the shop at general repairs they were electric welded at the back flue sheet.

The results were all that could be expected. The expense, aside from the construction of the reservoirs and hot water

*Abstract of paper read at Master Boiler Makers' Convention, held in Chicago, May 23 to 26.

† Superintendent of motive power of the New York Central and St. Louis Railroad.

washout plant, was negligible and today a flue failure in that territory is almost unknown.

The more powerful locomotives are bringing with them better combustion and much higher firebox temperatures, particularly with stoker fired engines and it is much easier for a small deposit of scale to cause overheating and cracking of sheets. The danger of scale on firebox sheets is so well known to all of you that I doubt whether you realize that it is not always so well understood by the men who have immediate charge of washing the boilers.

REMOVING WASHOUT PLUGS

Too much cannot be said about the absolute necessity for the removal of all washout plugs, the careful and thorough cleaning of all arch tubes and the proper inspection of the boiler by a competent inspector before the plugs are re-applied.

It has been found good practice to maintain gages for staybolts and taps. Bolts that fit with reasonable tightness in the sheets before they are driven will stay tight much longer than bolts that have to be driven up to make them tight. Heavy holding on bars should be used when driving staybolts in order to keep from driving the bolts against the threads.

The proper beading of flues is another matter that must be watched very closely where the flues are afterwards welded as it has been found sometimes that a man in beading flues will not bead them sufficiently figuring that they are to be welded later and that the welding will take care of it. If a welded flue is found leaking the welding as a rule should be chipped off and the flue re-welded immediately.

The same thing should be applied to any welding in the firebox. If a leak starts, the engine should under no circumstances be allowed to run that way but the crack should be chipped out and re-welded. The peining or hammering of the welding is only a makeshift.

Fuel economy is of course very intimately connected with boiler making. To produce maximum economy, the locomotive boiler must be as free as possible from scale and from steam and water leaks. There is no necessity for going into details with you but it is a fact that the fuel saving of the boiler under good condition as compared with the same boiler under bad condition is very apparent.

With superheater engines particularly the proper cleaning out of flues and keeping the superheater element free from cinders is most important.

The question is sometimes raised as to how far it pays to go with good maintenance with respect to the cost feature. I recall a time when I had something to do with the operation of a large roundhouse in which it was common practice to thimble flues in the back flue sheet. I am pleased to say, however, that this was a good many years ago. One day orders came to discontinue applying flue thimbles and if a flue was found defective it should be replaced. Consternation reigned in the shop for a few days and then the trouble with leaks began to grow less than before we learned to make proper repairs.

It is always possible to spend money without getting an adequate return and this must be guarded against. But when we consider the reliability and efficiency of service that is required today from steam locomotives, I believe I am voicing the sentiment of you all in saying that the best possible locomotive boiler maintenance, involving the provision of good water, the proper repair facilities and the intelligent use of these facilities is a paying proposition for the railroads in the long run.

# Promoting Locomotive Safety*

**By A. G. Pack†**

HEAVY responsibility rests with the Master Boiler Makers and they have a sturdy, unyielding duty to perform in so constructing and repairing the large modern high pressure locomotive boilers in such manner that they will render economic service without unnecessary peril to the lives and limbs of our fellow beings who are called upon to operate them under the most strenuous conditions known to boiler operation. It is generally conceded that no other boiler meets with the same severe operating condition as does that of the locomotive. It is subjected to severe shocks, stresses and constantly varying temperatures under high steam pressure and under forced operation.

By the nature of our duties, and I speak advisedly when I say our, a locomotive boiler in importance should be given first consideration by those present. Its size and the pressure which it contains has been greatly increased in the past few years, and the number of appurtenances thereof are constantly increasing; therefore, the increased responsibility of the master boiler makers in so directing their subordinates that the best workmanship may be performed both in the interest of safety and economy.

In performing the duties of Chief Inspector of Locomotive Boilers for the United States Government I am probably afforded an opportunity to observe the general condition of approximately 70,000 locomotive boilers coming under our jurisdiction.

The investigation of accidents due to the failure of boilers and their appurtenances daily brings to our attention many conditions which serve to impress upon those responsible for the construction, inspection, repair, and operation of such boilers, the necessity for great care and thoroughness in their work. Many of the most innocent looking and apparently insignificant defects cause our fellow men great injury and possibly loss of life. For instance, a short time ago it was brought to our attention that a washout plug and bushing had blown out of a boiler while carrying 200 pounds steam pressure while the boiler was being tested after the locomotive had received classified repairs, resulting in the death of two men and the serious injury of three others. Upon investigation it was disclosed that the hole in the back head where the bushing had been screwed was practically void of threads, it having been only slightly scratched by the tap when the bushing was originally applied.

Another instance of striking lack of realization as to the results, was not long ago brought to our attention when we were called upon to investigate an accident resulting in the horrible death of the engineer and the most serious injury to the fireman. In this instance, the engineer reported a leak at the mud ring; it coming from underneath the jacket made it impossible for him to say just what caused the leak. However, when the jacket was removed it was found that the leak was from a telltale hole caused by a broken staybolt near the bottom of the back head. After the foreman made an examination and found the cause of the leak, he ordered repairs made by driving a nail in the

*Abstract of paper read at Master Boiler Makers' Convention, held in Chicago, May 23 to 26.

†Chief Inspector, Bureau of Locomotive Inspection, Interstate Commerce Commission.

telltale hole to stop the leak. Later while the locomotive was in the performance of its regular duty, the back head ruptured along the top edge of the mud ring for a distance of 24 inches, causing an aperture 1⅝ inches wide at its greatest width. Investigation disclosed that 5 adjacent staybolts next to this aperture and in the same horizontal row as the plugged bolt were also broken and that every bolt in the two bottom rows across the back head were either broken or fractured. The sheet being heavily grooved and without the support of the staybolts gave way with the result just referred to.

In this instance it was disclosed that the staybolts had not been hammer tested from time to time as required by the Government regulations, because of being covered with the jacket and lagging on the outside and grate bars on the inside, notwithstanding less than a month prior to the accident a sworn report had been filed showing that the locomotive had been inspected in accordance with the Act of Congress approved February 17, 1911, as amended.

### Accidents From Broken Staybolts

There has been a number of accidents reported to our bureau where the ends of broken staybolts blew out of firebox sheets while being calked, because of leakage, and the telltale hole found riveted over or plugged. Imagine the result of a hole 15/16 to 1⅛ inches in diameter in the firebox sheets of a locomotive boiler with 100 to 150 pounds steam pressure and yourself in the firebox at the time. Leaky staybolts, crown stays, and firebox sheets certainly do not contribute to the efficient operation of locomotives, nor do defective, unsafe and inefficient locomotives contribute to the efficient operation of the railroads.

Since the establishment of the locomotive boiler inspection law the number of accidents and casualties have been greatly decreased. For instance, a comparison of the first nine months of the current fiscal year with the same period of 1912, the first year of the existence of the law shows a decrease of 67 percent in the number of accidents, 74 percent decrease in the number of persons killed, and 67 percent decrease in the number of persons injured, due to the failure of some part or appurtenance of the locomotive boiler only. These decreases are certainly gratifying, and yet I believe if a proper understanding is had of the necessity for making prompt and substantial repairs at the right time, a further decrease in the damage to property and the loss of life and limb can be accomplished.

### Water Registering Appliances

The water-registering appliances can be easily cleaned and maintained in a safe and proper condition, yet some of the most disastrous explosions causing great loss of property and life and limb are strongly contributed to by the failure to keep these devices so that they will properly perform the functions for which they are intended.

Autogenous welding, which has come into such prominent use within the past few years, is frequently employed where other means of construction and repair could be more profitably, as well as more safely, employed. Do not understand me, as being opposed to autogenous welding where it can be safely, properly and economically employed, but I do oppose it and will continue to oppose its use with all the influence at my command where through its failure increased loss of life, limb, and property are the results. On the other hand, whenever it has reached a state of efficiency where it can be safely depended upon and where its quality can be determined in advance of failure, then I will lend my influence in extending its use.

I recognize that autogenous welding is one among the great modern inventions and can be by its judicious use made to accomplish great saving in both time and money, but it has not yet reached that state of perfection where it can be safely used or depended upon on any part of a high pressure boiler which is wholly in tension while under working conditions or where the strain to which the structure is subjected is not carried by other construction which meets the requirements of the Law and Rules. Nor should it be used on any part of the locomotive subjected to severe stresses and shocks where through its failure, accident and personal injury might occur. Nor should it be used, in my opinion, in the construction or repair of firebox sheets within 15 inches of the highest part of the crown sheet or the so-called "low water zone" where through failure of the crown sheet to sustain the pressure to which it is subjected from any cause undue strain might be thrown upon such welding.

My conclusions in this are based entirely upon conditions brought to my personal attention and by reports covering accident investigation in which autogenously welded seams are involved. For instance, during the fiscal years 1916 to 1921, inclusive, our records show that there were 81 crown sheet failures in which autogenously welded seams were involved; in 63 of which the welding failed. During the same period, riveted seams were involved, in exactly the same manner, in 207 cases where 35 of such seams failed. Stated otherwise, approximately 80 percent of the autogenously welded seams involved in firebox failures have torn, while 16.9 percent of the riveted seams involved under the same conditions have failed. This gives an opportunity for comparison between the value in strength of the two seams as they have been constructed.

It has been said that these accidents were primarily caused by low water permitting the crown sheet to become overheated, which I admit is true, in a majority of the cases, yet it is evident that the violence of the explosion and consequent results are greatly increased by failure of these welded seams and we should avoid any method of construction or repair that will increase the hazard of operation, although the failure may be primarily due to other causes.

Those of you who have read my Tenth Annual Report to the Interstate Commerce Commission will recall a cut showing a welded seam in the knuckle of a back head which failed, without warning, for a distance of 21 inches, with sufficient severity that the escaping steam and water blew the engineer from his seat to the deck of the locomotive and also resulted in the serious injury of the fireman.

We do not undertake to distinguish between the electric and gas welding process in the construction and repair of the locomotive and feel that either should be confined to parts and appliances where through failure injury or death will not result. I am in hopes that some day this process may be so perfected that entire dependence can be placed upon it. However, until that time is reached, great care, extreme caution and good judgment must be exercised in its use.

### Proper Application of Arch Tubes

Another condition, which has on many occasions confronted us, is the application of arch tubes. We have found many cases where the tube does not extend through the sheet; others where they do not extend through far enough to be either belled or beaded to secure them in place. Many such conditions have been found by our inspectors in the course of their regular work and proper repairs required before accidents occurred. Others have pulled out of the sheets, resulting in serious injury and death. Where arch tubes are used they should be thoroughly washed each time the boiler is washed and scaled with an automatic cleaner at each monthly inspection. When being applied they should by all means extend through the sheet far enough to be properly belled or beaded. Personally I believe that properly belling a tube is the safest method of application.

A great majority of the accidents which occur could be

(*Continued on page* 214)

# Second Revision of A. S. M. E. Boiler Code

A HEARING is held by the boiler code committee at least once in four years, at which all interested parties may be heard, in order that such revisions may be made as are found to be desirable, as the state of the art advances. The year 1922 becomes the period of the second revision, the first revised edition of the boiler code having been issued in 1918. The boiler code committee plans to hold a public hearing in connection with the next annual meeting of the society in December, 1922, to which the membership of the society and everyone interested in the steam boiler industry will be cordially invited to attend and present their views.

In the course of the boiler code committee's work during the past four years, many suggestions have been received for revisions of the power boiler section of the code, as a result of the interpretations issued and also of the formulation of the locomotive boiler and miniature boiler codes. In order that due consideration might be accorded to these recommendations, the committee began in the early part of 1921 to devote an extra day at each of its monthly meetings to the consideration of the proposed revisions. As a result of this many of the recommendations have been accepted and revisions of the paragraphs formulated.

The revisions which have met the approval of the boiler code committee are here published. It is the request of the committee that these revisions be fully and freely discussed so that it may be possible for anyone to suggest changes before the rules are brought to final form and presented to the council for approval. Discussions should be mailed to C. W. Obert, secretary to the boiler code committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the boiler code committee for consideration.

The revisions here published are limited to the paragraphs appearing in the 1918 Edition of the A.S.M.E. Boiler Code, and the paragraph numbers refer to the paragraphs of similar number in that edition. 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. 9 REVISED: Cross pipes connecting the steam and water drums of watertube boilers, headers, cross boxes and all pressure parts of the boiler proper over 2-inch pipe size, or equivalent cross-sectional area, shall be of wrought steel, or cast steel of Class B grade, as designated in the Specifications for Steel Castings, when the maximum allowable working pressure exceeds 160 pounds per square inch. THE USE OF BESSEMER STEEL IS PROHIBITED FOR THE PRESSURE PARTS OF BOILERS. Malleable iron may also be used when the maximum allowable working pressure does not exceed 200 pounds per square inch, provided the form and size of the internal cross-section perpendicular to the longest dimension of the box, is such that it will fall within a 7 inch by 7 inch rectangle.

PAR. 12 REVISED: Cast iron shall not be used for nozzles or flanges attached directly to the boiler for any pressure or temperature. CAST IRON SHALL NOT BE USED [nor] for boiler and superheater mountings such as connecting pipes, fittings, valves and their bonnets, for steam temperatures of over 450 degrees F.

PAR. 20 REVISED: The minimum thicknesses of tube sheets for FIRE-TUBE [horizontal return tubular] boilers, shall be as follows:

When the diameter of tube sheet is

| 42 inches or under | Over 42 inches to 54 inches | Over 54 inches to 72 inches | Over 72 inches |
|---|---|---|---|
| ⅜ inch | 7/16 inch | ½ inch | 9/16 inch |

PAR. 25 REVISED: *Chemical Composition.* The steel shall conform to the following requirements as to chemical composition:

| | Flange | Firebox |
|---|---|---|
| Carbon | Plates ¾ inch thick and under—not over [0.12] 0.25 percent | |
| | Plates over ¾ inch thick—not over [0.12] 0.30 percent | |
| Manganese | 0.30-0.60 percent | 0.30-0.50 percent |
| Phosphorus, Acid | Not over 0.05 percent | Not over 0.04 percent |
| Phosphorus, Basic | Not over 0.04 percent | Not over 0.035 percent |
| Sulphur | Not over 0.05 percent | Not over 0.04 percent. |

PAR. 29 REVISED: *Modifications in Elongation.* (*a*) For material over 11/16 inch in thickness: From the figure representing the percentage of elongation required as determined in accordance with Par. 28 *a*, there shall be deducted an amount equal to four times the difference between the ordered thickness in inches and ¾ [11/16] inch, except that the minimum elongation required shall in no case be less than 20 percent.

(*b*) For material ¼ inch in thickness, the elongation shall be measured on a gage length of 6 inches.

PAR. 36 REVISED: *Marking.* (*a*) Each shell plate shall be legibly stamped by the manufacturer with the melt or slab number, name of manufacturer, grade and the minimum tensile strength of the stipulated range as specified in Paragraph 28, in TWO [three] places, [two of] which shall be located NOT LESS THAN [at diagonal corners about] 12 inches from the edge [and one about the center] of the plate, or at TWO [a] points selected and designated by the purchaser so that AT LEAST ONE [the] stamp shall be plainly visible when the boiler is completed.

(*b*) Each head shall be legibly stamped by the manufacturer in two places, about 12 inches from the edge, with the melt or slab number, name of manufacturer, grade and the minimum tensile strength of the stipulated range as specified in Paragraph 28, in such manner that the stamp is plainly visible when the boiler is completed.

(*c*) Each butt strap shall be legibly stamped by the manufacturer in two places on the center line about 12 inches from the ends with the melt or slab number, name of manufacturer, grade, and the minimum tensile strength of the stipulated range as specified in Paragraph 28.

(*d*) The melt or slab number shall be legibly stamped on each test specimen.

ADD THE FOLLOWING TO PARAGRAPH 36:

(*e*) IT IS PERMISSIBLE TO TRANSFER, WITHOUT IMITATION, THE MARKINGS ON THE PLATE UNDER AUTHORITY OF AN AUTHORIZED INSPECTOR IN CHARGE; SAID INSPECTOR TO PUT HIS PRIVATE MARK AFTER THE TRANSFERRED STAMP.

(*f*) IF, DURING FABRICATION IN THE BOILER SHOP, REMOVAL OF BOTH GROUPS OF THE PLATE MANUFACTURER'S STAMPS CANNOT BE AVOIDED BECAUSE OF THE CUTTING OR PUNCHING OF NECESSARY HOLES IN THE PLATES, ONE GROUP OF SUCH STAMPS MAY BE TRANSFERRED TO A PERMANENT POSITION BY RESTAMPING UNDER THE SUPERVISION OF AN AUTHORIZED STATE, MUNICIPAL OR INSURANCE COMPANY INSPECTOR. WHEN STAMPS ARE TRANSFERRED THE PLATE MANUFACTURER'S NAME SHALL NOT BE IMITATED. THE INSPECTOR SHALL PUT HIS PRIVATE STAMP BESIDE THE TRANSFERRED GROUP AND A RECORD OF THE TRANSFER AND THE INSPECTOR'S STAMP SHALL BE NOTED ON THE DATA SHEET. A GROUP OF STAMPS CONSISTS OF THE MANUFACTURER'S NAME, MANUFACTURER'S TEST IDENTIFICATION NUMBER, GRADE AND TENSILE STRENGTH.

PAR. 48 REVISED:

IV PERMISSIBLE VARIATIONS IN GAGE

The gage of each bar shall not vary more than 0.01 inch from that specified.

PAR. 180. ADD FOLLOWING PARAGRAPH:

THE FACTOR OF SAFETY USED IN DETERMINING THE MAXI-

MUM ALLOWABLE WORKING PRESSURE CALCULATED ON THE CONDITIONS ACTUALLY OBTAINED IN SERVICE SHALL NOT BE LESS THAN FIVE.

PAR. 182 REVISED: 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 $\frac{P}{[D]d}$ is 4 or less, the minimum value shall be 2 [D]d;

(*b*) If $\frac{P}{[D]d}$ is over 4, the minimum value shall be:

$$2[D]d + 0.1(P - 4[D]d)$$

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, inch. (It is here assumed that the joints are of the usual construction where the rivets are symmetrically spaced.)

[D]d = diameter of the rivet holes inches.

PAR. 194 REVISED: *Domes.* THE REQUIREMENTS OF PARAGRAPHS 187 AND 188 SHALL APPLY TO RIVETED LONGITUDINAL JOINTS OF DOMES EXCEPT THAT FOR DOMES 24 INCHES AND LESS IN DIAMETER FOR PRESSURES EXCEEDING 100 POUNDS, THE LONGITUDINAL JOINTS MAY BE LAP-RIVETED IF THE FACTOR OF SAFETY IS NOT LESS THAN 8. [The longitudinal joint of a dome 24 inches or over in diameter shall be of butt and double-strap construction, irrespective of pressure. When the maximum allowable working pressure exceeds 100 pounds per square inch, the flange of a dome 24 inches or over in diameter shall be double-riveted to the boiler shell.]

THE FLANGE OF A DOME 24 INCHES OR OVER IN DIAMETER SHALL BE DOUBLE-RIVETED TO THE BOILER SHELL. WHERE THE FLANGE OF THE DOME IS USED FOR REINFORCING OR ATTACHING IT TO THE SHELL, THE DIAMETER OF THE DOME SHALL NOT EXCEED ONE-HALF THE DIAMETER OF THE SHELL OR BARREL OF THE BOILER. [The longitudinal joint of a dome less than 24 inches in diameter may be of the lap type, and its flange may be single-riveted to the boiler shell provided the maximum allowable working pressure on such a dome is computed with a factor of safety of not less than 8.]

The dome may be located on the barrel or over the firebox on traction, portable or stationary boilers of the locomotive type up to and including 48-inch barrel diameter. For larger barrel diameters, the dome shall be placed on the barrel.

Flanges of domes shall be formed with a corner radius, measured on the inside, of at least twice the thickness of the plate for plates 1 inch thick or less, and at least three times the thickness of the plate for plates over 1 inch in thickness.

PAR. 201 REVISED: *Structural Reinforcements.* When channel irons or other members are securely riveted to the boiler heads for attaching through stays, the transverse 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 DETERMINED BY THE FORMULA IN PARAGRAPH 199 USING 135 FOR THE VALUE OF C [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 resisting 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 these 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.

PAR. 205 REVISED: The distance from the edge of a staybolt hole to a straight line tangent to the edges of the rivet holes may be substituted for $p$ for staybolts adjacent to the riveted edges bounding a stayed surface. 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, $p$, PLUS THE INSIDE RADIUS OF THE FLANGE [$p$ shall be measured from the inner surface of the flange, at about the line of rivets to the edge of the staybolts or to the projected edge of the staybolts].

PAR. 206 REVISED: The MAXIMUM PITCH $p$ AS GIVEN IN PARAGRAPH 199 [distance between the edges of the staybolt holes] may be INCREASED BY THE STAYBOLT HOLE DIAMETER WHERE [substituted for $p$ for] staybolts ARE adjacent to a furnace door or other boiler fitting, tube hole, handhole or other opening.

PAR. 212*c* REVISED: (*c*) A FURNACE FOR A VERTICAL FIRE-TUBE BOILER, 38 INCHES OR LESS IN OUTSIDE DIAMETER, WHICH REQUIRES STAYING, SHALL HAVE THE FURNACE SHEET SUPPORTED BY ONE ROW OF STAYBOLTS, OR MORE, THE CIRCUMFERENTIAL PITCH NOT TO EXCEED 1.05 TIMES THAT GIVEN BY THE FORMULA IN PARAGRAPH 199 AND IN TABLE 4.

THE LONGITUDINAL PITCH BETWEEN THE STAYBOLTS, OR BETWEEN THE NEAREST ROW OF STAYBOLTS AND THE ROW OF RIVETS AT THE JOINTS BETWEEN THE FURNACE SHEET AND THE TUBE SHEET OR THE FURNACE SHEET AND MUD RING, SHALL NOT EXCEED THAT GIVEN BY THE FOLLOWING FORMULA:

$$L = \frac{(220 \times T^2)^2}{(P \times R)}$$

EXCEPT WHEN THIS VALUE IS LESS THAN THE CIRCUMFERENTIAL PITCH, IN WHICH CASE THE LONGITUDINAL PITCH MAY BE AS GREAT AS THE ALLOWABLE CIRCUMFERENTIAL PITCH.

where

L = LONGITUDINAL PITCH OF STAYBOLTS

T = THICKNESS OF FURNACE SHEET IN SIXTEENTHS OF AN INCH

P = MAXIMUM ALLOWABLE WORKING PRESSURE IN POUNDS PER SQUARE INCH

R = OUTSIDE RADIUS OF FURNACE, IN INCHES.

THE STRESS PER SQUARE INCH IN THE STAYBOLTS SHALL NOT EXCEED 7,500 POUNDS AND SHALL BE DETERMINED IN THE WAY SPECIFIED IN PARAGRAPH 212*d*.

PAR. 212*d* INSERT NEW SECTION AS FOLLOWS:

(*d*) FOR FURNACES OVER 38 INCHES IN OUTSIDE DIAMETER OF VERTICAL FIRE TUBE BOILERS AND OTHER TYPES OF FURNACES AND COMBUSTION CHAMBERS NOT COVERED BY SPECIAL RULES IN THIS CODE, WHICH HAVE CURVED SHEETS SUBJECT TO EXTERNAL PRESSURE, THAT IS, PRESSURE ON THE CONVEX SIDE, THE STAYING, BOTH CIRCUMFERENTIAL AND LONGITUDINAL, SHALL BE PROVIDED FOR IN ACCORDANCE WITH THE FOLLOWING FORMULA:

$$P = \frac{CT^2}{p^2} + 250\frac{T}{R}$$

WHERE $p$ AND THE VALUE OF C ARE AS GIVEN IN PARAGRAPH 199, $p$ SHALL NOT EXCEED 2T, AND $p^2$ SHALL NOT EXCEED 0.008CTR.

THE STRESS PER SQUARE INCH IN STAYBOLTS SHALL NOT EXCEED 7,500 POUNDS, BASED ON A TOTAL STRESS OBTAINED BY MULTIPLYING THE PRODUCT OF THE CIRCUMFERENTIAL AND LONGITUDINAL PITCHES BY

$$(P - 250\frac{T}{R}).$$

PAR. 217 REVISED: The net area to be stayed in a segment of a head may be determined by the following formula:

$$\frac{4(H-d-2)^2}{3}\sqrt{\frac{2(R-d)}{(H-d-2)}} - 0.608 = \text{area to be}$$

stayed, sq. in. where;

H = distance from tubes to shell, inches.
$d$ = distance DETERMINED [given] by formula in Par. 214.
R = radius of boiler head, in.

PAR. 243. IN THE CONSTANT C FOR MORISSON FURNACES, CHANGE TO READ AS FOLLOWS:

C = 15,600 a constant for *Morisson furnaces*, when corrugations are not MORE [less] than 8 inches from center to center and the radius of the outer corrugations is not more than one-half that of the suspension curve.

PAR. 247 REVISED: Where NO RULES ARE GIVEN AND it is impossible to calculate with a reasonable degree of accuracy the strength of a boiler structure or any part thereof, a full-sized sample shall be built by the manufacturer and tested to destruction in the presence of the Boiler Code Committee or one or more representatives of the Boiler Code Committee appointed to witness such test. IN SUCH A STEEL-PLATE OR CAST-STEEL STRUCTURE, THE PRESSURE CORRESPONDING TO THE YIELD POINT SHALL BE ACCURATELY DETERMINED AND THE MAXIMUM ALLOWABLE WORKING PRESSURE SHALL NOT EXCEED THAT OBTAINED BY DIVIDING THIS PRESSURE BY 2.5 SUCH STRUCTURES WHEN OF CAST IRON SHALL BE TESTED TO THE BURSTING POINT.

PAR. 250 REVISED: A fire tube boiler WITH TUBES UNDER 5 INCHES DIAMETER shall have [both ends of] the tubes [substantially] rolled and beaded, or rolled and welded at the firebox or combustion-chamber end, AND ROLLED AND BEADED AT THE OTHER END. IN THE CASE OF TUBES UNDER 1¼ INCHES DIAMETER, THE TUBES MAY BE EXPANDED BY THE PROSSER METHOD IN PLACE OF ROLLING. IN THE CASE OF TUBES 5 INCHES IN DIAMETER AND OVER, THE TUBES SHALL BE SECURED BY RIVETING OR OTHER APPROVED METHOD AT BOTH ENDS.

PAR. 252 REVISED: The ends of all tubes, suspension tubes and nipples of watertube boilers and superheaters shall project through the tube sheets or headers not less than ¼ inch nor more than ½ inch before flaring. WHERE THE TUBES ENTER AT AN ANGLE, THE MAXIMUM LIMIT OF ½ INCH SHALL APPLY ONLY AT THE POINT OF LEAST PROJECTION.

PAR. 253 REVISED: *Drilling of Holes.* All rivet holes and staybolt holes and holes in braces and lugs shall be drilled [full size] or they may be punched not to exceed ¼ inch less than full diameter for material over 5/16 inch AND NOT EXCEEDING ⅝ INCH in thickness, and ⅛ inch less than full diameter for material not exceeding 5/16 inch in thickness [and then drilled or reamed to full diameter]. 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 [all rivet holes in boiler plates except those used for the tack bolts]. THE FINISHED HOLES MUST BE TRUE, CLEAN AND CONCENTRIC. HOLES SHALL NOT BE PUNCHED IN PLATE OVER ⅝ INCH THICKNESS.

PAR. 259 REVISED: A manhole reinforcing ring when used, shall be of steel or wrought-iron, and shall be at least as thick as the shell plate THICKNESS REQUIRED BY PARAGRAPH 180.

PAR. 260 REVISED: Manhole frames on shells or drums when used, shall have the proper curvature, and on boilers over 48 inches in diameter shall be riveted to the shell or drum with two rows of rivets, which may be pitched as shown in Fig. 21. The strength of manhole frames and reinforcing rings shall be at least equal to the tensile strength (REQUIRED BY PARAGRAPH 180) of the maximum amount of the shell plate removed by the opening and rivet holes for the reinforcement on any line parallel to the longitudinal axis of the shell through the manhole, or other opening.

PAR. 268 REVISED: *Threaded Openings.* ALL PIPE THREADS SHALL CONFORM TO THE AMERICAN PIPE STANDARD AND ALL [a pipe] connections 1 inch in diameter or over shall have not less than the number of threads given in Table 8.

If the thickness of the material in the boiler is not sufficient to given such number of threads, the opening shall be reinforced by a pressed steel, cast steel, or bronze composition flange, or plate, so as to provide the required number of threads.

When the maximum allowable working pressure exceeds 100 pounds per square inch, a NOZZLE OR SADDLE FLANGE [connection] riveted to the boiler to receive a flanged fitting shall be used for all pipe openings over 3 inch pipe size.

PAR. 299 REVISED: [Nozzles and] *Fittings.* Flanged cast-iron pipe fittings used for boilers, [parts,] for pressures up to and including 160 pounds per square inch, shall conform to the American Standard given in Table [s] 16 of the Appendix, FOR PRESSURES UP TO 50 POUNDS and Table 17 FOR ALL HIGHER PRESSURES AND FOR STEAM, FEED AND BLOW-OFF PIPES UP TO THE STOP VALVE, except that the face of the flange of a safety valve as well as that of a safety valve nozzle, may be flat and without the raised face.

(Note: Balance of paragraph remains unchanged.)

PAR. 307 REVISED: *Blow-off Piping.* A surface blow-off shall not exceed 1½ inch pipe size and the internal and external pipes, when used, shall form a continuous passage,

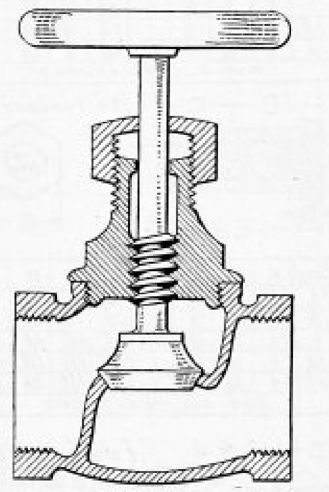

Fig. 22½.—Type of Globe Valve

but with clearance between their ends and arranged so that the removal of either will not disturb the other. A properly designed brass or steel bushing SIMILAR TO OR EQUIVALENT OF THOSE [as] shown in Fig. 22, or a flanged connection, shall be used.

PAR. 308 REVISED: 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 inch and the maximum size shall be 2½ inches. STRAIGHTWAY GLOBE VALVES OF THE ORDINARY TYPE AS SHOWN IN FIG. 22½, OR VALVES OF SUCH TYPE THAT DAMS OR POCKETS CAN EXIST FOR THE COLLECTION OF SEDIMENT, SHALL NOT BE USED ON SUCH CONNECTIONS. [Globe valves shall not be used on such connections.]

PAR. 314 REVISED: *Feed Piping.* The feed pipe of a boiler shall have an INTERNAL DIAMETER NOT LESS THAN ¾ INCH [open end or ends inside the boiler.]

PAR. 325 REVISED: Lugs or brackets, when used to support a boiler of any type, shall be properly fitted to the surfaces to which they are attached. The shearing and crushing stresses on the rivets used for attaching the lugs or brackets shall not exceed 8 percent of the strength given in paragraphs 15 and 16. WHERE IT IS IMPRACTICAL TO USE RIVETS, STUDS WITH NOT LESS THAN 10 THREADS PER INCH MAY BE USED. IN COMPUTING THE SHEARING STRESSES, THE AREA AT THE BOTTOM OF THE THREAD SHALL BE USED. [For traction or portable boilers, studs with pipe threads may be used.]

FIG. 32 REVISED:

A Change dimension line to center of stayrod.
D Change dimension line to center of staybolt.
F Change dimension line to center of door ring rivet.
H Give eighth sketch in drawing the designation "H."

PAR. 423.—CHANGE SECOND SECTION TO READ AS FOLLOWS:

A bevel-seated 3½ inch valve WITH [is marked by the manufacturer] 0.11 inch lift HAS A [and] discharge capacity AT [for] 100 pounds pressure OF [ = ] 4,840 pounds; hence two such valves would be required.

*Fusible Plugs.*

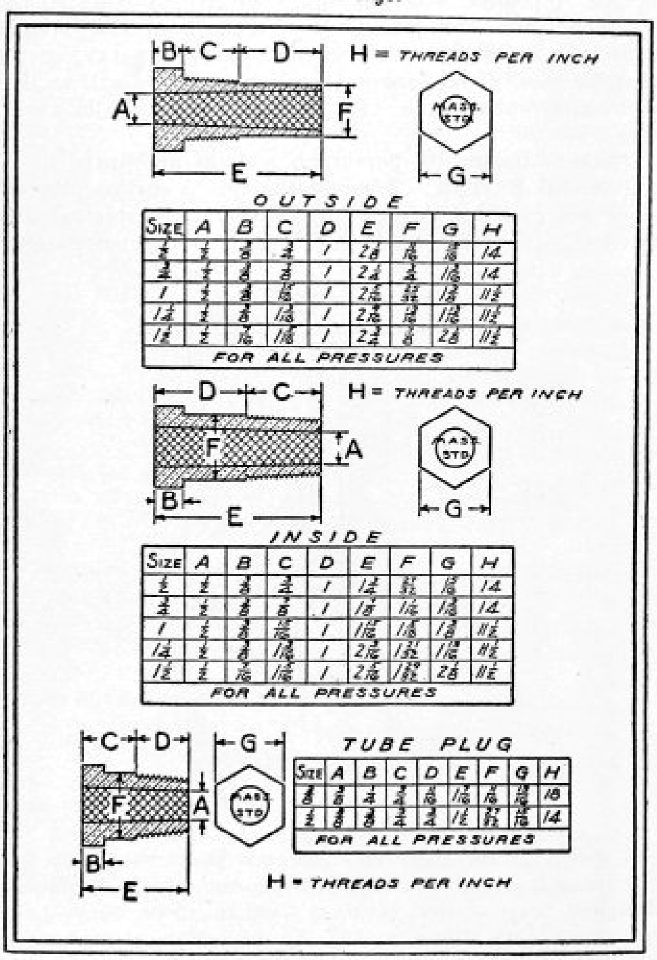


**Fig. 33½.—Acceptable Forms of Fusible Plugs**

PAR. 424.—CHANGE SECOND SECTION TO READ AS FOLLOWS:

A bevel-seated 2½ inch valve WITH [is marked by the manufacturer] 0.08 inch lift HAS A [and] discharge capacity AT [for] 275 pounds pressure OF [ = ] 6,350 pounds; hence two such valves would be required.

PAR. 425.—CHANGE SECOND SECTION TO READ AS FOLLOWS:

A bevel-seated 2 inch valve WITH [is marked by the manufacturer] 0.07 inch lift HAS A [and] discharge capacity AT [for] 150 pounds pressure OF [ = ] 2,500 pounds; hence one such valve would be required.

TABLE 16.—CHANGE TITLE TO READ AS FOLLOWS:

AMERICAN STANDARD 125-POUNDS WORKING PRESSURE PER SQUARE INCH STANDARD CAST-IRON FLANGE FITTINGS, STRAIGHT SIZES (SEE FIG. 33).

TABLE 17.—CHANGE TITLE TO READ AS FOLLOWS:

AMERICAN STANDARD 250-POUNDS WORKING PRESSURE PER SQUARE INCH, EXTRA HEAVY CAST-IRON FLANGE FITTINGS, STRAIGHT SIZES (SEE FIG. 33).

PAR. 428 REVISED: Fusible plugs, if used, shall be filled with tin with a melting point between 400 and 500 degrees F., and shall be renewed once each year. WHERE THE BOILERS ARE TO BE OPERATED AT WORKING PRESSURES IN EXCESS OF 225 POUNDS PER SQUARE INCH GAGE, THE USE OF FUSIBLE PLUGS IS NOT ADVISABLE.

# Relative Advantages of Non-Lifting and Lifting Injectors*

FOR the purposes of securing data on this subject a questionnaire was prepared and sent to sixteen railroads from which eleven replies have been received. The advantages of the non-lifting injectors are reported as follows: (1) Larger capacity for same size injector, injector pipes and connections; (2) grades closer, giving a wider range for each size of injector; (3) gives less trouble from restricted openings in the feed water supply pipe; (4) located on the outside of the cab, thus relieving congested conditions inside; (5) more reliable and dependable; (6) application and maintenance cost less; (7) more accessible for repairs and repairs can be be made on the injector in place without disconnecting from the piping; (8) will work with less water in tank, also operate with feed water at a considerably higher temperature.

The disadvantages of this type injector are its greater liability to being knocked off by derailment, side swipe, etc., and the liability to freeze in extremely cold weather.

### ADVANTAGES AND DISADVANTAGES OF INJECTORS

The advantages of the lifting injectors are stated as follows: (1) Mounted in cab where engineman can more easily see and observe its workings; (2) if trouble occurs on the road it is easier for the engineer to remedy it; (3) self contained and fewer parts to operate; (4) easier operated and controlled.

Its disadvantages are: (1) Less grading range than the non-lifter; (2) more readily affected by restricted feed water opening and length of lift; (3) must be taken down from pipe connections to repair the tubes; (4) tubes coat up more rapidly than in the non-lifters; (5) it is subject to failure from a leaky boiler check, worn steam nozzle or combining tube, leak in feed pipe, or if injectors become overheated they must be cooled off before they will operate.

It would appear from the replies received that:

(a) Little is known about the comparative efficiency of the two types of injectors with respect to steam consumption for a given quantity of water delivered; (b) the cost of repairs and maintenance is less with the non-lifting injector; (c) the non-lifting injector is more easily located and repaired; (d) the non-lifting injector is generally considered preferable and is gaining in favor, particularly on large locomotives.

*Section of locomotive construction committee report read at Atlantic City convention of the American Railway Association—Division V—Mechanical, held June 14, 1922.

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Commissioner Connelley, chairman of the Industrial Board of the Pennsylvania Department of Labor and Industry, has recently notified all approved boiler inspectors of Pennsylvania that boilers of the marine type, such as were built for the United States Shipping Board and are located at Hog Island, Pa., are not eligible for installation in the Commonwealth of Pennsylvania. This ruling is in strict accordance with the provisions of the Pennsylvania Boiler Code which states that only boilers built for stationary purposes and in strict accordance with the Code may be installed and operated in the industrial establishments of the Commonwealth. Boilers which are subjected to Federal inspection or control, including marine boilers, boilers of steam locomotives and other self-propelled railroad apparatus are entirely without the jurisdiction of the Boiler Code and cannot be installed and operated in industrial establishments in the State.

As a matter of fact, a number of marine watertube boilers built originally for the Shipping Board have already been installed for stationary service in Pennsylvania and in certain of these cases permission has been granted conditionally for their use as the installations had been made before they were brought to the notice of the State authorities. In other cases where a petition has been made for the installation of such boilers the petition has been denied.

Unquestionably the Pennsylvania Boiler authorities are entirely justified in carrying out the letter of the law in this respect and the fact that such boilers are outside their jurisdiction casts no reflection on the construction of the marine boilers as such. If any exception were permitted in this case, however, a dangerous precedent would be established which might lead to serious complications in the enforcement of the law in the case of other boilers whose design involved radical departures from the requirements imposed by the Code.

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When the Boiler Code of the American Society of Mechanical Engineers was originally formulated, the Society, realizing that changes in boiler design and advances in the manufacture and quality of material would require future revision of the Code, provided that every four years such a revision would be made. During the year 1918 the first revised edition of the Code was issued and now the Boiler Code Committee is preparing to hold a public hearing in connection with the annual meeting of the Society in December to consider the second revision of the Code. At that time the membership of the Society and everyone interested in the steam boiler industry will be given ample opportunity to discuss the provisions.

The Boiler Code, with its various sections for power boilers, locomotive boilers and miniature boilers, has become the recognized standard of construction for many States in this country and, for this reason, should receive the interest and support of those connected in any way with the construction, inspection, repair and use of boilers. In order that ample time be given to study the changes and modifications which will be presented at the public hearings, the Boiler Code Committee has given out for publication those revisions which have so far met with the approval of the members.

From time to time differences of opinion have arisen in connection with certain sections of the Boiler Code but insofar as possible interpretations for special cases have been made in order that its range of applications might be general. The opportunity is now available to those who, through investigation, experiment or practical application of methods or materials which are not in accordance with the existing Code, have found that such methods are entirely safe, to bring them up for consideration by the American Society of Mechanical Engineers for inclusion in the revised Code. Several months will elapse before action is taken on the proposed modifications and advantage should be taken of this period in making recommendations for the consideration of the committee.

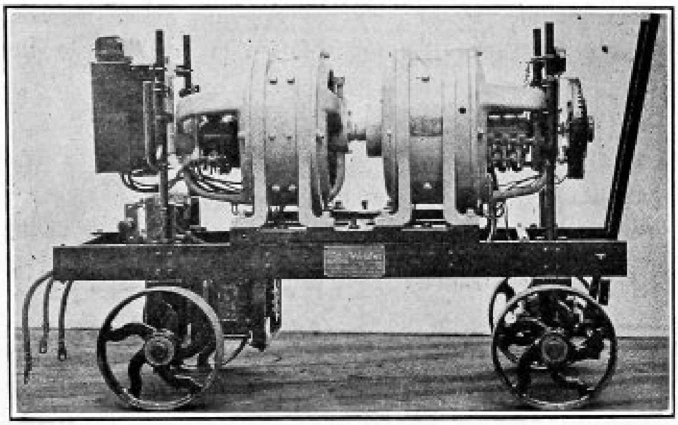
# Engineering Specialties for Boiler Making

**New Tools, Machinery, Appliances and Supplies for the Boiler Shop and Improved Fittings for Boilers**

## A Large Capacity Welding Set

A portable welding outfit of increased capacity is now being built by the U. S. Light & Heat Corporation, Niagara Falls, N. Y. It consists of a motor-generator set and control apparatus mounted on a four-wheel hand truck.

The generator has a continuous capacity of 300 amperes, and for cutting and other work of an intermittent nature will develop 400 amperes. It is designed with inherent regulation and has the same characteristics as the 200-ampere machine made by the same company. The generator is also furnished for belt or gas engine drive.



**The 350-Ampere U. S. L. Welding Set**

The set is supplied with either a direct or alternating current motor and weighs complete about 1,700 lb.

## Devices Designed to Cut the Cost of Air Drill Operation

The lubrication of air drills is not generally considered as one of the items of shop operation subject to the promotion of economy, yet in plants where such tools are used to any great extent, it is necessary to lubricate them at least once a day and in many cases oftener. Certain drills require 15 minutes to lubricate and others as high as 30 minutes. With this fact as a basis, the Chicago Pneumatic Tool Company, Chicago, Ill., carried out an extensive survey of air drill operating costs, which led to the design of an oil vent to prevent air leakage and lessen the necessity of frequently oiling these tools.

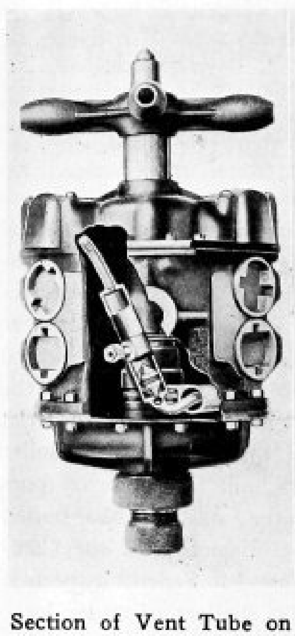
This oil vent is applicable to most sizes and types of "Little Giant" air drills. On new drills it is furnished as regular equipment, and is also attachable to drills now in use. The vent contains a sliding top-shaped plunger which automatically prevents oil leakage regardless of the operating position of the drill.

The estimated saving in time, labor and lubricant based on time and wage factors which are more or less indeterminate is shown by the following comparative figures submitted by the manufacturer:

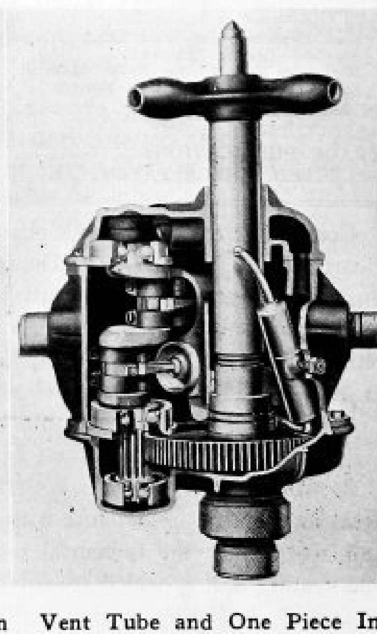
| | | |
|---|---|---|
| (1) | Grease per day, ½ pound, at 10 cents per pound | $0.05 |
| | Labor per day, ½ hour, at 60 cents per hour | .30 |
| | Total upkeep per day | $0.35 |
| | Total upkeep cost per six-day week | $2.10 |
| | Less one application per week for machine with vent tube | .35 |
| | Net saving per week | $1.75 |
| | Net saving during 52 weeks | 90.00 |
| (2) | Grease per day, ½ pound, at 10 cents per pound | $0.05 |
| | Labor per day, ¼ hour, at 60 cents per hour | .15 |
| | Total upkeep per day | $0.20 |
| | Total upkeep cost per six-day week | $1.20 |
| | Less one application per week for machine with vent tube | .20 |
| | Net saving per week | $1.00 |
| | Net saving during 52 weeks | 52.00 |
| (3) | Grease per day, ½ pound, at 10 cents per pound | $0.05 |
| | Labor per day, ½ hour, at 50 cents per hour | .25 |
| | Total upkeep per day | $0.30 |
| | Total upkeep cost per six-day week | $1.80 |
| | Less one application per week for drill with vent tube | .30 |
| | Net saving per week | $1.50 |
| | Net saving during 52 weeks | 78.00 |
| (4) | Grease per day, ½ pound, at 10 cents per pound | $0.05 |
| | Labor per day, ¼ hour, at 40 cents per hour | .10 |
| | Total upkeep per day | $0.15 |
| | Total upkeep cost per six-day week | $0.90 |
| | Less one application per week for drill with vent tube | .15 |
| | Net saving per week | $0.75 |
| | Net saving during 52 weeks | $39.00 |

### One-Piece Interchangeable Toggle

Another new air drill feature applicable to all "Little Giant" air drills is known as the "Invincible" one-piece interchangeable toggle. The toggle bearing and connecting rod are integral and are secured in place in pairs by means of hinged split collars. It is claimed that this feature provides an opening at the top and bottom of the toggle bearing



**Section of Vent Tube on "Little Giant" Air Drill**

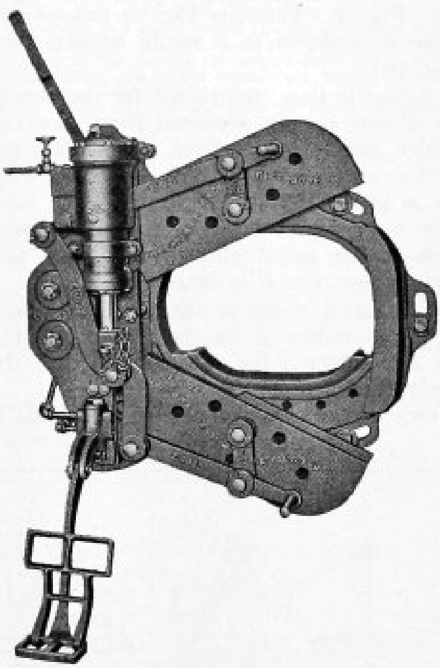


**Vent Tube and One Piece Interchangeable Toggles**

which permits the lubricant to come in direct contact with the crank pins. All parts are interchangeable, there being no inside or outside toggle, each being subjected only to the stresses of its own piston. The toggle may be assembled and dis-assembled without dismantling the drill.

## Shoemaker Radial Fire Door

The Shoemaker radial fire door is a special feature of this year's developments of the National Railway Devices Company, Chicago. This new device from the older types of Shoemaker horizontal and vertical doors combines the feature of air operation with balanced arc-moving doors and results in an effective automatic fire door that is locked shut when not operating. The doors are air operated, the control valves being opened and closed by connection from a foot pedal.



Shoemaker Radial Fire Door

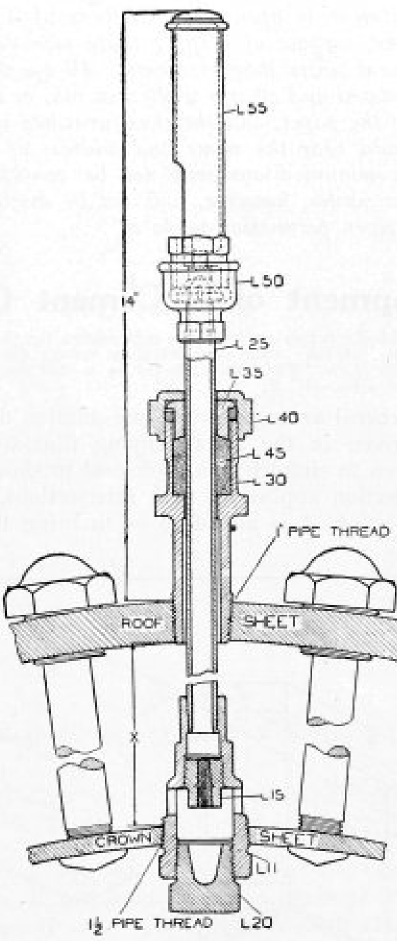
By using two pistons of different size combined with suitable ports, the doors are cushioned both in opening and in closing, so that they do not open with a jar or slam shut. Provision is also made for cracking the door when entering terminals or at other times when steam is shut off, this being accomplished by opening a pet cock and then throwing over the lever shown at the top of the illustration.

These doors insure protection against accidents from steam or gas blowing back through the fire opening, provide quick movement combined with quiet action, are easy to operate, and give full width of opening for the shovel.

## Cleveland Low Water Alarm

The Cleveland low water alarm made by The Talmage Manufacturing Company, Cleveland, Ohio, is a simple foolproof, reliable device which can be easily applied and cheaply maintained. It consists of a steel cage, ordinarily mounted on the highest point of the crown sheet, from which a copper pipe leads up through a roof sheet stuffing box to a whistle. The crown sheet cage carries the fusible plug which is suspended slightly above the crown sheet and removed from the intense heat and firebox gases. A closing firebox plug is screwed into the bottom of the crown sheet cage and furnishes a means for removing the fusible plug.

The fusible plug in the alarm device bears no relation to the fusible plug of common practice which upon melting allows a small jet of steam to blow into the firebox. In the Cleveland low-water alarm the melting of the fusible plug opens a direct passage way only to the alarm whistle, thereby warning the enginemen of the dangerous condition in the boiler in time for them to replace the water without any damage to the boiler. After the water rises to a point above the openings in the crown sheet cage, the whistle will stop blowing but the water will continue to escape from the whistle. As the opening in the fusible plug is only ¼ in. in diameter, the loss of water through the whistle does not




Construction of Cleveland Low Water Alarm

necessitate killing the engine but acting as a tell-tale it at once fixes the responsibility for low water. The elimination of all levers, valves, springs and moving parts of any description, and the use of a suitable trap for the fused metal in the firebox plug insures the proper operation of this device while the government requirements concerning fusible plugs at the monthly washouts insures its proper maintenance.

The continual loss of life and great property damage resulting from crown sheet failures due to overheating emphasizes the need of a reliable low-water alarm which will give a warning, even though the present boiler appurtenances or the human element fails to function.

The Wilson Welder & Metals Company, Inc., 132 King Street, New York, N. Y. recently appointed King-Knight Company, Underwood Building, San Francisco, California, exclusive representatives in Central and Northern California for Wilson products.

# Questions and Answers for Boiler Makers

## Information for Those Who Design, Construct, Erect, Inspect and Repair Boilers—Practical Boiler Shop Problems

**Conducted by C. B. Lindstrom**

*This department is open to subscribers of* THE BOILER MAKER *for the purpose of helping those who desire assistance on practical boiler shop problems. All questions should be definitely stated and clearly written in ink, or typewritten, on one side of the paper, and sketches furnished if necessary. 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 permission to do so.*

## Development of a Cement Chute

Q.—Will you kindly supply me with the information for the development of a cement chute. I have made one, but it is wrong; the cement slides to one side of the chute. The bottom should be so that the cement slides the same on both sides.—H. F.

A.—The general arrangement of one solution of the chute problem is given in the accompanying illustration. This method is given to simplify the work and to show the principles of projection applied in such intersections. You will note that a section *A* is added so as to bring the opening square with a vertical plane *y-y*. If the oblique pipe *B* is cut as indicated in the plan view, as shown by the plane *y-y*, the section *B* would be out of proportion at this point.

The solution of the problem is based on the following: Assume that in the front elevation, the center *x-x* is definitely fixed and that the shape of the sections or profile of the chute will appear as shown by the rectangular sections.

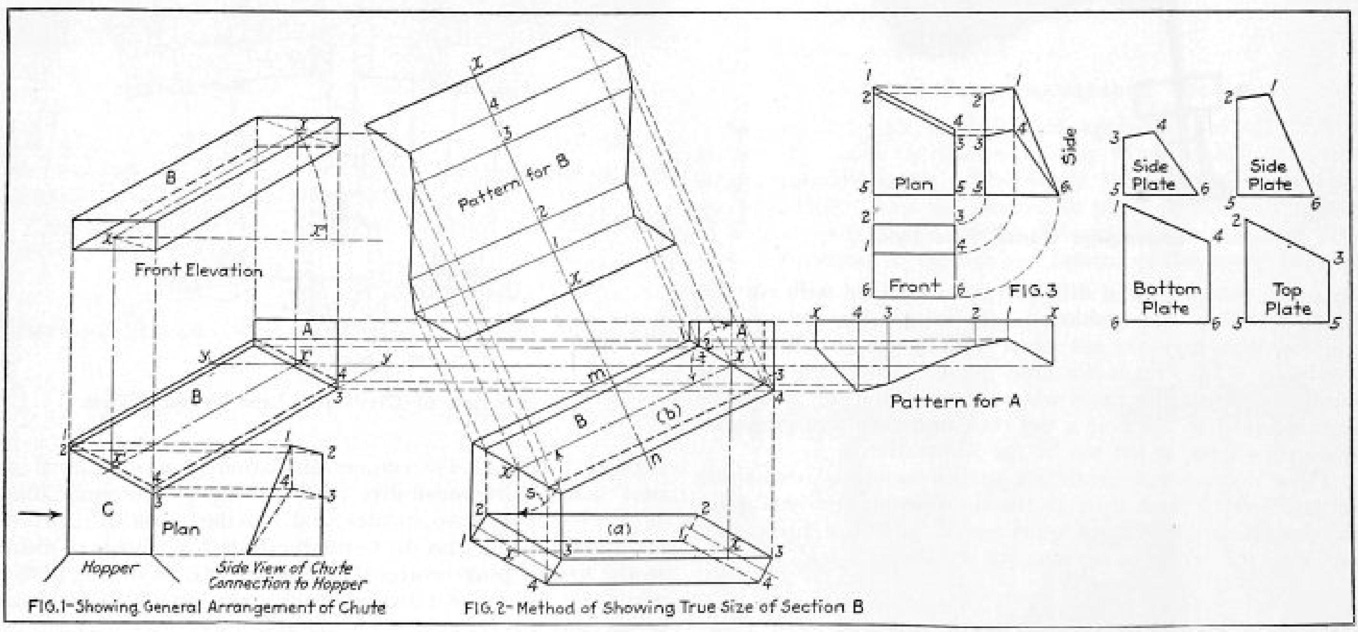
In the plan the center line *x′-x′* is then located. To obtain a full view of the pipe sections in their proper relationship so that when they are assembled in place the oblique pipe will have the correct inclination, it is necessary to employ an auxiliary construction, as shown in Fig. 2. In this case, the front elevation is considered to be revolved until its axis *x-x* is parallel with the horizontal, as shown at *x-x″* in the front view, Fig. 1. Thus in Fig. 2 this position of the oblique pipe *B* is shown as it would appear when revolved in the view (*a*).

At (*b*) a plan is thus constructed for the new position by projection. Points *x-x* are projected from view (*a*) to intersect projection lines extended from *x′-x′* of the plan, Fig. 1 to Fig. 2. The miters are then laid off in Fig. 2 by bisecting the angles *s* and *t*. Projectors drawn from the view (*a*) from points *1-2-3* and *4* intersect the miter lines. Connect these points on the miter with straight lines and the full view of the oblique pipe *B* is developed.

The foreshortened views of the plan are now completed from Fig. 2, as indicated by the projection of the points *1-2-3* and *4* to intersect the vertical projectors drawn from the front elevation.

A side view of the chute connection that joins the hopper is indicated to the right of the plan, which is taken in the direction of the arrow. A complete development of this section is shown in Fig. 3. The three views, plan, front and side elevation, show fully the general shape of this transition piece. The bottom plate will have a slight sweep to one side, due to the shape and position of the opening in the pipe *B*, to which the section joins.

The patterns *A* and *B* are laid off respectively at right angles to the views of these sections, Fig. 2. Make the respective stretchouts on *x-x* and *m-n* equal to the straight




**General Arrangement of Cement Chute Sections**

lengths around the chute sections. Then draw the construction lines perpendicular to the stretchout lines as from the points *1-2-3* and *4*. Add for laps. The seams are made to come in the center of the widest straight sides, as between points *1* and *4*. The seams should be opposite each other, so as to break the overlapping plate.

# Calculation for Determining Width of Reinforcing Liners and Number of Rivets

Q.—While making an interior inspection of a locomotive boiler, after the tubes had been removed, I discovered two cracks (1 inch in length each) in the shell plate and reinforcing liner at the boiler check opening. As this defect required a patch that would not reduce the factor of safety and consequently reduce the allowed working pressure, (which is 200 pounds per square inch on this boiler) the mechanical engineers' office was consulted and the enclosed drawing is a copy of the patch they recommended. The inside diameter of this course is 5 feet 5 inches and the shell plate is stamped 55,000 pounds tensile strength. As you no doubt know, the Locomotive Inspection Bureau allows 44,000 pounds per square inch of cross sectional area on rivets in single shear and 88,000 pounds per square inch of cross sectional area on rivets in double shear.

Will you, therefore, kindly furnish me with the following information: How to figure the strength of this patch and if a higher strength of joint could have been attained if ¾-inch rivets, 13/16-inch holes, and same pitch had been used instead of the 15/16-inch rivets and 1-inch holes shown in the drawing?—L. S.

A.—From the arrangement of the riveting and the large rectangular reinforcing liners shown in your patch, Fig. 1, I am not certain as to what conditions the designer had in mind when figuring the strength of the patch plates and rivets. Too many rivets do not increase the strength of the liners, in fact the plate section is weakened. Further, I do

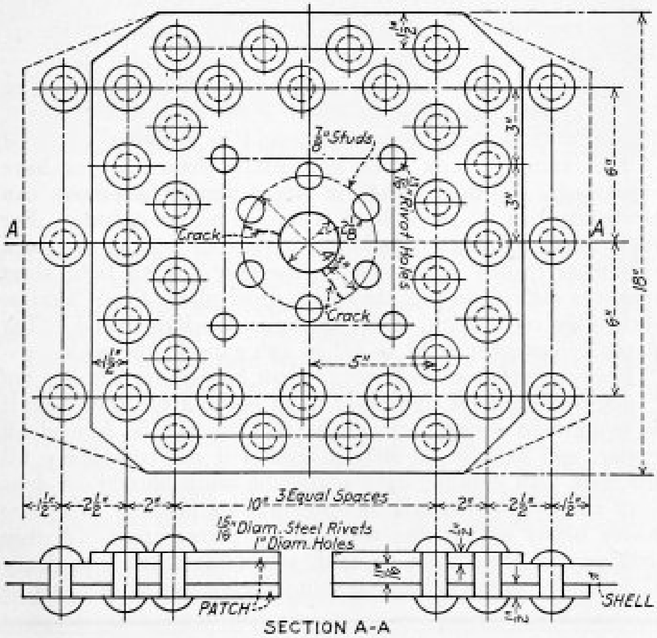



Fig. 1.—Original Liner Design

not see the reason for using the four 13/16-inch rivets and the large number of 1-inch (driven size) rivets on each side of the center line *A-A*.

The sketch, Fig. 2, illustrates a double reinforcing ring, using 15/16-inch rivets, 1 inch driven size. The following formula was used in determining the width of the ring on each side of the opening as measured in line parallel with the axis of the boiler shell.

$$W = \frac{l \times t_1}{4 \times t} + 2d$$

in which, $W$ = least width of the reinforcing ring, inches.

$l$ = length or diameter of opening in shell in direction parallel with the axis of the shell, inches.

$t_1$ = thickness of shell plate, inches.

$t$ = thickness of reinforcing liners, inches.

$d$ = diameter of rivet when driven, inches.

In Fig. 1, the diameter of the original reinforcing plate, taken to the outside edge of the rivet holes marked ⅞-inch studs, equals 5⅝ inches. In this example this dimension will be used in determining the required width of the rings. Consider that the plate is removed to make a circular open-

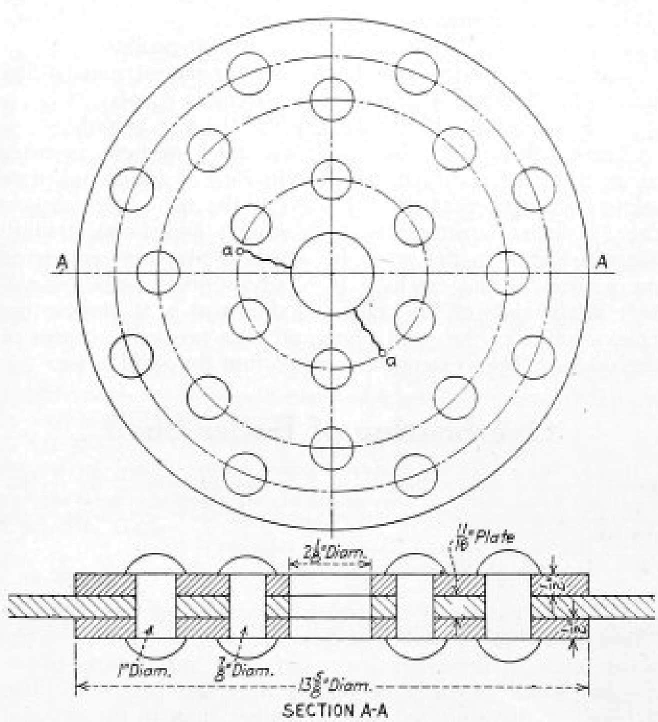



Fig. 2.—Illustrating Arrangement of Circular Liners.

ing 5⅝ inches in diameter, which would remove the damaged plate around the circular opening 2⅛ inches in diameter. However, in applying the required reinforcing liners this metal would not be removed. The original reinforcing liner would be taken off and holes placed in the new reinforcing rings to correspond with the arrangement of the ⅞-inch stud holes on the 4¾-inch circle. As the opening is considered to be 5⅝ inches in diameter, the use of the formula is as follows:

$$W = \frac{5.625 \times 0.6855}{4 \times 0.5} + 2 \times 1 = 1.935 + 2.00 =$$

3.935 inches.

Fig. 2 shows the relative arrangement of the rings with dimensions indicated. Since the calculated width 3.935 inches equals 4 inches, nearly, this width is used. The number of rivets for a single or double reinforcing ring may be determined by the formula:

$$N = \frac{5.1 \times T \times a}{S \times d^2 \times 0.7854}$$

in which,

$N$ = number of rivets.

$T$ = tensile strength of plate in reinforcing rings, in pounds per square inch of section.

$a$ = net section (area) of one side of ring or rings, in square inches.

$S$ = Shearing strength of rivets, pounds per square inch.
$d$ = diameter of rivets when driven, inches.

Substituting the value, of the example and the value, 88,000 pounds, as the shearing value of rivets in double shear, in the formula,

$$N = \frac{5.1 \times 55{,}000 \times 3.935 \times 0.5 \times 2}{88{,}000 \times 1^2 \times 0.7854} = 16$$

The arrangement of the 16 rivets is shown in Fig. 2, and their shearing value on each side of the center line *A-A*, must equal or exceed the ultimate tensile strength of the plate removed from the shell. In this case there are 7 rivets 1-inch in diameter, driven size, on each side of line *A-A*. Their combined shearing strength equals:

$$1^2 \times 0.7854 \times 88{,}000 \times 7 = 440{,}000 \text{ pounds.}$$

The plate section considered to be removed equals 5⅝ inches in diameter and its tensile strength equals,

$$5.625 \times 11/16 \times 55{,}000 = 212{,}850 \text{ pounds.}$$

These calculations show that the rivet strength is twice as much as the plate removed, but in view of additional plate section strength obtained by leaving the net section up to the 2⅛-inch diameter, the patch secures additional strength not considered in the example, which is also not considered on account of the cracks. It is advisable to drill a small hole at the ends of the cracks as shown at *a*, tc remove the crack section in the solid plate and thus break the course of the fracture from extending further into the solid plate.

## Overheating of Boiler Shell

Q.—(1) If you had two horizontal return tubular boilers carrying 100 pounds pressure and you looked into the firebox and noticed that you had a red spot on the shell and, after fifteen minutes watching to see if the spot were any larger, you noticed that it had turned black, what action would you take?
(2) How would you keep your boiler running?
(3) Is it safe to run the boiler?
(4) What is the cause? A. W. S.

A.—Overheating of the boiler plate sets up the condition referred to. If the red spot develops to the extent that the plate takes a permanent set and does not return to its original shape, a *bulge* or *bag* is thus formed. The plate is consequently stretched and is thinner than in the original shape. Unless this condition is discovered in time the plate will crack and possibly lead to a boiler explosion. It is advisable when such a condition is noticed to put the boiler out of operation by drawing the fires and closing the steam valve leading to the main steam piping. After the boiler has cooled sufficiently an internal inspection should be made of the shell and, if the plate has bulged, a new section of plate should be installed to replace the damaged part. The boiler plate and tubes should be thoroughly cleaned.

Bulges arising from overheating of the plate may be caused in cases of this kind by incrustation, collection of mud or oil on the heating surface. The plate as a result becomes red hot and soft, thus yielding to the steam pressure forming a bag. It is not safe to run a boiler showing and developing a weakness of this nature. It is always safer to take the conditions in hand at the time noticed than to wait, as accidents happen too frequently.

## Load on Vertical Seam in Furnace of Vertical Boiler

Q.—Is the vertical seam in the furnace of a vertical boiler in tension or compression either when stayed or unstayed and what objection is there to welding this seam?—A. McK.

A.—The cylindrical furnace of the vertical firetube type boiler is subjected to compressive loads. According to the A. S. M. E. Boiler Code 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.

## General Tank Construction

Q.—Would you please let me know the proper way of riveting and calking steel tanks? I have just completed three wagon tanks for hauling oil. They were made of No. 10 galvanized iron, 6 feet by 18 feet long and ⅜-inch hot rivets 1¼-inch centers were used. The rivets were driven from the outside and the holder-on was placed on the inside of the tank and a flat head was made. Would it be advisable to drive cold rivets if a water-tight job has to be made? What would be the best way to make a large tank watertight in this case? What size of chipping hammer should be used on light material?—O. M.

A.—The making of sound riveted joints on vessels that must be steam or watertight is one of the most important operations in plate work. There are several practical considerations in handling the building of water or oil tight tanks: namely: (1) The respective metal sheets should be laid out so that the rivet holes fair up, as blind holes must be either reamed or drifted into place thus enlarging the hole and making it impossible for the rivet to fill the enlarged rivet space. (2) The pitch of rivets should be such that the plate or sheet iron will be sufficiently close together when riveted to insure tight seams. (3) The overlapping edges of the joints should be laid up against each other to remove buckles and spring in the plate. (4) The rivets should be driven by skipping several rivets alternately. By so doing any excess material is uniformly distributed throughout the entire length of the seam. (5) The rivets must not be too large in diameter as this will require a large pitch and lap. (6) The rivets should not be too small as this incurs additional expense in the operations of laying out, punching and riveting. Ordinarily for most tank work, the rivet diameter can be made equal to 1¼ times the plate thickness, as:

$$d = 1.25\sqrt{t}$$

in which; $d$ = diameter of rivet in inches.
$t$ = thickness of plate in inches.

To illustrate, using a plate thickness of No. 10 gage, which, according to the U. S. standard sheet metal gage equals 0.141 inch. Then

$$d = \sqrt{.141} = 0.375 \times 1.25 = 0.46875 \text{ or } 15/32 \text{ inch.}$$

Either a ⅜ or 7/16-inch rivet would be suitable.

The rivets for tank work are usually driven as you have explained. By this method a larger number of rivets can be driven than when the head is formed on the outside. For tight work, the rivets should be driven red hot, as the stock will more readily upset and fill the hole. With light sheet iron it is difficult to keep the overlapping plates firmly against each other on account of the spring in the light metal. Tar paper is generally used to fill in the gaps in the seam.

Leaky rivets frequently occur from holders on who do not "buck up" the rivet right, that is, in holding the dolly bar, if it is not held square against the rivet, it will be formed off center, and thereby the driven rivet will not completely fill the hole. In calking light plate, the work should be done with a light powered calking and chipping hammer, otherwise heavy blows will spring the lapping plates apart. A thin calking tool should not be used, as this also has a tendency to raise the metal at the edge and spring the plate apart.

## BUSINESS NOTES

E. R. Fish of the Heine Boiler Company, St. Louis, Mo., has been appointed a member of the Conference Committee of the A. S. M. E. Boiler Code Committee to represent the State of Missouri. Mr. Fish is also a representative of the American Boiler Manufacturers' Association on the A. S. M. E. Boiler Code Committee.

Charles M. Schwab, chairman of the board of directors of the Bethlehem Steel Corporation, has been elected chairman of the board, also, of the Chicago Pneumatic Tool Company, New York, to succeed John R. McGinley, who resigned as chairman but who remains as a director of the company.

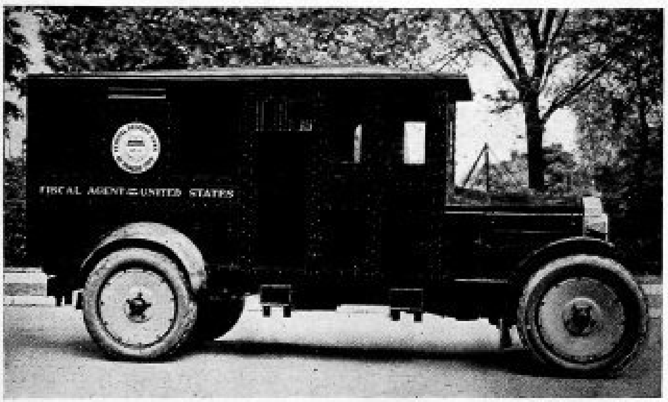
# Letters from Practical Boiler Makers

**This Department Is Open to All Readers of the Magazine —All Letters Published Are Paid for at Regular Rates**

## New Departure for Boiler Shop

The accompanying illustration shows a rather unusual job for a contract boiler shop to turn out. It is an armored truck body for the Federal Reserve Bank of Kansas City and is one of the first, if not the first of its kind, to be built in the United States. It is as nearly "bandit proof" as it is possible to make it and is used to transport money and securities between banks. The entire body was designed and built in our plant, the bare truck chassis being delivered to us.

The body is built throughout of 3/16-inch steel plate, except the roof, which is No. 14 gage metal. The wind shield and windows are equipped with ¾-inch bullet proof glass. The steps are so constructed as to fold up as the doors close. The cab and the rear compartment are separated by a steel partition, there being no communication between them.



Armored Truck Body Produced in Plate Shop

The rear compartment has seats for two armed guards and an emergency brake, so the truck may be stopped by the guards if necessary. The rear wheels are covered by crown fenders of a special design, being inclined at an angle of 45 degrees to the side of the body to prevent any one from obtaining a foothold upon them. The outside of the body is so made as to prevent a handhold or foothold being gained any place upon it.

This truck has been in service for almost a year and has attracted very favorable comment. We are now building a similar body for use in St. Louis.

Kansas City, Mo. W. R. Starke.

## Staybolt Testing Hammer

Practically every boiler inspector and boiler maker has some favorite shape and weight of hammer that appeals to him. As a roundhouse boiler inspector in the course of a day's duty has several thousands of staybolts and radial stays to test, it is necessary that the hammer used should be of such weight that it will not hang too heavy on the wrist. A design of testing hammer used successfully by the writer for several years has the thin tapered end brought to a center point, which is found useful in picking away corrosion to ascertain the condition of sheets. The weight of the hammer with a 12-inch handle is one pound.

Some inspectors and boiler makers have the idea that a bulging sheet will show that staybolts are broken. Why wait for the sheet to bulge? In my twenty-nine years at the boiler trade I have only seen one case of bulged sheet due to broken staybolts and that was in an old-style ogee firebox when one row of staybolts for the entire length of the box was broken.

I do not wish to convey the impression that the sheets will not bulge, they certainly will if enough adjacent bolts are broken; but the point I wish to bring out is that so many seem to be relying on the so-called breakless or flexible bolt that they are apt to become careless in their periodical inspections and, therefore, serious trouble may develop.

The flexible staybolt properly applied is a good thing, but by no means is it infallible. I have found six broken flexible bolts on an engine nine days after an inspector failed to find any broken.

All adjacent bolts appeared to fit snugly in their cups, so that it could not be said that the broken bolts were under a greater tension than the others.

Lorain, Ohio. Joseph Smith.

## Hints for the Round House Boiler Maker

The list of "Don'ts for Boiler Makers" in the May issue of The Boiler Maker are interesting; may I follow them with a few? Try this once and note the results. The engine being fired up after undergoing extensive repairs to the firebox, fifty to sixty pounds of steam shown on the gage, the mud-ring leaking pretty lively, looks as if you would have to drop the fire and calk. Try filling up to three gages of water, open the blow off valve quietly and run the water down to two gages. By doing this, the temperature of the water in the water leg is made to correspond with the rest of the boiler and more often than not the leakage disappears.

For leaky staybolts, either rigid or flexible, try a short stroke hammer with an ordinary bobbing tool. It is not the powerful blow that does the business, but the quick acting vibration of the sheet that loosens the scale. The use of a long-stroke is objectionable, as the blow is so severe that the rebound of the holding-on bar is not rapid enough.

Also in the case of flexible bolts, even where the sleeve and plunger are used, the drawing up process is so severe that it results in broken sleeves and also loosens up adjacent bolts.

Practically all engines are now fitted with non-adjustable petticoat pipe and diaphragm plates so if your front end is air-tight and all the leaks in the firebox taken care of, examine your flues. Superheater flues have a special appetite for clinkers as big as your fist. Also the top row of small flues and flues across the bottom become plugged up. Examine the firebox end of the superheater units. Very often they give out at that point.

Cab deck aprons should be semi-punched; if worn, don't rough them up with a gouge or chisel. If you haven't time to replace it with a new one, get your electric welder to spot it here and there. It makes a good job and also keeps the engine crew from cussing the roundhouse gang. Shoe leather is expensive.

Lorain, Ohio. JOSEPH SMITH.

## Experiences With Oil Well Boilers

In the May issue of THE BOILER MAKER the article the "Life Story of Two Staybolts" has interested me quite a lot. I have worked on oil well boilers for a good many years—since 1860, in fact, until I came here in 1892, so of course I do not know much about what they are made of.

There were a good many types of oil well boilers then and they were made of 1/4-inch plate. The Tifft boiler was in most use and it was made in three sizes, 15, 20 and 25 horsepower. The shells, wagontop and firebox wrapper for the 15 and 20 horsepower boilers were 1/4-inch iron front head; 5/16-inch firebox sheet; back head and throat sheet and dome sheet, 3/8-inch; the staybolts were 3/4-inch spaced 5 inches or 5 1/2 inches on centers. These boilers were tested to 150 pounds of steam per square inch.

They were filled up to the third gage or a little over and fired up until steam showed 150 pounds on the gage. The fire was then drawn and all leaks inside the firebox calked with the steam on and all leaks on the outside at the same time. Sometimes we had a pretty hot job in the firebox with 150 pounds of steam on.

Talk about inspection. What good would it do on the oil well boiler? I have seen a big bucket filled with scrap steel hung on the safety valve lever in addition to the original lever ball or weight. I could not tell you how many times the indicator on the gage went around the circle. What good would an inspection do then?

When the drill was down 3,000 feet or more, no 100 pounds on either a 15 or 20 horsepower boiler would bring it, let alone the cable, to the top.

Water was pretty scarce and what they used at first was pretty thick with mud excepting where there was a creek handy to pump from.

In 1871 I took charge of the Titusville Boiler Shop, and a short time after I was told to go and look at a boiler they had built for a man up on a hill just outside of the town. When I got there the boiler was leaking around the bottom. After I had made it tight I hung around to see if any more would show up. About five minutes after I had finished it commenced to leak again. I was surprised but went at it again with a fuller. I found that the sheet was eaten away until it was but a 1/16 inch thick where the leak was. There had been a small leak there when it left the shop and there had been several repairs made before.

I asked the man in charge what kind of water he used. He got some in a can and told me to taste it but not drink it. I put my finger in it and touched my tongue. Well, I could have sworn that *aqua fortis* was in that water. I had to put oil on my tongue and the finger I had dipped in the water.

Springfield, Ill. JOHN COOK.

## Promoting Locomotive Safety

*(Continued from page 202)*

prevented by means which are known to every well qualified mechanical official and employee in charge of the inspection, repair and operation of locomotives and tenders and that every means should be practiced by you to safeguard the lives and limbs of our fellow beings and it is your duty to see that those for whom you are responsible perform their work so that criticism may be avoided by your employer whom the law holds responsible for a proper compliance therewith.

## Tool Foremen's Convention

The convention of the American Railway Tool Foremen's Association will be held at the Hotel Sherman, Chicago, September 5-8, at the same time that the International Railway General Foremen's Association meets. The Supply Association of the American Railway Tool Foremen's Association is arranging to hold a convention and exhibit in connection with this joint meeting.

## National Safety Council

The eleventh annual Safety Congress of the National Safety Council will be held at Detroit, August 28 to September 1. The meetings will be held in the new Case Technical High School.

The Steam Railroad Section of which Isaiah Hale, safety superintendent, Atchison, Topeka & Santa Fe, is chairman, will hold its sessions on August 29 and August 30.

## PERSONALS

CHARLES R. TURN, treasurer and general manager of the International Boiler Works Company, East Stroudsburg, Pa., was born on August 16, 1865. His early education was obtained at Blair Hall, Blairstown, N. J., and Eastman's Business College, Poughkeepsie, N. Y. In 1890 he became connected with the East Stroudsburg Glass Company and after a period of five years with this company became interested in the International Boiler Works Company. In 1900 Mr. Turn was made general manager of this company and in 1910 he was made treasurer, holding both these offices until the present time. He is interested in various industrial enterprises and also in the civic affairs and institutions of East Stroudsburg.

Charles R. Turn

As a result of examinations held in June by the Industrial Board, Department of Labor and Industry, Commonwealth of Pennsylvania, for boiler inspectors, the following were granted certificates of competency and commission cards for the year 1922: George M. Painton, Philadelphia; John C. Tyler, Philadelphia; John M. Burns, Philadelphia; Charles M. Scannel, Philadelphia; George C. Derr, Mifflin.

## ASSOCIATIONS

### Bureau of Locomotive Inspection of the Interstate Commerce Commission

Chief Inspector—A. G. Pack, Washington, D. C.
Assistant Chief Inspector—J. M. Hall, Washington, D. C.

### Steamboat Inspection Service of the Department of Commerce

Supervising Inspector General—George Uhler, Washington, D. C.

Deputy Supervising Inspector General—D. N. Hoover, Jr., Washington, D. C.

## ASSOCIATIONS

### 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—John A. Stevens, Lowell, Mass.

Vice-Chairman—D. S. Jacobus, New York.

Secretary—C. W. Obert, 29 West 39th Street, New York.

### National Board of Boiler and Pressure Vessel Inspectors

Chairman—J. F. Scott, Trenton, N. J.

Secretary-Treasurer—C. O. Myers, State House, Columbus, Ohio.

Vice-Chairman—R. L. Hemingway, San Francisco, Cal.

Statistician—W. E. Murray, Seattle, Wash.

### American Boiler Manufacturers' Association

President—A. G. Pratt, Babcock & Wilcox Company, New York.

Vice-President—G. S. Barnum, The Bigelow Company, New Haven, Conn.

Secretary and Treasurer—H. N. Covell, Lidgerwood Manufacturing Company, Brooklyn, N. Y.

Executive Committee—F. C. Burton, Erie City Iron Works, Erie, Pa.; E. C. Fisher, Wickes Boiler Company, Saginaw, Mich.; C. V. Kellogg, Kellogg-McKay Company, Chicago, Ill.; W. S. Cameron, Frost Manufacturing Company, Galesburg, Ill.; W. A. Drake, The Brownell Company, Dayton, Ohio; Alex. R. Goldie, Goldie & McCullock Company, Galt, Ont., Can.; F. G. Cox, Edge Moor Iron Company, Edge Moor, Del.; J. C. McKeown, John O'Brien Boiler Works Company, St. Louis, Mo.

### International Brotherhood of Boiler Makers, Iron Ship Builders and Helpers of America

J. A. Frank, International President, suite 522, Brotherhood Block, Kansas City, Kansas.

William Atkinson, Assistant International President, suite 522, Brotherhood Block, Kansas City, Kansas.

Joseph Flynn, International Secretary-Treasurer, suite 504, Brotherhood Block, Kansas City, Kansas.

James B. Casey, Editor-Manager of Journal, suite 524, Brotherhood Block, Kansas City, Kansas.

H. J. Norton, International Vice-President, Alcazar Hotel, San Francisco, Calif.

International Vice-Presidents—Thomas Nolan, 700 Court St., Portsmouth, Va.; John Coots, 344 North Spring St., St. Louis, Mo.; M. A. Maher, 2001-20th St., Portsmouth, Ohio; E. J. Sheehan, 7826 South Shore Drive, Chicago, Ill.; John J. Dowd, 953 Avenue C, Bayonne, N. J.; R. C. McCutcheon, 15 La Salle Block, Winnipeg, Man., Can.; Joseph P. Ryan, 7533 Vernon Ave., Chicago, Ill.; John F. Schmitt, 605 East 11th Ave., Columbus, Ohio.

### Boiler Makers' Supply Men's Association

President—W. M. Wilson, Flannery Bolt Company, Pittsburgh, Pa. Vice-President—George R. Boyce, A. M. Castle Company, Chicago, Ill. Secretary—W. H. Dangel, Lovejoy Tool Works, Chicago, Ill.

### Master Boiler Makers' Association

President—Thomas Lewis, G. B. I., L. V. System, Sayre, Pa.

First Vice-President—E. W. Young, G. B. I., C. M. & St. P. R. R., 81 Caledonia Place, Dubuque, Iowa.

Second Vice-President—Frank Gray, G. F. B. M., C. & A. R. R., 705 West Mulberry St., Bloomington, Ill.

Third Vice-President—Thomas F. Powers, System G. F. Boiler Dept., C. & N. W. R. R., 1129 Clarence Ave., Oak Park, Ill.

Fourth Vice-President—John F. Raps, G. B. I., I. C. R. R., 4041 Ellis Ave., Chicago, Ill.

Fifth Vice-President—W. J. Murphy, G. F. B. M., Penn R. R. Lines West, Fort Wayne Shops, Allegheny, Pa.

Secretary—Harry D. Vought, 26 Cortlandt St., New York City.

Treasurer—W. H. Laughridge, G. F. B. M., Hocking Valley Railroad, 537 Linwood Ave., Columbus, Ohio.

Executive Board—L. M. Stewart, G. B. I., Atlantic Coast Lines, Waycross, Ga., Chairman.

## TRADE PUBLICATIONS

Vulcabeston.—The Johns-Pratt Company, Hartford, Conn., has just distributed its first catalogue which deals exclusively with Vulcabeston products, which include various forms of air pump, rod and valve stem asbestos packings, pump valves, disks, bushings, rings, gaskets, washers, etc. Complete decriptions of the various products, together with price lists, are included in the pamphlet.

Seamless Steel Tubes.—The first of a series of illustrated bulletins, describing the manufacture of seamless steel boiler tubes, has been published by the Standard Seamless Tube Company, Pittsburgh, Pa. This first bulletin includes the manufacturing processes up to the point of piercing the solid billet and by means of illustrations gives an excellent idea of the equipment and methods employed. The second of the series of bulletins will be published within a short time, showing the tube mill operations including the piercing of steel billets.

Fuel Oil Burning Systems.—A catalogue, consisting of three bulletins describing mechanical fuel oil burning systems and fuel oil burners in which the oil is atomized by low or high pressure air and steam, is being distributed by Schutte-Koerting Company, Philadelphia, Pa. The catalogue discusses thoroughly the installation, operation and maintenance of oil burning equipment, the characteristics, requirements and functions, as well as the relative merit of mechanical spray oil burners, the use of air control registers, oil pumping outfits and fuel oil heaters. Instructions are given for the general arrangement of steam boiler furnaces for burning oil.

Preventing Corrosion of Boiler Tubes.—A complete treatise in bulletin form on the prevention of corrosion in boiler tubes has been published by the National Tube Company, Pittsburgh, Pa. The subject of corrosion in general is treated, followed by details showing how this expensive item of locomotive boiler operation may be eliminated or reduced. This section includes methods of treating feed water, types of repairs and the like. The problem in the case of power and heating boilers is less difficult to remedy than for locomotives, being mainly a case of proper purification and softening of the feed water. In marine boilers the treatment of feed water is much the same as in stationary units. Authorities on the subject of corrosion have collaborated in preparing material for this bulletin.

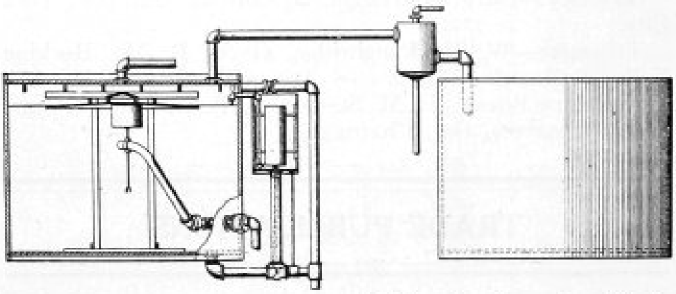
# SELECTED BOILER PATENTS

Compiled by
GEORGE A. HUTCHINSON, Patent Attorney,
Washington Loan and Trust Building,
Washington, D. C.

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

1,418,092. APPARATUS FOR WASHING OUT AND REFILLING BOILERS. SPENCER OTIS, OF CHICAGO, ILLINOIS, ASSIGNOR TO NATIONAL BOILER WASHING COMPANY, OF CHICAGO, ILLINOIS, A CORPORATION OF MAINE.

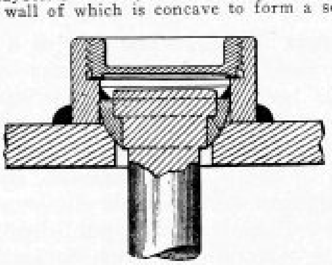
*Claim* 1.—A boiler blowoff and wash-out system comprising a tank having a single compartment in which it receives and separates steam, water and



sludge, means delivering steam, water and sludge from locomotives, directly and collectively to said tank, means conveying away steam from the top of said tank, means conveying away sludge from the bottom of said tank, and means drawing off wash-out water from the upper portion of said tank below the water level therein. Sixteen claims.

1,417,150. STAYBOLT CONSTRUCTION. ETHAN I. DODDS, OF PITTSBURGH, PENNSYLVANIA, ASSIGNOR TO FLANNERY BOLT COMPANY, OF PITTSBURGH, PENNSYLVANIA.

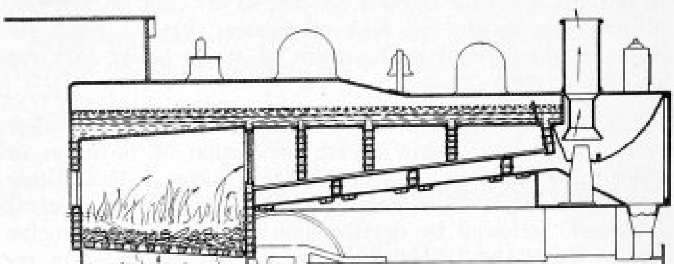
*Claim* 1.—In a staybolt structure, the combination of a boiler sheet having a bolt opening the wall of which is concave to form a seat for a bolt bear-



ing member, a convex bolt bearing member mounted in said seat and provided with a seat for a bolt head, a bolt the head of which is supported by and mounted to move in said bearing member, a sleeve welded to the boiler sheet arround the bolt opening and a cap closing the outer end of said sleeve, the said bolt bearing member being welded to the sleeve. Two claims.

1,416,805. BOILER. PETER H. FERRIER, JR., OF CHICAGO, ILLINOIS.

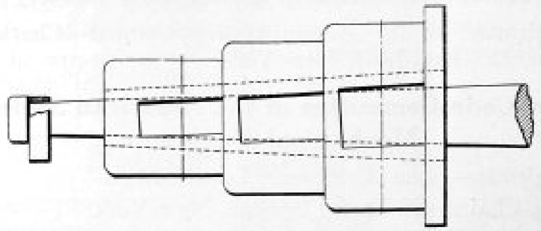
*Claim* 1.—In a boiler, the combination, of a firebox having hollow water containing walls, a main water and steam chamber, a stack, an enclosed passage way communicating with said stack and firebox, and a plurality of water conducting tubes positioned within said enclosed passage and having direct communication with the interior of one wall of the firebox and with said main water and steam chamber, and a plurality of hollow baffles extend-



ing into said enclosed passage and having communication with the interior of said main water and steam chamber, said baffles arranged in staggered relation to guide the combustion gases in a sinuous path from the firebox to said stack, the inner wall of said firebox provided with an opening having communication with said enclosed passage, and a plurality of vertical tubes extending across said opening and having communication with the interior of the main water and steam chamber and the interior of the inner wall of the firebox. Three claims.

1,417,979. MULTIPLE TUBE EXPANDER. THOMAS J. DIXON, OF MADISON, WISCONSIN, ASSIGNOR TO LOVEJOY TOOL WORKS, OF CHICAGO, ILLINOIS, A CORPORATION OF ILLINOIS.

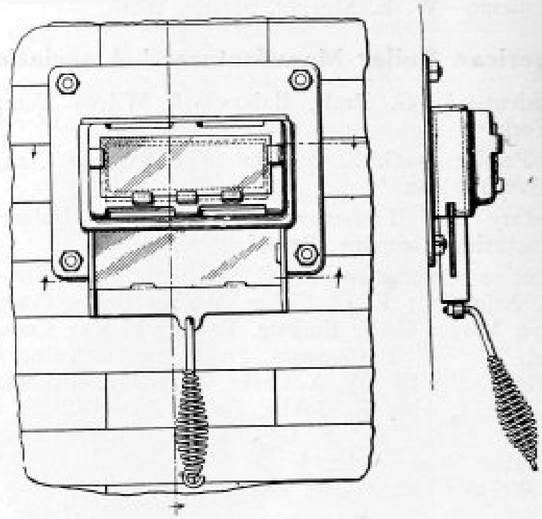
*Claim* 1.—In a tube expander, the combination with an expanding unit including a set of radially shiftable expanding rollers, and a mandrel that engages the said set of rollers and holds them to their operative position,



the said mandrel having an annular enlargement or head at the forward end; of a ring of flexible metal adapted for being slipped onto the mandrel over the head, and for being compressed around the mandrel to constitute a retainer to prevent the separation of the mandrel and the expanding unit. Two claims.

1,417,976. OBSERVATION WINDOW FOR FURNACES. MALCOLM CURRY, OF SCARSDALE, NEW YORK, AND STARR H. BARNUM OF HAMDEN, CONNECTICUT.

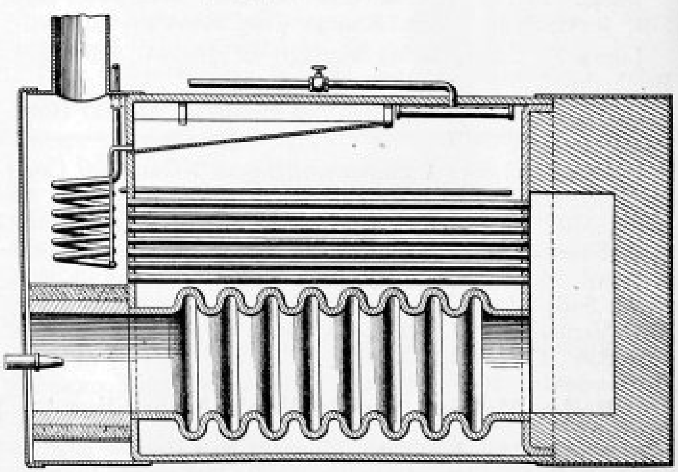
*Claim* 1.—The combination with a furnace having a peep opening, of means for supporting a panel of transparent glare eliminating material outside of the furnace in line with said opening, a support slidable transversely



of the line of vision through said transparent panel and opening, and panels of heat-resisting material carried by said slidable support and movable therewith to alternately close the peep-opening, one of said heat-resisting panels being transparent and the other being formed of material which is a non-conductor of heat. Ten claims.

1,417,615. HIGH PRESSURE BOILER FOR TRACTION USE AND OTHER USES. THOMAS J. McDONALD, OF KNOXVILLE, TENNESSEE.

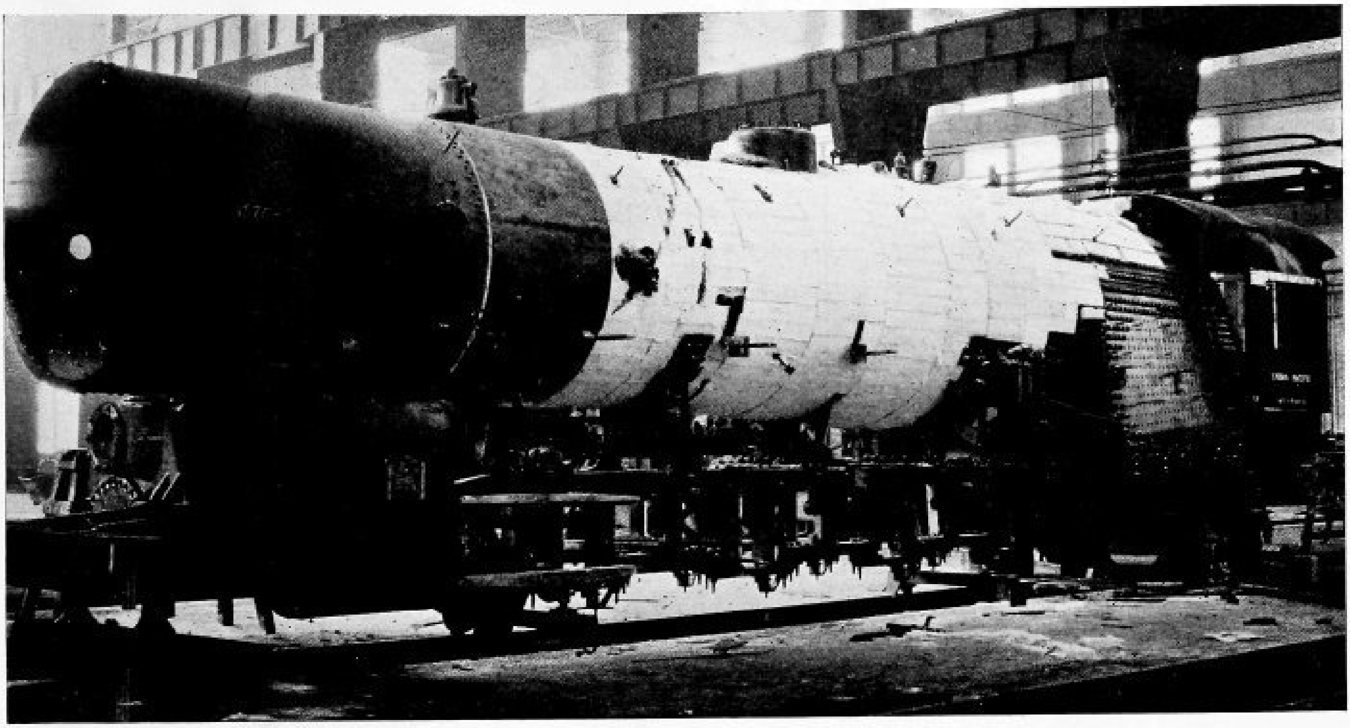
*Claim* 1.—The combination with a steam boiler and a superheater, of means for automatically supplying to the superheater, when the boiler ceases



to generate steam, sufficient water to prevent injury to the superheater when the boiler is again put into operation, the amount of such water being insufficient to do any injury to an engine connected with the boiler in case it is forced thereinto. Ten claims.

# The Boiler Maker

AUGUST, 1922

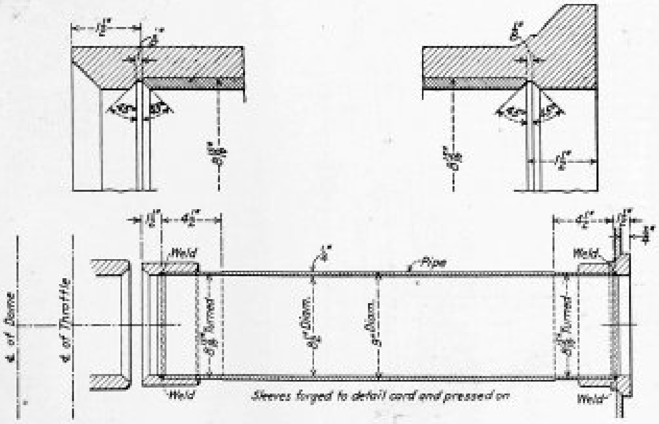
Boiler of Union Pacific Mountain Type Locomotive No. 7,000 Nearing Completion

## Boiler of Union Pacific Mountain Type Locomotive

### High Boiler Capacity Obtained in 4-8-2 Locomotive Which Is the Lightest Per Unit of Power Ever Built

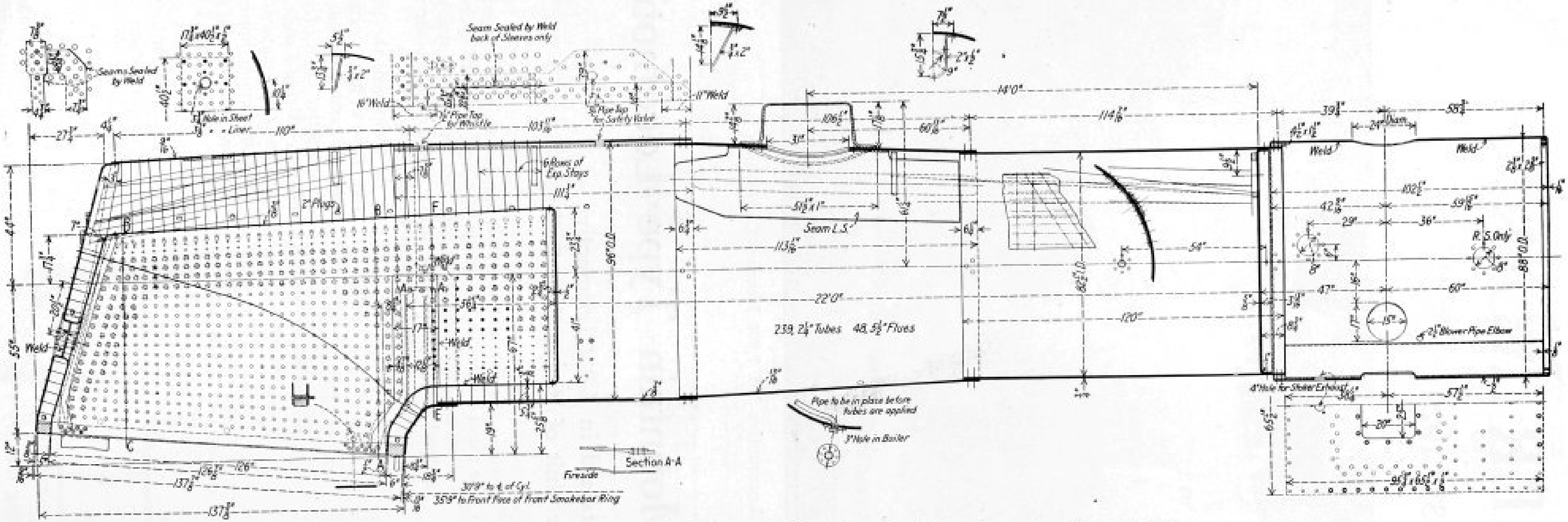
THE Union Pacific Railroad Company recently received from the American Locomotive Company the first Mountain type locomotive to be built for its passenger service. The design of the locomotive was worked out practically complete in detail by the railroad's own engineering staff and includes many refinements which make it the lightest in proportion to maximum horsepower of any locomotive of this type yet built.

In designing this locomotive, the only limitation involved besides the track conditions was that the maximum weight of the locomotive should not exceed 345,000 pounds. The problem required the securing of the greatest boiler and cylinder capacity within this weight. In accomplishing this result painstaking care was exercised in the elimination of all surplus weight. Contrary to the usual custom in the design of a new locomotive, first cost was not a dominating factor. In fact, no expense was spared in developing a locomotive which would produce the maximum power on the minimum weight.

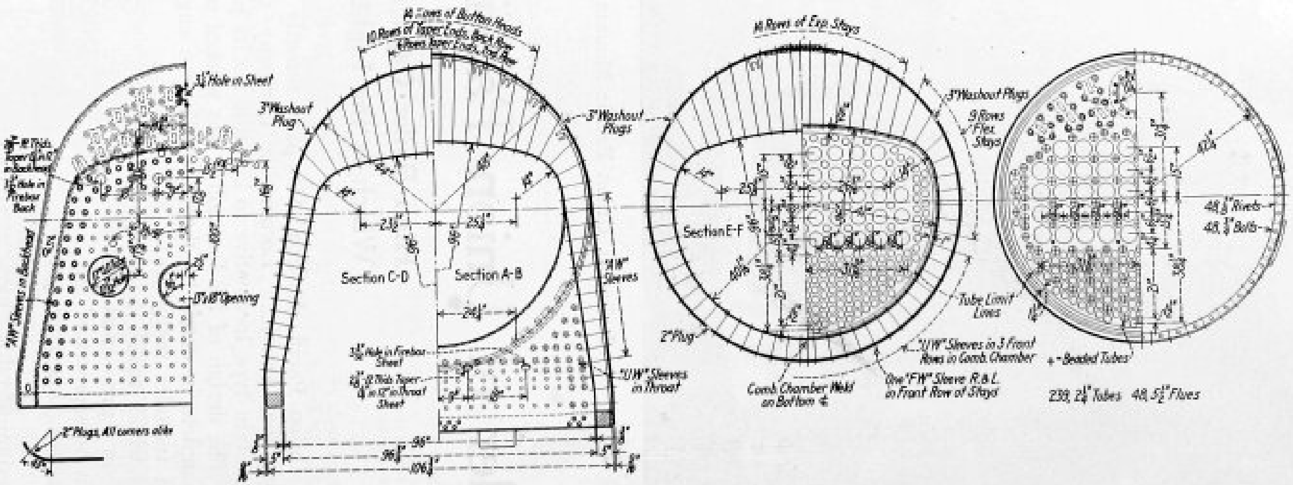



Method of Welding the Dry Pipe

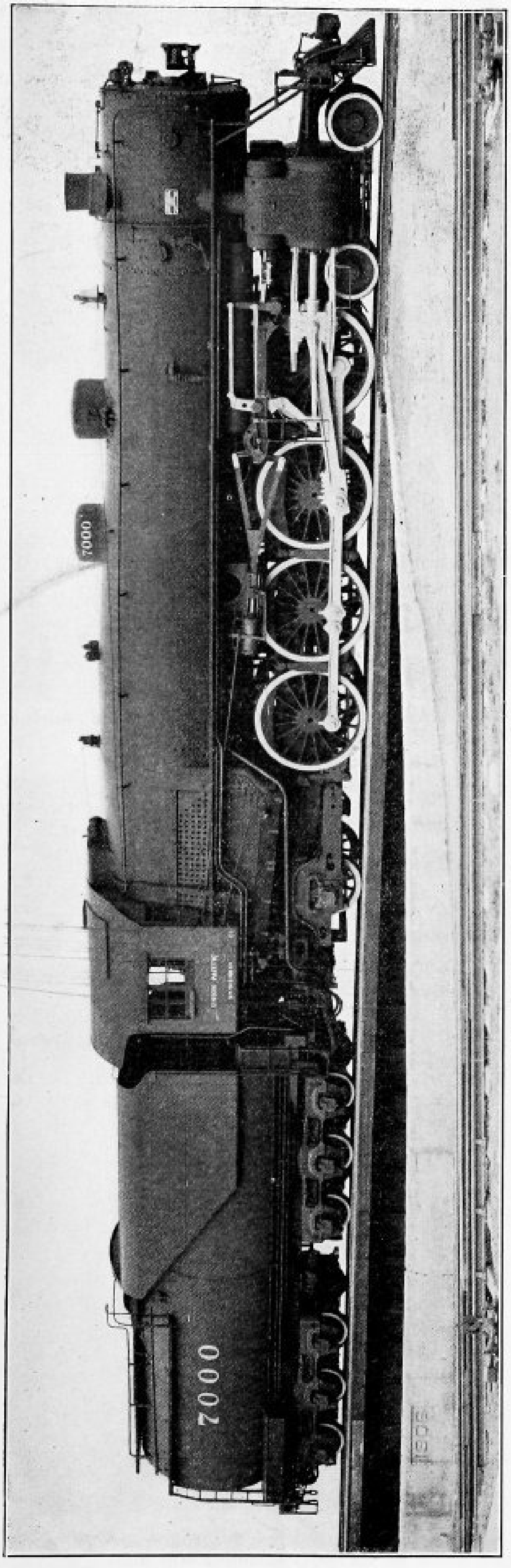
As completed, the locomotive has a total weight of 345,000 pounds and a maximum tractive effort of 54,800 pounds. Using Cole's ratios as a basis of comparison, it has a maximum horsepower capacity of 3,030 with a 98.5 percent boiler and a grate area about 4 percent greater than that called for by Cole's ratios, in proportion to the evaporative capacity. The weight per cylinder horsepower is 113.9 pounds and per boiler horsepower 115.8 pounds. Semi-bituminous coal, low in ash but high in




Longitudinal Section of Boiler of Union Pacific Mountain Type Passenger Locomotive




Cross Sections of Boiler



Union Pacific Type Locomotive for Heavy Passenger Service

moisture and with a heat value of about 12,000 British thermal units, is used as fuel.

The new locomotive is intended primarily for use in passenger service between Cheyenne, Wyo., and Ogden, Utah, a distance of 484 miles, over which, because of the long and frequent grades encountered, passenger trains are now handled by the Mikado type locomotive. To maintain the required schedules, calling for speeds of from 30 to 40 miles per hour with trains varying from 8 to 13 cars, it has been necessary with the Mikado locomotives to resort to high running speeds on the down grades to make up for the comparatively low speeds on the heavy up-hill pulls. This has had a marked effect in increasing track maintenance and, to some extent, the cost of locomotive maintenance.

The Mountain type locomotive, with its high sustained capacity is expected to bring the maximum and minimum operating speeds more nearly to the average, which, in addition to its effect on maintenance cost, will produce more economical locomotive operation and facilitate the operation of the road generally. With a locomotive suitably proportioned to meet the requirements and to afford some measure of reserve capacity, it is expected that marked economies of operation will be secured, particularly with respect to fuel consumption.

The design of a locomotive of this type was first considered in the fall of 1920. During the preliminary stages of design, many valuable suggestions were received from both the Baldwin Locomotive Works and the Lima Locomotive Works, Inc., as well as from the American Locomotive Company. The final design, however, was worked out, as previously stated, by the railroad's own staff—a point worthy of note, as in recent years the tendency has been toward placing more and more responsibility for locomotive design in the hands of the builder.

In general, the boiler of the locomotive, which is designed for a working steam pressure of 200 pounds per square inch, is similar in capacity and dimensions to the boiler of the Union Pacific 2-10-2 type locomotive also built by the American Locomotive Company. It is conical in form with an outside diameter of 84 inches at the front barrel course, increasing to 96 inches at the combustion chamber course. The firebox measures 126 inches by 96 inches at the grate and includes a combustion chamber 40 inches long by 64 inches in diameter, the length of which is such as to provide for tubes 22 feet long.

### Unusual Features Incorporated in the Boiler

Foremost among the striking features in the design of boiler is the ample capacity afforded by the large radiant heat absorbing surfaces of the firebox and combustion chamber together with the unusual tube and flue heating area for passenger locomotive design. Another striking feature is the construction of the firebox and combustion chamber. The firebox side and crown sheets and the combustion chamber were made from a single plate, the widest ever rolled, whose dimensions were 241 inches by 195 inches by ⅜ inch. The throat sheet was flanged from ½ inch plate and welded to the firebox and combustion chamber.

Other notable features of the boiler are the application of a new "universal" type of drop forged crowfoot brace for staying the front and back heads and the location of the steam dome on the conical course at a point above the center of oscillation of the water in the boiler, which provides a uniform steam space under all conditions of grade, considerably removed from the zone of violent ebullition over the crown sheet.

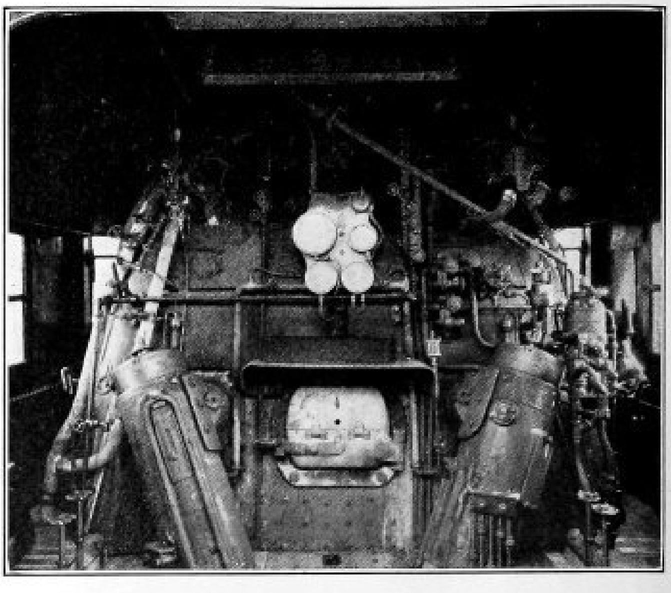
### Construction Details

The front boiler course is of ¾-inch plate, 120 inches long and 82½ inches inside diameter. The conical course is of 13/16-inch plate, 113 1/16 inches long, 84 inches inside diameter at the forward end and 92⅝ inches inside diameter at the rear end. The rear course is of ⅞-inch plate, 111¾ inches long and 96 inches outside diameter. The wrapper sheet is 9/16 inch thick, the firebox side and crown sheets and the combustion chamber are ⅜ inch thick; the throat sheet ½ inch thick; the front tube sheet ⅜ inch thick; the back tube sheet ½ inch thick and the back head 9/16 inch thick. The mud ring in the firebox is 5 inches wide at the sides and 6 inches wide at the ends.

The firebox is stayed with Tate flexible staybolts with welded sleeves and reduced body bolts arranged in vertical rows. The crown sheet is stayed with 1-inch radial stays. The water space at the front of the firebox is 6 inches wide and at the sides and back 5 inches wide.

The tubes and flues, all of seamless steel, are 22 feet long. There are two hundred and thirty-nine 2¼-inch tubes, 0.125-inch thick, and forty-eight 5½-inch flues, 0.150-inch thick. The tube spacing is ¾ inch.

The heating surface of the boiler, which totals 4,974 square feet, is divided as follows: Tubes, 3,084 square feet; flues, 1,508 square feet; firebox, 354 square feet; arch tubes, 28 square feet. The superheating surface, comprising forty-eight units, totals 1,242 square feet; the grate area is 84 square feet.



Interior of Cab, Showing Arrangement of Fittings

### Reduction of Weights

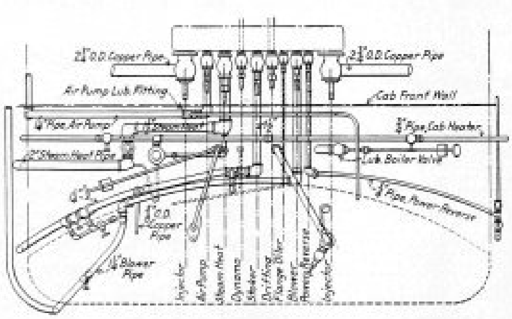
With the object of eliminating as much surplus weight as possible the sand box is of pressed steel instead of the usual casting. In this case it is stated that the weight of the completed sand box filled with sand is less than that of an empty cast iron box of the same capacity. Similar construction is employed in the smokebox where the usual cast iron stack extension is replaced with pressed steel. Due to the character of coal burned, the use of an extended front end and a large netting area was found desirable in this locomotive. In this case the angle iron to which the netting is bolted is welded to the inside of the smoke arch.

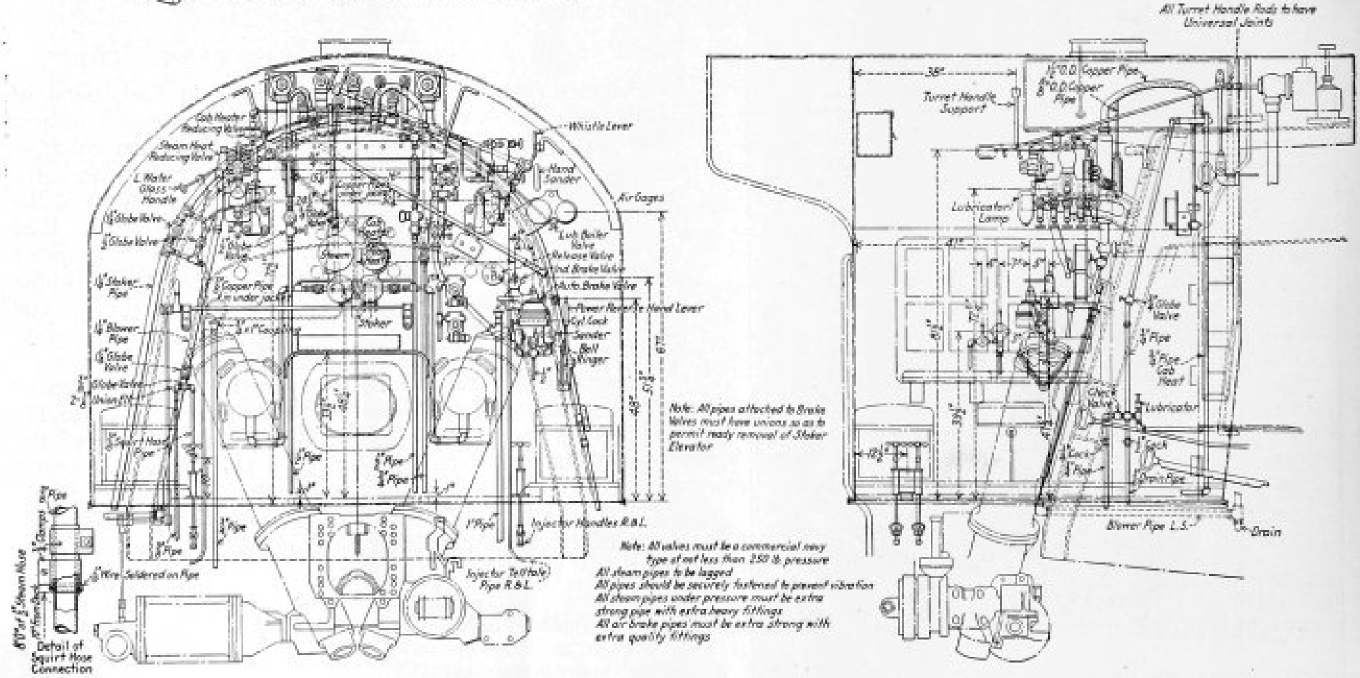
### Ashpan

The ashpan, which drops below the trailer frame, is composed entirely of straight sheets, which are flanged and bolted at the edges, thus obviating the usual angle iron.

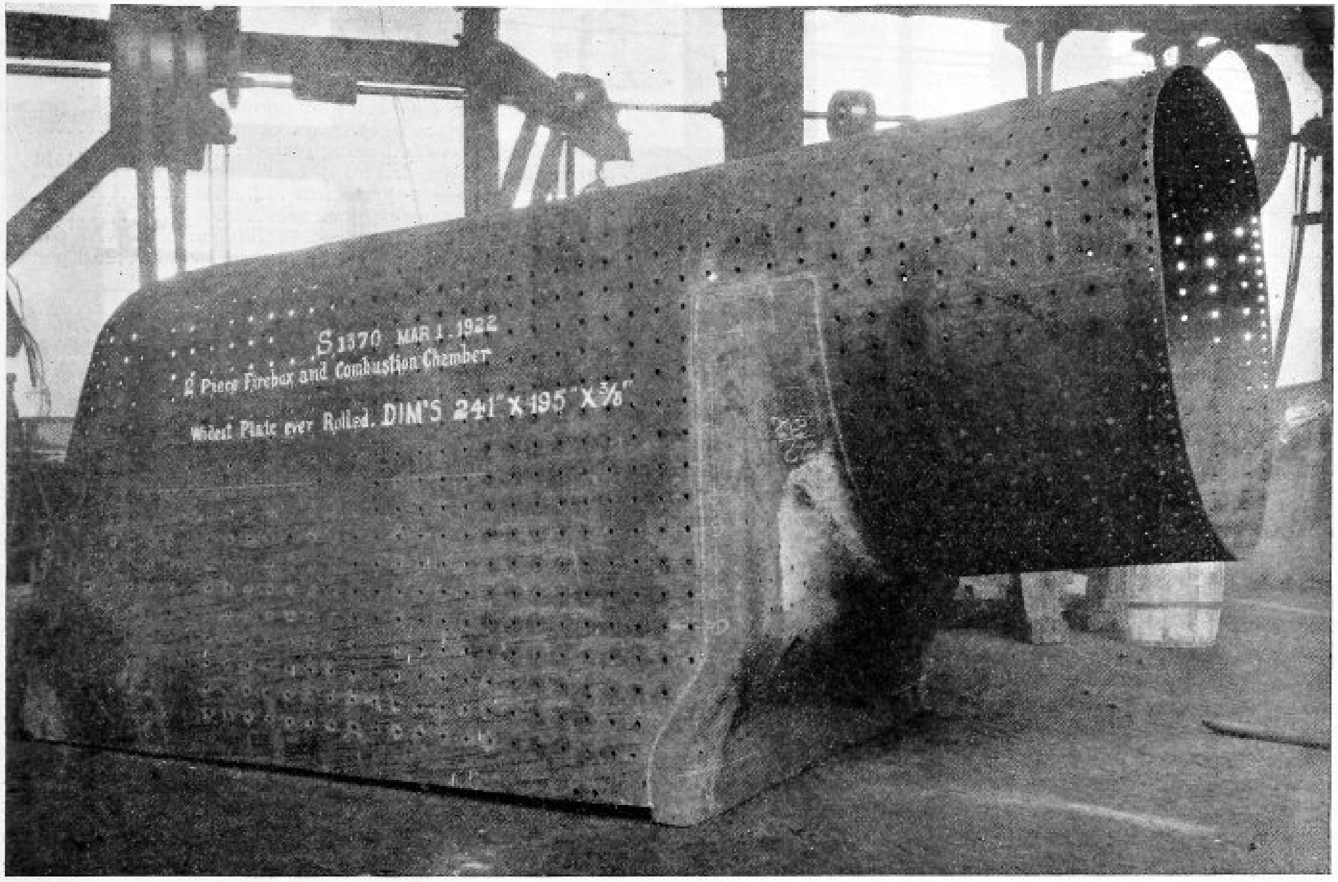
### Novel Arrangement of Fittings

One of the notable features in the design of the locomotive is the care which has been exercised in locating the cab fittings and the piping and in securing rigidity in the attachment of air drums, piping and other appurtenances commonly secured to the running board. All of the apparatus on the back boiler head and all piping on the locomotive was carefully located in the drawing room. One of the photographs

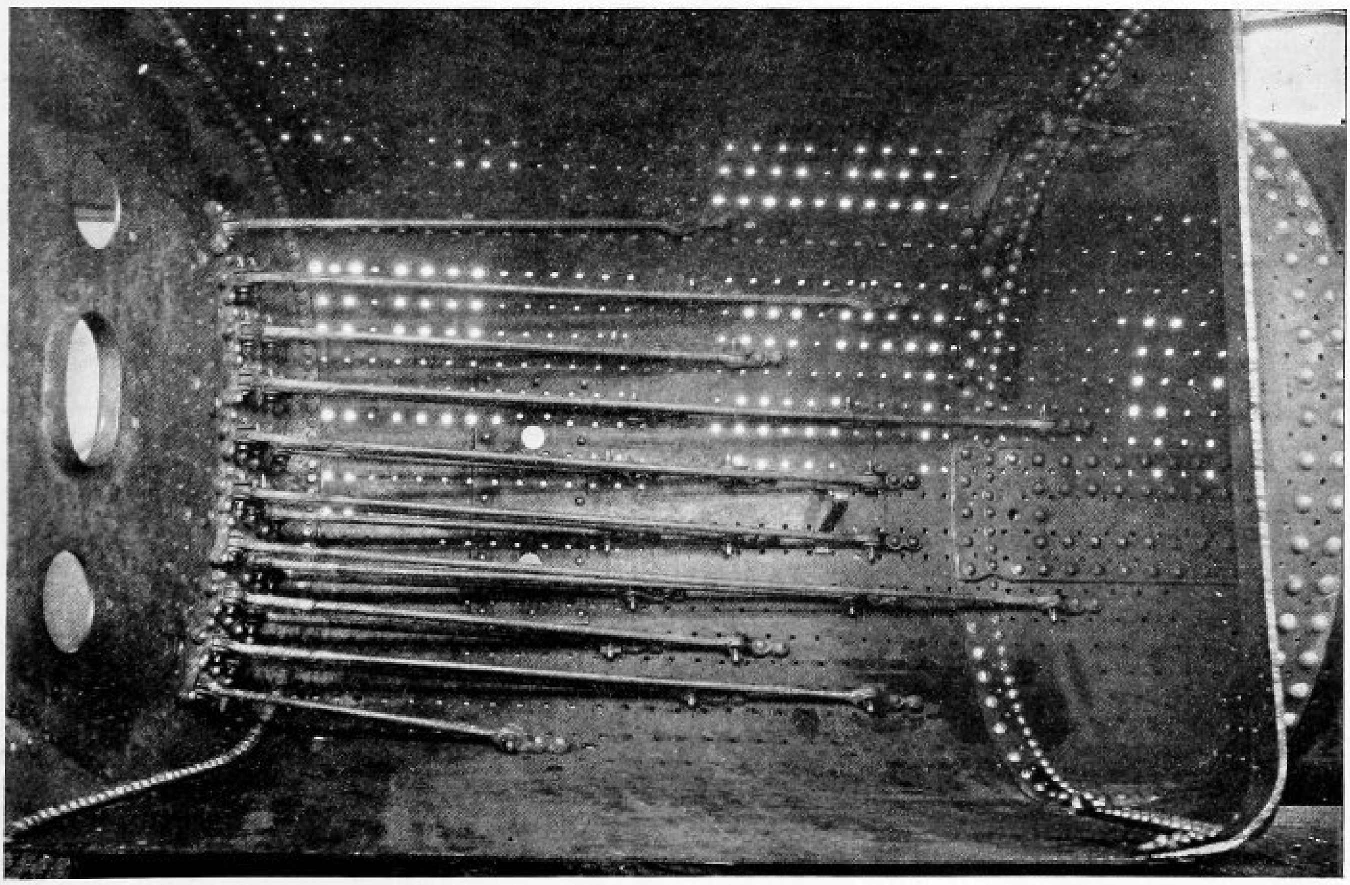



All Cab Fixtures Were Located and Piping Laid Out on the Board Before the Locomotive Was Built




The Firebox Side and Crown Sheets and Combustion Chamber Are All in One Piece, the Throat Sheet Being Welded in as Shown by the Light Line



Interior of Firebox Section of Boiler Shell, Showing Method of Staying Door Sheet with "Universal" Forged Crowfoot Braces shows the resulting neat and uncrowded appearance of the back head. All outside piping has been located under the running board, as little in evidence as possible, an arrangement which not only improves the appearance of the locomotive but offers an opportunity for the employment of effective clamps subjected to the minimum of vibration. The main reservoirs are located well down under the barrel of the boiler to which they are securely attached.

Each side of the cab in front of the window opening is hinged at the front and may be opened outward to facilitate staybolt work or other jobs requiring access to the narrow space at the sides of the boiler. When the locomotive is in service and the doors do not need to be opened, they are permanently closed with bolts.

CONSTRUCTION OF THE TENDER

The tender is of the Vanderbilt type with a water capacity of 12,000 gallons and a coal capacity of 20 tons. The tank is carried on a Commonwealth cast steel underframe. The transverse members of the underframe, which form the tank saddles, are bored out to receive thin filler blocks of wood which are accurately surfaced to conform to the contour of the tank. The tank is secured to the underframe by cast steel brackets of angle section, the vertical flanges of which are bolted to the cross members of the underframe.

One of the unusual devices which forms a part of the equipment of the locomotive is a low water alarm invented by Mr. C. E. Fuller, superintendent of motive power of the Union Pacific railroad. This device has already been successfully applied to a number of the Union Pacific locomotives.

The principal dimensions and data of the locomotive are as follows:

DIMENSIONS, WEIGHTS AND PROPORTIONS

| | |
|---|---|
| Service | Passenger |
| Cylinders, diameter and stroke | 29 inches by 28 inches |
| **Weights in working order:** | |
| On drivers | 230,000 pounds |
| Total engine | 345,000 pounds |
| Tender | 237,800 pounds |
| **Boiler:** | |
| Type | Conical |
| Steam pressure | 200 pounds |
| Fuel, kind | Semi-bituminous, 12,000 British thermal units |
| Diameter, first ring, outside | 84 inches |
| Firebox, length and width | 126 inches by 96 inches |
| Height, grate to crown sheet, back | 72 inches |
| Height, grate to crown sheet, front | 84 inches |
| Arch tubes, number and diameter | 4—3½ inches |
| Combustion chamber, length | 56¼ inches |
| Tubes, number and diameter | 239—2¼ inches |
| Flues, number and diameter | 48—5½ inches |
| Tubes and flues, length | 22 feet |
| Grate area | 84 square feet |
| **Heating surfaces:** | |
| Firebox, incl. comb. chamber and arch tubes | 382 square feet |
| Tubes | 3,084 square feet |
| Flues | 1,508 square feet |
| Total evaporative | 4,974 square feet |
| Superheating | 1,242 square feet |
| Comb. evaporative and superheating | 6,216 square feet |
| **Tender:** | |
| Style | Cylindrical tank |
| Water capacity | 12,000 gallons |
| Coal capacity | 20 tons |
| **General data, estimated:** | |
| Rated tractive force, 85 percent | 54,838 pounds |
| Cylinder horsepower | 3,030 horsepower |
| Boiler horsepower | 2,980 horsepower |
| Speed at 1,000 feet piston speed | 46.5 miles per hour |
| Steam required per hour | 6,300 pounds |
| Boiler, evaporative capacity per hour | 6,200 pounds |
| Coal required per hour, total | 9,843 pounds |
| Coal, rate per square foot grate per hour | 117 pounds |
| **Weight proportions:** | |
| Weight on drivers ÷ tractive force | 4.19 pounds |
| Weight on drivers ÷ total weight engine | 66.7 percent |
| Total weight engine ÷ cylinder horsepower | 113.9 pounds |
| Total weight engine ÷ boiler horsepower | 115.8 pounds |
| **Boiler proportions:** | |
| Boiler horsepower ÷ cylinder horsepower | 98.5 percent |
| Comb. heating surface ÷ cylinder horsepower | 2.05 |
| Tractive force ÷ comb. heating surface | 8.82 |
| Tractive force × dia. drivers ÷ comb. heating surface | 644 |
| Cylinder horsepower ÷ grate area | 36.1 |
| Firebox heating surface ÷ grate area | 4.55 |
| Firebox heating surface ÷ evap. heating surface | 7.7 percent |
| Superheating surface ÷ evap. heating surface | 25.0 percent |

# Why Lose Money on Field Erection?

**By D. M. McLean**

IN making estimates for a large job including field erection, the steel construction estimator often feels like taking his coat off when he comes to that part relating to the probable cost of the field work. So many possibilities are hidden away in small compass in almost any erection job that the experienced estimator is apt to be a bit wary and keep his guard up, and he finds that more than human powers are needed at times to provide for everything without "queering the quotation."

It is safe to say that fully 90 percent of the field erection contracts which have put red ink on the wrong side of the ledger started with estimates made without full knowledge of the field conditions. Successful estimating, which usually means successful business, depends on cutting down the unknown to the lowest possible degree. Study of the conditions at the site in person means expense which may lead to no results on the order book, and so most of us depend on the information we can extract from the customer (extract is usually right), or gather from Eddy Airgun who had charge of a job up there a year or two ago.

The following actual letter refers to a typical case:

"In connection with a recent erection job of two large steel tanks for a paper company, the contract for which we had taken complete and erected, we ran into certain local conditions where, as a result of the presence of noxious gases, our erecting gang were all carried off to the hospital, and the expense of erection trebled as a result of the unsatisfactory local conditions concerning which we had no information at the time of submitting our tender.

"This experience leads us to caution you that wherever we undertake erecting work in the field, a clause should be provided in your erection contract that will insist that local conditions will have to be such that men will not be subject to interruption of their duties or physical injury due to having to work in localities where they are exposed to gases, dusts, liquids, or anything that will delay or incapacitate them. Please bear this in mind wherever you have occasion to quote on work of this kind and insure that such a protection clause is included in your agreement.

"It is also advisable that a clause be inserted specifying that free and unobstructed access must be allowed to the site of the work, and ample clearance provided at all working points so that no delay shall result to our men in performing and completing any part of the work.

"The foregoing is often necessary on account of the unsuspected nearness of a wall, fence, a tank or a machine, etc., and if conditions cannot be altered, the clause gives scope for getting some allowance for the delay or expense resulting."

Now, why was no information available about these conditions at time of estimating? Well, the sales department was unwilling to take a chance and incur the expense of a trip to the site. An unsuspecting estimator made no provision for the existence of bad working conditions, and the customer took no steps to bring such conditions to the notice of the contractor. The mill people had overcome the trouble as far as their own operations were concerned, and the presence of the gases had become such a matter-of-course to them that the possibility of interference with the work of those coming in from outside was altogether lost sight of.

Plainly, a steel construction contractor is better off without such work unless he is prepared to spend some time and money in investigating all conditions in advance, or can induce his customer to enter into a contract containing such protective clauses as are set out in the above letter. Unless he can do either one or the other, he will be in somewhat the position of the baseball captain addressed by the captain of a powerful opposing nine,—"Which 'ud you rather do—die or lose this game?"

# Design and Maintenance of Locomotive Boilers*

*In the following comparison of the radial stay and Belpaire types of boiler construction the conclusion is drawn that for a given diameter of boiler shell the Belpaire type has the advantage of greater steam storage space; greater steam disengaging surface; greater firebox heating surface; greater number of tubes, and that all vertical stays are of uniform length. Recommendations are also given which deal with boiler shop practice and the suggestions should prove of value to all our readers.*

THERE are two general styles of locomotive boilers at present being applied to locomotives in this country, the Belpaire and the radial stay.

The radial stay type of boiler was preceded in use by the crown bar type. As the demand for larger boilers and higher pressure took place, the weight of bracing necessary to support the crown sheet became excessive, increasing the difficulty in washing out and keeping the crown clear of sediment, due to the obstruction of crown bars.

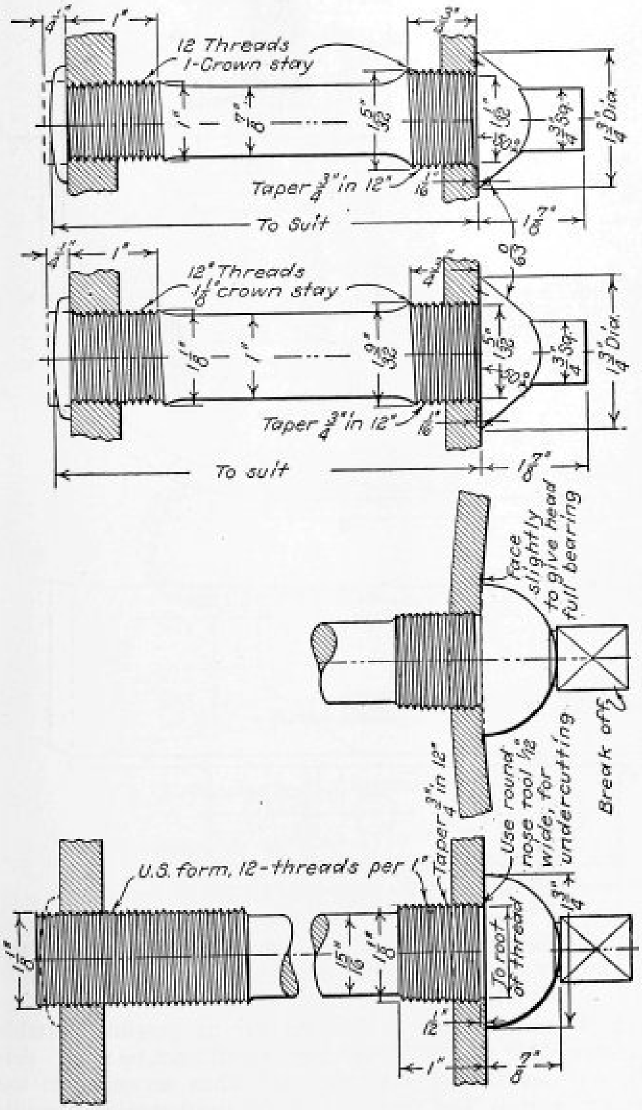


Fig. 1—Recommended Form of Buttonhead Crown Stays

In the earlier style of radial type the crown sheets were so much arched that it was possible to apply only two center rows of radial stays with buttonheads to bear squarely against the under side of the crown sheet, and the angle of the stays was such that the heads of the outer rows would not bear squarely against the under side of the crown; the end through the outer shell was at such an angle that it was impossible to get a continuous full thread fit within the thickness of the shell sheet, resulting in leaky staybolts.

In the later designs of radial stay fireboxes the crown sheet was very much flattened, permitting the application of buttonhead stays to approximately the full width of the crown. In the first design of radial stay fireboxes, in order to get the number of flues to correspond with those used in equal size crown bar boilers, the crown was carried higher than in the crown bar boiler, resulting in restricted steam space. In flattening the crown sheet, the steam storage space was increased, but the firebox heating surface reduced as compared with earlier designs.

In the Belpaire type, the outside and inside firebox sheets are arranged with the surfaces of sheets practically parallel, permitting the application of braces at right angles to the plate supported, thus giving maximum fit for the threads of the stays or sleeves in the sheets and enabling the use of buttonhead stays through the full width of the crown.

With the Belpaire type, a given diameter of the boiler shell gives: (1) greater steam storage space, (2) greater steam disengaging surface, (3) greater firebox heating surface, (4) greater number of tubes, (5) all vertical stays of same length which results in less variation in expansion and contraction, less distortion of shell sheets, less breakage of bolts, and less number of staybolts to be kept in stock for repairs.

Since the history of boiler design shows that the firebox crowns have been shaped to provide for the application of buttonhead crown stays for the support of the crown sheets, the committee feels that this type of stay as shown by Fig. 1 should be adopted as recommended practice for other than oil-fired boilers.

Mud rings with drop corners, Fig. 2, are worthy of consideration. They can be easily made since it is the almost universal practice to use cast steel mud rings. This strengthens the corner of the mud ring, and provides for three rows of rivets, one row fitting into the thin sections of the mud ring which will draw the sheet tighter to the mud ring and give better backing up when calking the edge of the sheet than is the case when patch bolts are used in the corner.

Consideration should be given to provide protection for return bends of superheater units. No design other than the ordinary damper appears to have been developed or at least is not within the knowledge of this committee. In this connection protection to the superheater units could be obtained by locating the throttle between the superheater and the engine, and developments along this line should be considered.

Improvement should be made in the usual form of tapered screw washout plugs threaded directly in the shell of the boiler. It would be desirable to design a screw plug wherein the plug proper was not screwed directly into the shell of the boiler and the cap or plug should be so designed as to eliminate the possibility of crossing threads in screwing to place.

### Dry Pipe Specifications

Some communications have been had with the National Tube Company with a view of determining on dry pipe

*Report read at Atlantic City convention of the American Railway Association, Division V, Mechanical, held June 14 to 22.

dimensions which would eliminate special sizes now required to be rolled for locomotives, thereby enabling the manufacturer to fill orders from pipe in stock, which would facilitate making prompt shipments for both new work and repairs.

The dimensions of dry pipe most commonly used are shown in Table 1. The information was supplied by the manufacturers from sales of pipe during 1919.

Table I—Dimensions of Dry Pipe Most Commonly Used

| Outside diameter in. | Thickness in. | Outside diameter in. | Thickness in. |
|---|---|---|---|
| 4½ | ¼ | 7 | .180 |
| 5 | ¼ | 7 | ⅜ |
| 5½ | ¼ | 7 | .300 |
| 6 | ¼ | 7⅝ | ⅜ |
| 6 | .180 | 7⅝ | .300 |
| 6 | .300 | 8 | ¼ |
| 6 | ⅜ | 8 | 5/16 |
| 6½ | ¼ | 8 | .165 |
| 7 | ¼ | 8 | .180 |
| 7 | 3/16 | 8 | .203 |
| 7 | 5/16 | 8 | .300 |
| 7 | .165 | 8 | .284 |
| | | 9 | ¼ |

The nearest to the outside diameters of pipe and casing which are customarily ordered are shown in Table II.

Table II—Pipe and Casing Sizes

| Pipe size in. | Pipe: Outside diameter in. | Pipe: Thickness in. | Casing: Casing size, outside diameter, in. | Casing: Thickness in. |
|---|---|---|---|---|
| 4½ | 5 | .247 | 5 | .152 |
| 5 | 5.563 | .258 | 5½ | .154 |
| 6 | 6.625 | .280 | 6 | .164 |
| 7 | 7.625 | .301 | 7 | .174 |
| 8 | 8.625 | .227 or .332 | 8 | .186 |
| 9 | 9.625 | .342 | 9 | .196 |

The casing diameters of standard weights approaching the heaviest demand for 5-in., 6-in., 8-in. and 9-in. outside diameter dry pipes are shown in Table III.

Table III—Casing Sizes Most Nearly Approaching Dry Pipe Sizes

| Outside diameter, in. | Thickness in. | Outside diameter, in. | Thickness in. |
|---|---|---|---|
| 5 | .241 or .301 | 7 | .231 or .275 |
| 6 | .224 or .275 | 8 | .236 |

In the 9-in. outside diameter the lightest standard casing is .196 in. thick, and, therefore, it would be better to have pipe size adopted in either 8⅝-in. or 9⅝-in. diameter. The 8⅝-in. would be either .277 in. or .322 in. and the 9⅝-in. outside diameter .342 in. thick.

We recommend that the sizes in Table IV be used for dry pipe and that they be adopted as recommended practice.

Table IV—Pipe Sizes Recommended for Dry Pipe

| Present pipe: Inside diameter, in. | Present pipe: Thickness, in. | Present pipe: Outside diameter, in. | Present pipe: Nominal inside diameter, in. | Proposed pipe: Actual inside diameter, in. | Proposed pipe: Thickness, in. | Proposed pipe: Outside diameter in. |
|---|---|---|---|---|---|---|
| 5 | ¼ | 5½ | .. | No corresponding size | ... | .... |
| 5½ | ¼ | 6 | 5 | 5.047 | .258 | 5.563 |
| 6 | ¼ | 6½ | 6 | 6.065 | .280 | 6.625 |
| 6½ | ¼ | 7 | 7 | 7.023 | .301 | 7.625 |
| 7½ | ¼ | 8 | 8 | 8.171 | .227 | 8.625 |
| 8 | 5/16 | 8⅝ | 9 | 8.941 | .342 | 9.625 |
| 9 | 5/16 | 9⅝ | .. | No corresponding size | ... | .... |

Consideration should be given to the design of cast iron dry pipes, in view of the present usual practice.

## Boiler Maintenance

The renewal of firebox sheets is the principal expense in boiler maintenance. There has come into use the last few years, the gas cutting torch for cutting out, for removing defective parts, and autogenous welding for uniting plates.

The autogenous welding process is used for the application of patches to firebox inside sheets, of half and full side sheets, of crown sheets, of whole and part back flue sheets, of whole and part door sheets, of door collars and door hole patches, of mud ring corner patches, and of welded fireboxes complete; for reinforcing mud ring corners and rivet seams, and for welding broken mud rings. For other than fireboxes is used for welding outside side sheets, electric welding flues, welding cracks and holes and fastening studs.

The use of the autogenous system of welding brings with it so many advantages from the standpoint of decreased thickness of material and decreased cost of maintenance that it should be developed to the fullest extent possible, but at the present time the state of the art is not sufficiently developed to warrant the committee making definite detailed recommendations. Attention is called to the practices of the Baltimore & Ohio, Chicago, Rock Island & Pacific, Atchison, Topeka & Santa Fe, Union Pacific System and other leading railroads in the country, all of which have established practices well worthy of consideration which doubtless will be further developed.

Tools and accessories required in electric welding work are as follows: Electrode holders for metallic arc welding,

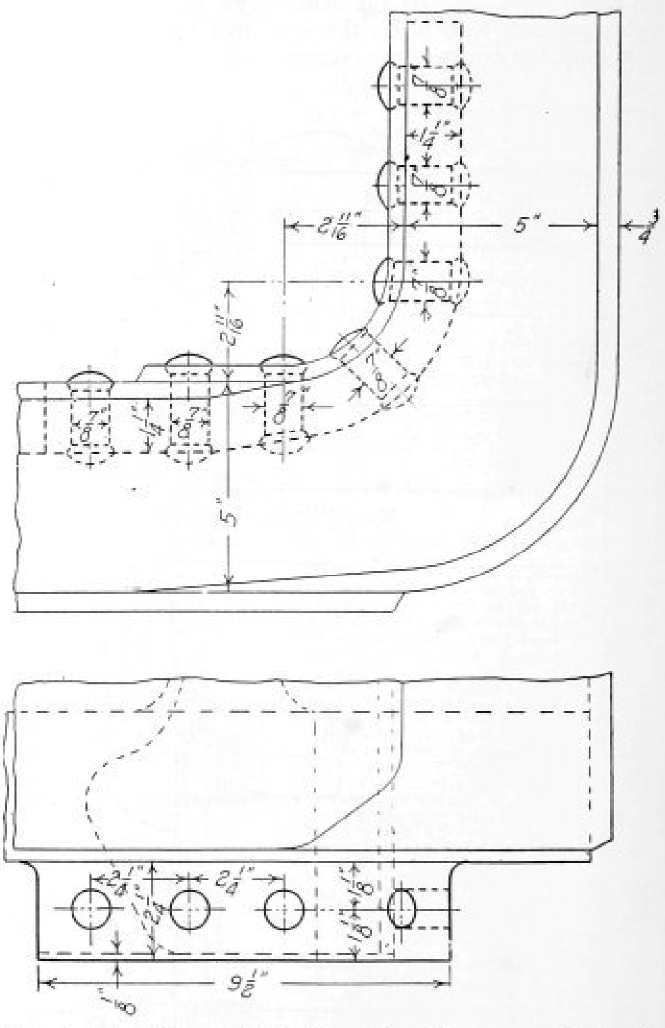



**Fig. 2—Drop Corner Mud Rings Are Recommended by the Committee**

Fig. 3, and welding cable. As far as possible portable welding cable over 50 ft. in length should not be used. Additional outlets should be provided when necessary to use longer cables. The condition of the insulation of portable cable should be watched and repairs made when insulation shows signs of breaking through. Bare spots in the cable may cause short circuits that will result in considerable damage. In welding, the surface should be kept clean, operators using brush for this purpose.

In the majority of shops and roundhouses the track rail is used as a part of the circuit for welding current. When welding work on unwheeled locomotives, tanks, boilers or other metal parts supported on wooden blocks, the electric circuit between the work and the rail is to be made by the use of "ground" cables, as shown on Fig. 4. In attaching these cables for work on which welding is to be done care must be taken to see that a good electrical contact is secured between the end of the cable and the work, the connection to be made as near as practicable to the point at which welding is to be done. Where carbon arc welding is to be done at least three No. 2 A. W. G. ground cables should be used. Poor electrical contact can be detected by excessive heating and should be corrected when found. For these ground cables welding cable on which the insulation has badly worn may be used.

Welding operators should be fully familiar with starting and stopping of welding motor generator sets, regulating voltage or adjusting current to give the desired amount of heat, etc. The welding electrode is to be connected to the negative side of the circuit which is taken care of in the permanent wiring where a ground rail return circuit is used. A short steady arc should be held, maintaining approximately ⅛ in. between end of electrode and the work and with sufficient current to insure a uniform flow of metal

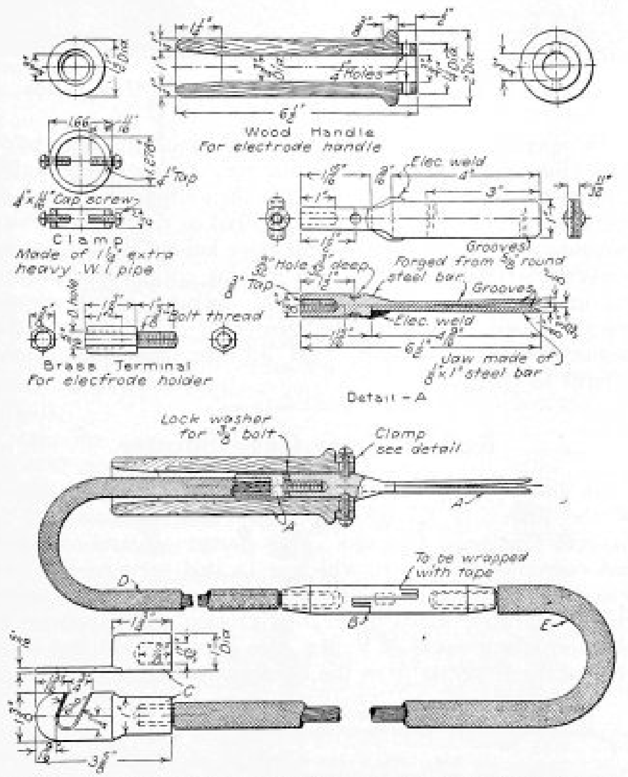



**Fig. 3—Electrode Holder and Cable for Use in Welding**

and producing at least 1/16 in. penetration. With clean surface and other conditions correct, if the current is too low the electrode will melt slowly and quietly and will not unite properly with the work, while if the current is too great the electrode will melt rapidly, the arc biting deep into the work, producing a hissing sound and the deposited metal tending to boil, giving a porous appearance.

When a welding operator is through working he should disconnect all cables, return them to their proper place and open those switches governing his work.

Carbon arc welding can be done only with welding generator sets of 600 ampere capacity or larger. Where 600 ampere capacity set is used for carbon work, only the operator doing this work can use the machine at one time. Welding circuits, panels, welding cables, electrode holders, etc., must also be of sufficient capacity and suitable for this character of work. In this connection sufficient capacity in the welding panels and permanent wiring can be secured by operating two panels and circuits in parallel. Portable welding cable of the size specified on Fig. 3, for carbon arc welding, should be used, but where this is not available, two cables connected in parallel of the size used for metallic arc welding can be used.

In electric welding there are certain general rules which should be observed. For welding, the pieces are to be kept thoroughly clean and free from grease, rust, scale and other foreign substances. Places that are not chipped clean in beveling should be cleaned at least one-half inch on each side of the bevel.

Never apply a weld to the barrel of the boiler. Never weld studs to the barrel of the boiler. Autogenous welding should not be permitted on any part of a locomotive boiler that is wholly in tension under working conditions; this includes arch and water bar tubes.

### Water Treatment

An important factor in the cost of boiler maintenance is the quality of water used, and we can not emphasize too strongly the desirability of furnishing the best possible, by which we mean water free from suspended matter, corrosive and scale-forming substances and as low as may be in alkaline salts.

Scale and corrosion greatly diminish the life of a boiler, which with the expense of repairs is largely dependent on the amount of impurities in the feed water. In districts where good water is available, flues and sheets readily last the legal limit, but when water high in scale-forming substances is used the life of the flues is reduced to less than one year. In this latter case frequent washing is necessary, sheets leak around flues and bolts and the repeated working and calking and the bombarding in the effort to remove scale keep the locomotives in shop a large part of the time and result in premature failure and relegation to the back shop for classified repairs.

When natural waters of good quality are not available, those of poorer quality should be given treatment to improve them and emphasis should be given to the conclusion that the effectual way to prevent the formation of scale is to remove the impurities in properly designed and operated plants, before the water is introduced into the boilers. The results of such pre-treatment are so well-known that it is not necessary to quote figures here, but it may be noted that the installation of treating plants in hard water districts offers an investment that will show a big return by reducing the cost, not only of boiler maintenance, but also of general operation.

The committee strongly urges the serious consideration by the railroad management, the installation of water treating plants.

### Circulation

The committee urges the careful consideration of the design of boilers to the end of perfecting circulation of water.

### Feed Water Heaters

The committee is of the opinion that attention should be given to the further development of feed water heaters in order to effect more economical operation of locomotives.

### Boiler Wash-Out and Fill Systems

The cost of boiler maintenance can be very materially kept down and the maximum efficiency of the boiler more nearly obtained by the consistent use of hot water washout and fill systems. In the use of hot water, in order to be effective for the loosening of scale and washing out mud from the interior of the boiler, it should be under a pressure of about 130 lb. per sq. in., and at a temperature of about 150 deg. F. This force and temperature will quite effectively remove scale and clean the boiler.

There are three general types of washout and fill systems in use.

1. The ejector type, in which washout water is slightly

heated and placed under pressure by injecting steam into it through a suitably designed nozzle. This is the simplest and least expensive type, but appears to be the least desirable.

2. The pump and heater system, where the water is heated in an open or closed heater, distributed through a pipe line in the engine house and forced under a pressure of about 130 lb. into the locomotive through a hose and nozzle. This type is fairly effective and can be installed without violating any patent rights. For a medium sized terminal, such a system with two water tanks, one washout and one filling pump and two pipe lines into the engine house, will afford washout water at 150 deg. and filling water at 200 deg. F. at a small operating expense. Where exhaust steam is available for heating water, this type is an excellent one for a medium sized terminal.

3. The blow-back type, where the steam blown off the locomotive is utilized to heat the wash and filling water. Such systems which also provide for the automatic tempering of the water used in washing out and the use of a circulating line to keep the water always hot in the engine house lines, are protected by patents. This system is the most effective one, and provides washout water at all times of the proper temperature, and reused water and steam blown off from the locomotive instead of washing it.

The committee earnestly urges upon the management of the railroads the importance of installing hot water washout and fill systems, thereby effecting economies and efficiency with little expenditure of capital.

### Recommendations

The committee makes the following definite recommendations: 1. Button-head staybolts be adopted as recommended practice for crown sheets in other than oil-fired boilers; 2. The proposed pipe sizes be adopted as recommended practice for dry pipes in designing new boilers; 3. The practice of autogenous cutting and welding be further developed; 4. Hot water washout systems be adopted as recommended practice in washing and testing of locomotive boilers; 5. The installation of water treating plants be generally adopted in the bad water districts; 6. Improvement be made in the usual form of tapered screw washout plugs.

The report is signed by: G. H. Emerson (Chairman), B. & O.; C. B. Young, C. B. & Q.; A. W. Gibbs, Penn. System; J. Chidley, N. Y. C.; R. W. Bell, Illinois Central; W. H. Wilson, Northern Pacific; W. W. Lemen, D. & R. G. W.; R. J. Williams, Pere Marquette; J. Snowden Bell, and Geo. L. Bourne, Superheater Company.

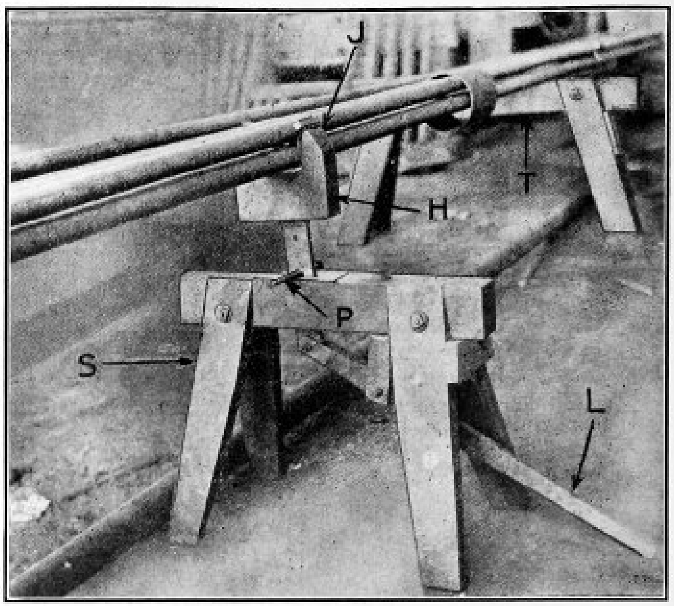
*(The discussion of this report will be published in a later issue of* THE BOILER MAKER.)

## Banding Superheater Units

**By E. A. Murray***

A SIMPLE device which has proved unusually effective at the Huntington shops of the Chesapeake & Ohio for banding superheater units is shown in the illustration. The units are supported on two carpenters' trestles, one of which is shown at *T* in the illustration. This trestle is 26 inches high and 65 inches long, having a sufficient capacity to hold nine superheater units while the joints are being ground and bands applied. The work of renewing bands and applying rivets is greatly facilitated by means of the trestle *S* shown in the foreground of the picture. This device is provided with a holder *H* of the correct dimensions to fit accurately around the superheater band and capable of vertical adjustment by means of foot lever *L*.

*Shop Superintendent, Chesapeake & Ohio, Huntington, W. Va.

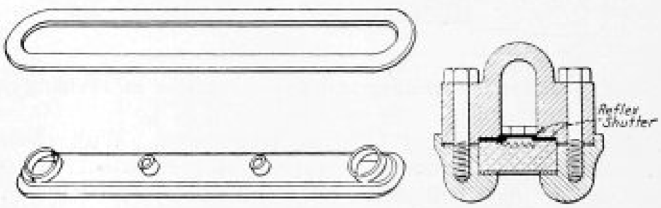



Device to Facilitate Applying Superheater Unit Bands

In operation all superheater units requiring new bands have the old ones removed and new ones placed lightly around the pipes. The trestle *S* is then slipped along under the units to the band which it is desired to rivet. Downward pressure on the foot lever *L* will raise holder *H* until it supports the weight of the unit, pin *P* being applied and holding the unit at this elevation until the operator can head over the rivets which are backed against jaw *J* of the holder. The device is light in weight, costs little to make and is successful in operation.

## Reflex Water Gage Shutter

An interesting protector or shutter for water gage glasses of the Reflex or Klinger types has been perfected by the Sargent Company, Chicago. This shutter consists of a thin, non-corrosive diaphragm which is located between the water space and the gage glass. Its use will prevent or very greatly reduce the three kinds of wear or erosion which reduces the life and effectiveness of Reflex gage glasses. Distilled water, constantly dropping from the condensation in the water gage top, has a strong affinity for glass. The shutter is, therefore, so shaped that such condensation is prevented from coming in contact with the exposed upper part of the glass.




Sargent Reflex Water Gage Shutter

Water gages must be frequently blown out and this rush of steam and water has an erosive effect on the inner Reflex glass face which the shutter also prevents. Moreover, the shutter is so fitted between the gasket and the glass as to give added tightness to that steam joint, consequently preventing leakage which quickly ruins the glass. It will also be noticed from the illustration that the shutter is provided with holes which allow a free circulation and the clearances are such that there is no difference in the appearance of water and steam spaces from that of the gages not equipped with a shutter.

# Advantages of Treating Locomotive Feed Water

## Abstract of Committee Report and Discussion Presented at Annual Convention of Master Boiler Makers' Association

APPROXIMATELY 60,000 locomotives in this country are forced to use hard water in the boilers which causes the formation of an amount of scale in each locomotive, conservatively estimated at 1,500 pounds per year. Assuming a 5 per cent fuel loss from this cause the annual coal wastage amounts to the staggering total of 15,-625,000 tons a year. Railway managements in general are vitally interested in this problem, but the real work of maintenance is the boiler maker's job.

Very few good boiler waters are found naturally and the railroad is indeed fortunate where these possibly can be secured. The proper development of such supply warrants considerable expense as it assures constant good performance in boilers with the elimination of the cost and uncertainty of any treatment.

The common constituents carried by water are generally known as "lime," "gyp" and "alkali." The "lime" refers to the carbonates or soft forming scale; "gyp" is applied to the sulphates or hard scale, and "alkali" to the miscellaneous dissolved salts, mainly sulphate and chloride of sodium which do not precipitate at ordinary boiler water concentration. A detailed description would involve a lengthy report in itself and is not within the province of this report.

A perfect boiler water is one which will allow the tubes to run the full government amount with but a white wash coating of scale, and will cause no delays to locomotives attributable to water conditions, with but minimum attention at terminals.

Soda ash, the commercial carbonate of sodium, is probably the most common chemical used as a scale preventative. Its action is on the "gyp" or hard scale and similar to the action of boiler compounds throws down the scale as sludge which can be blown out of the boiler.

Complete treating plants give the most efficient and satisfactory means of handling bad water propositions. In these the scale and injurious impurities are removed and settled or filtered out and a good clear, soft water given to the locomotives. The only disadvantage in this method of treatment is the high initial expenditure, but this is warranted in most cases by the large return on the investment in decreased fuel consumption, increased life of flues, staybolts and fireboxes, reduction in necessary repairs and increased availability of locomotives with the attendant improved performance.

Treatment of water for its foaming qualities is usually in the engine tank with an anti-foaming compound, which is essentially a weak acid emulsion of castor oil so prepared that it will mix uniformly with the cold water in the tank.

With the advent of the heavy type of power and the large investment involved, the importance of continuous availability of the locomotives has been accentuated. The brick arch, superheater units, and front end rigging have made work on flues more difficult and requiring longer time. The advisability of so treating the water as to eliminate leaky conditions and avoid tying up this machinery, is generally recognized. Even the best of boiler work cannot eliminate engine failure on the road due to leaks, whereas experience has shown that by water treatment this is but one of the numerous advantages.

A questionnaire was submitted by the committee to the general boiler inspectors of the leading railroads and 10 answers were received covering experience and results on most of the territory in this country with the exception of the southeastern section. It appears that the northeastern section is not greatly troubled with water quality, but in the central and western sections waters of extremely bad quality for boiler purposes are frequently encountered and treatment has been applied with good results.

The committee which prepared this report consisted of T. P. Madden, general boiler inspector, Missouri Pacific Railroad, St. Louis, Mo., chairman; George Austin and E. W. Young.

E. W. Young prepared an additional report on hard water and its treatment which was presented as an appendix to the above report.

### Discussion

Dr. C. H. Koyl, engineer of tests, C. M. & St. P. R.R.: You all know how many years the subject of pitting has been studied, and you know how little is actually known of the cause today. Twenty to twenty-five years ago we knew that pitting took place in boilers which ran through the coal districts where the water had sulphuric acid in it coming from the coal pits. At that time it was not believed that anything except acid could produce pits in flues or boiler sheets.

Then pretty soon, when we were using waters which had no sulphuric acid, we discovered pits and it was concluded, tentatively, that perhaps carbonic acid, which is found in all waters to a greater or less extent but which is a very weak acid, could produce pitting. Then about twelve or thirteen years ago, tests were made which showed that in the majority of cases pitting was the result of an electrolytic action in the boiler; that the iron was taken from the flues in selected spots and actually dissolved in the water.

Then when someone must explain where this electro motive force came from it was concluded by most observers that since there was a difference in the constitution of flues, there being hard spots and soft spots, spots which were pure iron and spots which were composed of impurities of one kind and another, there was enough electro motive current to carry the metal in the solution.

On investigating conditions in the alkali country another thing was discovered, that when you put one pole of an electrometer or a volt meter in the water of a boiler and attach the other pole to one of the flues, there is a slight difference of potential, the higher potential being on the flue and, therefore, the tendency being constantly for an electric current to pass from the flue into the water and take the iron with it.

This electro motive force, this difference of potential that exists between the steel and the water, is quite small. I do not know that it ever exceeds one one-hundredth of a volt. But the odd part, the striking feature is that when the injector stops, the difference of electric potential disappears. In a few seconds after the injector has quit working, the electric potential is the same on the flues and in the water.

There is but one conclusion to draw from this and that is that in some manner or other, coming through the injector, the water has a negative electric potential imposed on it. Either because of the heat of the injector or the friction in the branch pipe, the water, when it comes into the boiler, has a different potential from that of the boiler itself. The higher potential being on the flues, the iron dissolves in the water and you have pitting.

Up in the northwest the pitting is in the front half of the boiler and by the time the water has gone down one side of the boiler and down the other and down the front flue sheet and has gone back toward the firebox, the electric potential in the flue has become the same and there is no pitting back there.

Information on the subject of pitting is required by the American Railway Engineering Association in all kinds of water districts and the assistance of the boiler makers will aid considerably in clearing up many of the difficulties now facing the railroad chemists.

J. A. Anderson, Industrial Works, Bay City, Mich.: I am not in a position to give any information whatever as to the cause of pitting, but I have had a great deal of it come under my attention.

My first case was in a heating boiler which I was called upon to examine because of the pitting.

The water was drawn out of the boiler and by taking a knife and picking the spots off the pits on the top of the flue, we found there was a cavity under each spot. In some cases you could take an ordinary pin and push it through the tube. That was my first case of pitting.

George Austin, Santa Fe: You are all familiar with the fact that the Santa Fe Railroad has eleven or twelve thousand miles of road and it runs through nine or ten states. In that stretch of railroad the Santa Fe has almost every kind of water except what might be considered good boiler water. That is, they did have every kind of water except what might be considered good boiler water, until they established treating plants for the purpose of improving the condition of the water.

I started looking after the boilers on the Santa Fe Railroad in May, 1903. In the last eight months of 1903 the Santa Fe made only 17,500 miles to a locomotive failure, on account of flues leaking. We did not count the flues pitting or bursted flues that made failures.

They then started the water treatment by taking care of the worst water first. The mileage between flue failures began to rapidly increase, until at the present time I should say in the last year, that so far as the engine miles in reference to failures on account of flue leakage, will run pretty well on to four or five hundred thousand miles.

Understand that the water treatment does not get the credit for all of that. A good many other improvements have been made on our road.

On our service charts the line of mileage between failures on account of flues leaking has been crossed by the line of failures on account of flues pitted or flues burst. All the failures we have that we call flues burst are not pitted flues; some of them are poor welds; occasionally we get a thin flue but the majority I should say are flues pitted. It would seem that the flues pitting is increasing. While that is apparent, it does not indicate to my mind that flue pitting is any worse than it was before.

Now our flues are staying in the boiler between settings so much longer than they did before that we get more failures on account of pitted flues.

The Santa Fe Railroad today has about 135 water treating plants in operation. The cost of water treatment ranges from one and a half cents per thousand gallons to nine and a half cents a thousand gallons. That is to say, in addition to the cost of producing the water, you have to add the nine and a half cents to the thousand gallons, and then you have to buy compound to keep it in the boiler. That includes the labor and the upkeep and the cost of water treating. They are not all that heavy. I suppose the average cost of water treating on the Santa Fe will run pretty close to six cents.

E. W. Young: We have some sections where we have pitting on the crown sheet. We have it in the bottom of the boiler, particularly in the first and second course and probably for about two feet on the third course. We want now to get information regarding this from different parts of the country.

John Holt, Chicago & Northwestern: I had trouble with flues bursting in the front end on a certain type of locomotives known as the "Class Q." This particular locomotive I speak of is in suburban service; it runs out 30 miles to a place known as West Chicago. The flues burst in that boiler in the front and they are located about 14 inches from the barrel of the boiler right close up to the sheet, and they are corroded or eaten through and pitted half way around right close to the sheet.

D. A. Lucas, Milwaukee, Wis.: We had conditions on one road I was connected with where a brand new flue would pit through in one shopping, after the engine was in service 18 to 20 months. We had the condition as mentioned here by the other men, of pitted crown sheets and pitted side sheets. We also had these pits around the staybolts, and I always claim that it was due to the expansion and working of the sheet where the staybolt worked the sheet.

W. J. Murphy: I might say that on the Pennsylvania Railroad we have trouble with pitting at the bottom of the front flue sheet, about two-thirds the way up along the running seams of the crown sheet across the top of the back flue sheet and in around a lot of the staybolts. We figured it out that this happens where the enamel is broken off the sheet; the acids do not seem to affect the sheet any other place than where the enamel is cracking.

Mr. Callahan, Bird-Archer Co.: My experience of the past several years—in the practical direction of the use of various boiler chemical compounds on the railroads of the west—has convinced me that there are very few, if any, trunk lines operating between the Alleghenies on the east and the Coast Range mountains on the west, which do not need the assistance of chemical compounds in the economical operation of their boilers.

This applies not only to the railroads which have no wayside treating facilities, but it applies to such lines as well. I mean by that remark that, where treating plants are in use, locomotives cannot be customarily operated for reasonably long mileage between boiler washouts, without the aid of anti-foaming compound. So that when we speak of the use of compounds, or the use of treating plants, we cannot completely separate the two methods. They are used together.

On the other hand, the use of anti-scaling compounds does not ordinarily result in sufficient foaming tendency to require the use of an anti-foaming compound. There are at least several members present who can bear me out in this statement.

Some of them have been puzzled as to why, when the treating plant is admittedly the best system in theory, the interior treatment by compounds shows up better in many cases in practice. The reason is that major reliance in treating water in wayside plants must be placed upon soda ash and lime. So far as the soda ash is concerned, it merely acts to change the scale forming sulphates into mud forming carbonates. This is the result whether the soda ash is put into the water in a treating plant, or in the boiler, as one of the ingredients of a compound.

Of course, it sounds better to any boiler maker to be told that his water is going to come to the boiler already treated, than to be told that the treatment is going to be made in the boiler. In practice, part of the treatment takes place in the boiler, in any case, because the reaction takes place in hot water much more readily than in cold. The added advantage of treating with compounds in the boiler is the smaller requirement of chemicals, due to direct action in hot water.

In my opinion, the use of compounds has fallen into ill repute in many cases when balanced against treating plants, for the reason that behind the treating plants we have the best technical talent on the railroad, while the compound is frequently looked upon as a mere make-shift and handled accordingly. Let the boiler foreman get behind any properly developed compound, use it judiciously and consistently; and he will have no occasion to be ashamed of the result from any standpoint, financial or otherwise.

W. H. Laughridge, Hocking Valley R.R., Columbus, O.: We have been using treated water for twelve years, we never knew what pitting was. Before I tell anything about the pitting, I would say that we get three hundred percent improvement on flues, three hundred percent more mileage on flues with treated water than we did without treated water and we get better than that for fireboxes.

So far as the pitting is concerned, we never knew what pitting was until the last three years. We are satisfied after using treated water twelve years that it is not the treated water. We never had to use an anti-foam compound since using treated water, but in this last three years our flues began to pit at the bottom in the front half of the flue. In this last year, we find it is becoming general all over the flues, we now lose from twenty to thirty percent of flues that have been in service fifteen months. Just a few days ago, we had a set that ran in a territory of untreated water that has only been in twenty-seven months. Heretofore our average for a body flue was twelve years.

P. J. Conrath: This is an endless subject and a problem that is unsolved. We have been after it and studying it for years. Sulphuric acid in the water will mingle with the scale forming matters wherever it is deposited it will pit. Carbonic acid causes gases in solution, these gases mostly deposit on the bottom of the tube. Again, where you have poor circulation, they deposit greater at the front end than at the back.

C. L. Hempel, U. P. R.R., Omaha, Neb.: We have been treating water for twenty years and we have found that we went too far, in some cases in treating water.

Now, how do you know where to treat this water? That is what your chemist is for, and that is what we are for, to work with them and show them what is taking place. If you have a deep well water and by treating it, it is pitting your boiler, you don't want to treat that water, or you want to reduce it.

Let me say, in treating the water we remove the solids and it gets back to a thin transparent scale. That is more injurious than a scale an inch thick. Put a drop of water on a thick piece of scale, and it will absorb the water, but a thin transparent scale, which forms after too heavy a treatment, is a non-conductor and it pits your metal.

In closing, I wish to say there is no question in my mind but what the treated water is beneficial on any railroad that has trouble from the encrusting solids being too great. Remove the solids as best you can.

T. F. Powers: We have on the Northwestern some of the worst pitting conditions in the country. We have territories between Boone and Council Bluff where brand new flues only last between twelve and eighteen months. We have the shells of our modern power, the first two courses on the passenger engines, eaten up so badly we have to take them out and renew them. We have other territories where the staybolt is eaten in the center; we have other territories where the crown sheet pit, and so far we have not found any solution of the difficulty.

We have been treating water for twenty years. Personally, I would be glad to have our railroad treat all the water that is bad, because I know we could extend the life of our boilers. We use anti-foam compound on three divisions, on one of which we treat the water, two where we do not treat the water. We find that the pitting on flues generally takes place at the bottom of the flue and mostly at the front end of the boiler. We find that the pitting of the shells takes place on the first two courses on the bottom.

E. W. Young: We have with us now Mr. Bardwell, Engineer of Water Service, of the Missouri Pacific, and I believe it would be well to grant him a few minutes time to give us a talk on that.

Mr. Bardwell: Mr. President and gentlemen: It is indeed a great honor to be invited to address this Association, and I assure you it was not my idea at all, but seeing that Mr. Madden was not able to be here from the Missouri Pacific, I am glad to have this opportunity of giving you an idea of the results we are getting from treating water on the Missouri Pacific.

I will try to keep as near the subject as I can, only I want to say this, that it was brought out in this very excellent report of the Committee that there really is no disadvantage of treating water, from the boiler makers' standpoint. As a matter of fact, it does increase foaming to a slight degree when the plants are started in operation, but if operated properly there will be no increase of foaming. That has been our experience on the Missouri Pacific, and on some of our districts we have more than doubled the time between washouts. We did have foaming when the plants were first started, when the old scale was loosened.

On the Missouri Pacific, we have in service now seventy-nine water treating plants. Altogether we have about three hundred and eighty-seven water stations, but we have water treating plants where most of the water is used. During 1921, we used approximately six billion gallons of water on the Missouri Pacific; about two billion gallons of that water was treated, or over thirty percent.

Before we started treating water on our Colorado Division, the flues had to be renewed frequently. Every four months, they would take them in and clean out the scale; at the end of eight months, they would renew the set of flues. With treated water those engines make their mileage in twenty or twenty-one months, but the flues are running through two mileage periods, forty to forty-two months; whereas, before water treatment, they only ran seven and eight months. There used to be a quarter to half an inch of scale. Now, at the end of forty-two months, the scale is not thicker than that piece of paper.

Two years ago, we installed water treating plants on all our Omaha divisions except one. The results have been marked. When we first put them in, we did have considerable trouble and complaints from foaming, but that is all over now. Where an engine used to have to be held in the shop three days every month, it is out now in a half day.

I could give any number of examples like that of results from treating the water on our railroad, and I am sure that any of the other gentlemen here, who have treating plants, could do the same thing.

Now in regard to pitting, a point on which a good deal of information was brought out this morning: On our Colorado division, in 1910, the railroad bought a number of Mikado type engines and in four years the fireboxes had to be renewed.

With treated water, fireboxes put in in 1914 are still in good shape and should run as long as the average fireboxes on other roads.

I am sure if the water department and the boiler makers' department cooperate on the subject of quality of water that any railroad can show a very marked improvement in the maintenance of their power and the maintenance of their boilers.

J. F. Raps: On the Illinois Central, we have gone into the matter of treating water very extensively. Some years ago, they appointed a water committee on the railroad, consisting of our engineer of tests—who handled the chemical end of it—our superintendent of water service, and myself. It is our duty to investigate conditions; and upon investigating water, we determine whether it will be more economical to install a treating plant and treat the water before going into the boiler, or use a local treatment in the tender. We are keeping our cost down and treating the water very carefully on most divisions.

We have three members of the A. R. E. A. today, and the three members who are with us are connected with the committee on pitting. I believe this organization could work very closely with this committee of the A. R. E. A. giving them information which they are seeking, in regard to the location of pitting.

I might say in conclusion that in very bad water districts out through Iowa, where we have installed treating plants over certain divisions, where it was necessary before the treating plants were installed to remove flues after twenty to thirty thousand miles and renew side sheets after about twelve to eighteen months' service, we are putting those same engines through the shop now for general repairs in some cases without even removing the flues, and our repairs to firebox sheets are going to be reduced, I would say offhand, about three or four hundred percent.

H. V. Stevens, A. T. & S. Fe R.R., Topeka, Kans.: We have in the last couple of years installed a treating plant one place where we operate about eighty switch engines and in that particular place they receive water from two different places. In one of the places the engines would run—prior to the installation of the treating plant—thirty days between washouts, if you would permit the engines to stay out that long.

Since the installation of these treating plants, the flues applied at that time, after the plant got in operation, are still in service, and they have about seventy-five percent more mileage out of the flues than they had prior to the installation of the plant.

George Austin: We have here with us today, at my invitation, a gentleman who has studied the action of water in locomotive boilers, in relation to pitting and corrosion, and scale formation, for many years. I think the convention would like to hear from the gentleman, and he would make clear just how this pitting occurs.

Mr. Convoyce: This question of corrosion naturally is a very serious one as it involves the absolute disintegration of metallic parts of your boiler. During the past fifty or more years, there has been more or less research work done by various scientists as to the whys and wherefores of corrosion, without endeavoring to even touch on researches in detail, I simply want to state that the final conclusions to date, in my judgment, and the theory that is the most applicable and proper, is that known as the electrolytic theory.

We all know, that is chemists know that each and every substance is electro negative or electro positive to other substances. We further know that it is only necessary to have three essentials to produce a galvanic unit, which will result in a current. This current may be extremely minute, however, it is measured by the use of scientific and delicate instruments.

It is a well known fact that the composition of boiler sheets and boiler tubes and flues is not continuous, it is made up of minute areas of iron in different chemical combinations, for instance, carbon, silicate, manganese, etc. That being the case, it is possible for one of these areas to be electro negative or electro positive to each other. It only requires a very weak solution of common salt for a conductor; in fact, the weaker solutions are better carriers of currents than are the stronger solutions of salt.

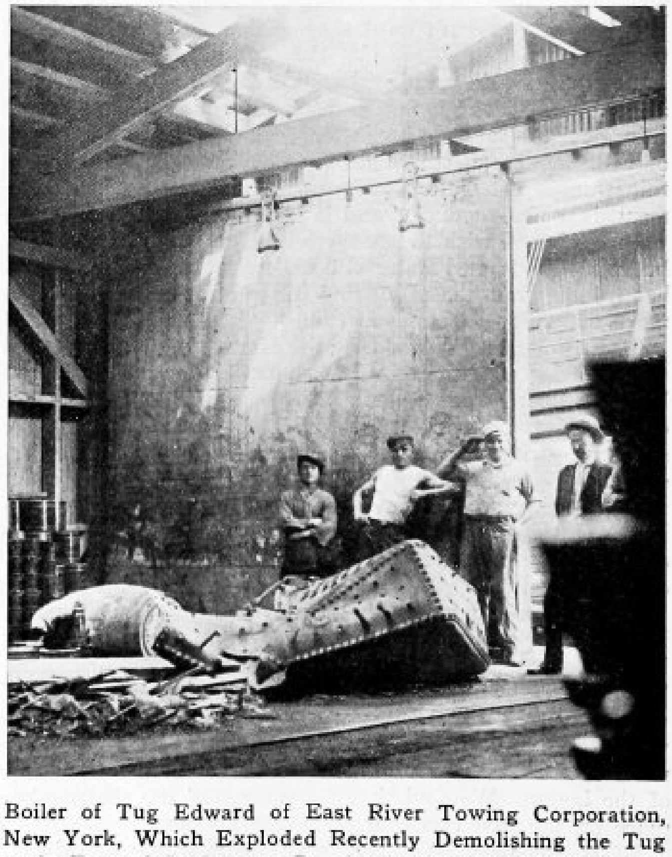
Now, under these conditions, and knowing further that in the case of all electrolytic action the positive pole is the pole or substance that is destroyed, consequently, that is the part where your pit first starts, and naturally proceeds for a while, evidenced by the destruction of that particular small area.

The first effect of corrosion is an action going on in solution in the water in the boiler of minute traces of the iron from that point or that particular compound. The iron then becomes converted into an insoluble form and is thrown out of solution, consequently, the water is taking up small portions of this metal in solution. The formation of this pit is shown by the iron being thrown out of solution in one form. As it progresses away from the actual surface of the bright metal, it becomes converted into iron rust. Assuming that pit is allowed to develop completely, it will have a scab over the top; that scab is composed generally, or principally, of the magnetic oxide of iron.

Now, it has been fairly well substantiated that, even in a pit well developed in that manner, we have a small galvanic cell which is sufficient of itself to stimulate continued action in the form of corrosion at that particular point.

We have corrosion that is attributable to other things, most of them we will not mention. We know that free mineral acids will cause corrosion, but it is not an uncommon thing to find quite serious corrosion taking place underneath the scale formation. You will find little elevations of the scale over the surface of the boiler, which apparently indicate nothing but that they are elevated, a little tap of the scraper removes it and you will find underneath a pit.

In many investigations that I have been conversant with, in practically all cases it is shown that the larger percentage of that scale was sulphate of lime. Now, sulphate of lime is a substance made up of common lime and sulphuric acid, or oil of vitriol. It is a well known fact that when this particular salt is submitted to a certain temperature, there is a decomposition of the sulphate of lime liberating sulphuric acid, especially where it is in contact with a metal which has a greater affinity for the acid than has the lime itself. Therefore, when the scale reaches a sufficient thickness to permit or cause a temperature at the point of contact with the shell, decomposition sets in immediately. The sulphuric acid attacks the metal, starts your corrosion and leaves the lime, because of the greater attraction that the metal has for the acid.



**Boiler of Tug Edward of East River Towing Corporation, New York, Which Exploded Recently Demolishing the Tug at the Foot of Gold Street, Brooklyn. The Boiler Was Hurled Over 100 Feet, Crashing Through the Roof of a Pier Shed.**

# Why Do Boilers Crack on Circumferential Seams?

## Extract from Discussion of Paper on "Boiler Shell Cracks" Read at Master Boiler Makers' Convention in Chicago

By E. W. Rogers*

THE fact that boilers crack in the circumferential seams after a few years of service brings forward a very serious question to those concerned with the design, construction and maintenance of locomotive boilers. This is especially so when we consider the extent to which the art of boiler making has advanced. For instance, the care, thought and expense incurred in producing the modern boiler of today. This, coupled with the scientific methods employed in developing plates—the problem is indeed unique and baffling.

The idea has been advanced that this trouble may be caused by improper fitting but an analysis would indicate that this is not possible, as shown by the following: The inner and outer courses on the ordinary boiler are developed from the neutral axis of each plate and, as there is no allowance made for "take up in rolls" it is fair to assume that the excess metal, if any, is negligible. We believe, therefore, that the only reason these two courses could be other than correct would be due to one or both plates being slightly over or under thickness due to rolling at the plate mill.

The American Locomotive Company's practice is to drill the rivet holes in the shell seam smaller than the diameter of the rivet before driving and to ream out the hole to a diameter of 1/16 inch larger than that of the rivet.

Previous to 1915 one of the sheets was punched and used as a template for drilling the remainder. Experience has shown, however, that punching a hole has a tendency to start a crack. We have, therefore, discontinued the practice of punching the plates used as templates. This template is now used for drilling two loads of 5 plates each.

Our practice at present is to fit the courses together after which we rivet up the longitudinal seams on the outer courses. However, it may be preferable to rivet up the longitudinal seams in both courses and, before connecting to heat up the end of the other courses by some method which will insure uniform heating and permit shrinking this course on the inner course.

Our practice, as outlined above, applies to work other than welded or partially welded courses on which horizontal seams are driven before connecting, after which they are heated and entered, as outlined hereafter.

Our method of alining these courses is as follows: Tram marks are located on each of the four quarters of the circumference at both courses permitting the use of a tram for taking a lap. The courses are then assembled and tacked by means of fitting up bolts, after which they are adjusted so as to tram at each of the four quarters. They are then secured in this position, rivet holes reamed through both plates and then riveted.

The table attached would indicate that 100 tons pressure per square inch of rivet area was considered good practice. However, in view of the fact that the pressure applied varies with the size of the rivet and the thickness of the plate, it might be advisable to conduct tests to determine the proper pressure for a given size of rivet and plate thickness. This would seem proper when we consider the possible effect of excess pressure caused by pressing a hot plastic rivet into a hole which approaches to some extent the action of a hydraulic press. This effect is sometimes apparent by the wavy appearance of the edge of the plate. The remaining effect is the squeezing action on the plates by the riveting dies tending to raise the edge of plates from contact with the adjacent one. It is evident, therefore, that excess riveting pressure if used to insure tightness would have the opposite effect, causing excess calkage.

A locomotive operating on a curve may under certain conditions have undue strains transmitted through wheels, frame, and finally to the boiler stressing it to the point where it is shown by cracks in the seams. This is not improbable when we consider the boiler barrel as a large flue, bending and twisting on which would be analogous to that on a staybolt. The above is particularly true in the case of Mallet articulated locomotives where the front end of the boiler overhangs for a considerable distance and is supported by sliding bearings and, for this reason, it is American Locomotive Company standard practice to triple rivet the circumferential seams at the ends of the shell course in which the high pressure cylinder saddle is attached when the boiler is more than 22 feet long over the tube sheets.

Ordinarily this effect would not be considered as liable to occur on locomotives other than articulated, but some special conditions may exist in connection with the locomotives on which the cracks had occurred which might make it desirable to consider triple riveting the circumferential seams. However, as a general practice for locomotives other than Mallet this is not recommended.

Many of you recall the time when iron boiler plates were used almost exclusively, using wrought iron rivets in all seams, thus having the plates and the rivets of the same material. These plates were very ductile and, as you know, withstood much rough handling with sledge and drift pin without apparent injury to the plate. These plates could not have had over 48,000 pounds tensile strength.

At the present time our requirements for boiler plates specify a very high tensile strength, 55,000 to 65,000 pounds per square inch for boiler steel and 52,000 to 62,000 pounds for firebox steel.

There may be a tendency on the part of engineers in the preparation of specifications for this material to place requirements on the plate manufacturer making it practically impossible to produce as homogeneous and pliable material as required to withstand the rolling, fitting, riveting and calking stresses which must of necessity enter into these plates when used in the construction of large modern locomotive boilers.

These high tensile requirements may lead a steel manufacturer to adopt methods in the manufacture of these plates that reduce their factor of safety in the fabricated boiler rather than obtaining the higher factor which the higher tensile requirements are supposed to give. I can conceive of plates during manufacture subjected to treatment which might harden their surface and show up splendidly under tensile test but, at the same time, render the plates too hard to stand the severe working necessary in the fabrication of the boiler and possibly leave minute fractures in the plates from this severe working.

Possibly the engineer in comparing his material specifications would work more closely in touch with the plate manufacturer and obtain the highest tensile strength consistent with ductility, bearing constantly in mind the severe stresses and rough usage to which the plates will be subjected in

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boiler construction, some practical advantage may be obtained that would overcome existing difficulties.

My conclusion as to the causes of such cracks and suggestions for improvements and based on the preceding are as follows:

The tensile strength of the boiler plate is too high and believe it should be lowered to firebox quality. The pressure applied on our riveters is high but, inasmuch as we have been unable to find any evidence of distorting holes or wavy edges, we do not believe the pressure to be excessive to an injurious extent. I believe the rivet seams should be of steel construction, as I do not favor iron rivets with steel plates.

Pressure required to drive hot rivets (from Kent's Mechanical Engineer's Pocket-Book, ninth edition, page 435): R. D. Wood and Company, Philadelphia, Pa., give the following table (1897):

POWER TO DRIVE RIVETS

| Size Inches | Tank Work Tons | Boiler Work Tons |
|---|---|---|
| ½ | 15 | 20 |
| ⅝ | 18 | 25 |
| ¾ | 22 | 33 |
| ⅞ | 30 | 45 |
| 1 | 45 | 60 |
| 1⅛ | 60 | 75 |
| 1¼ | 70 | 100 |
| 1½ | 85 | 125 |
| 1¾ | 100 | 150 |

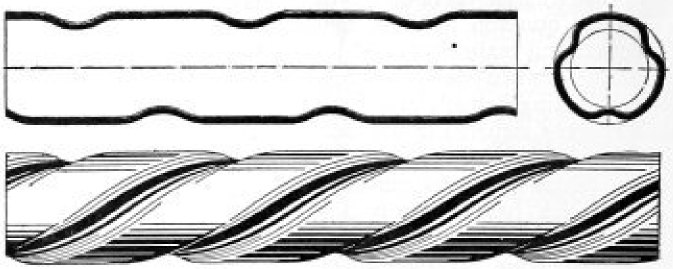
The above is based on the rivet passing through only two thicknesses of plate which together exceeds the diameter of the rivet but little if any.

As the plate thickness increases the power required increases approximately in proportion to the square root of the increase of thickness. Thus if the double thickness of plate is four times the diameter of the rivet, we should require twice the power given above in order to thoroughly fill the rivet holes and do good work. Double the thickness of plate would increase the necessary power about 20 percent.

# Spiral Boiler Tubes Developed in Sweden

SPIRAL boiler tubes of round section and of a form which might be called a single thread of small pitch have been used to a limited extent in European locomotives for many years. While they have often shown economies during tests, they have frequently failed to maintain such economies after continued service and their use has been discontinued in most places. The reason for their failure to meet expectations is apparently due to a large extent to their form and the small pitch which considerably increase the resistance to the passage of the smoke gases and in addition form pockets in which the soot lodges, thus reducing the heating efficiency of the tubes.

In an endeavor to overcome these faults, Nordling and Bengtzon of Amal, Sweden, brought out a few years ago a new form of spiral tube known as the "Ess" tube which is manufactured by the Uddeholms Aktiebolag, Uddeholm, Sweden. As will be noted from the illustration, the cross-section is of a circular form broken by three wave-like recesses while the pitch is about eight inches. This form offers less frictional resistance to the gases than the older



"Ess" Spiral Boiler Tube

form of spiral, has 90 percent of the cross-sectional area of the round tube and a slightly greater heating surface. It imparts to the gases a rapidly whirling motion and experience has shown that it is practically self-cleaning.

It is also claimed that this form of tube is a reliable spark extinguisher, the larger particles being broken up during their passage through the tubes. Several hundred coal-burning locomotives equipped with these tubes are operated in Sweden without other spark arresters, although with low exhaust nozzles a small deflector is attached to the front tube sheet. This practice is possible with the rates of combustion and amount of draft there used even though the same practice could not be followed under the conditions prevailing in American locomotive operation.

In superheated steam locomotives, the flow of gases must be properly divided between the small heating tubes and the large flues containing the superheater elements in order that the desired degree of superheat may be obtained. In locomotives equipped with spiral heating tubes, it has been found advisable to twist the superheater elements into a screw shape, two or three turns ordinarily being sufficient for European conditions. By so doing, the flow of gases through the tubes and flues is equalized and a rotating action is also imparted to the gases passing through the superheater flues, thus adding still further to the efficiency of the boiler.

Results of tests made with both saturated and superheated steam locomotives are tabulated below:

COMPARATIVE RESULTS OF BOILER TUBE TESTS

| | | | |
|---|---|---|---|
| Locomotive type | 0-6-0 | 0-8-0 | 4-6-0 |
| Service | Freight | Freight | Passenger |
| Weight on drivers | 70,350 lb. | 110,250 lb. | 81,600 lb. |
| Total weight of engines | 70,350 lb. | 110,250 lb. | 125,250 lb. |
| Cylinders, diameter and stroke | 17 in. by 24 in. | 21⅝ in. by $25\frac{3}{16}$ in. | 20½ in. by 24 in. |
| Grate area | 15.1 sq. ft. | 23.7 sq. ft. | 25.8 sq. ft. |
| Tubes, number and diameter | 186-1¾ in. | 127-1¾ in. | 127-1¾ in. |
| Flues, number and diameter | ............ | 21-5 in. | 21-5 in. |
| Tubes and flues, length | 9 ft. 9 in. | 13 ft. 11 in. | 13 ft. 11 in. |

| Test number | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Kind of tubes | Plain | Spiral | Plain | Spiral | Spiral | Plain | Spiral |
| Superheater units | ........ | ........ | Straight | Straight | Spiral | Straight | Spiral |
| Firebox | ........ | ........ | Copper | Copper | Steel | Steel | Copper |
| Length of run | 219 miles | 219 miles | 219 miles | 219 miles | 219 miles | 209 miles | 209 miles |
| Time of run | 12 hr. 59 min. | 13 hr. 14 min. | 13 hr. 22 min. | 13 hr. 22 min. | 13 hr. 22 min. | 6 hr. 24 min. | 6 hr. 24 min. |
| Coal burned | 10,212 lb. | 8,162 lb. | 13,944 lb. | 11,851 lb. | 10,553 lb. | 7,687 lb. | 7,284 lb. |
| Draft in smokebox water column | ........ | ........ | 3¼ in. | $2\frac{7}{16}$ in. | $2\frac{11}{16}$ in. | 3⅜ in. | $3\frac{3}{16}$ in. |
| Temperature gas from tubes | 630 deg. F. | 410 deg. F. | 545 deg. F. | 406 deg. F. | 433 deg. F. | 669 deg. F. | 520 deg. F. |
| Temperature gas from flues | ........ | ........ | 507 deg. F. | 475 deg. F. | 450 deg. F. | 565 deg. F. | 500 deg. F. |
| Boiler water temperature | 351 deg. F. | 352 deg. F. | 358 deg. F. | 360 deg. F. | 356 deg. F. | 374 deg. F. | 372 deg. F. |
| Superheated steam temperature | ........ | ........ | 504 deg. F. | 518 deg. F. | 514 deg. F. | 536 deg. F. | 559 deg. F. |
| Water evaporated per pound of fuel | 6.73 lb. | 8.26 lb. | 8.4 lb. | 9.3 lb. | 10.1 lb. | 8.06 lb. | 9.41 lb. |
| Increased boiler efficiency, per cent | ........ | 22.8 | ........ | 10.7 | 20.2 | ........ | 16.7 |
| Saving in fuel, per cent | ........ | 18.5 | ........ | 9.7 | 16.8 | ........ | 14.4 |

# Second Revision of A. S. M. E. Boiler Code, 1922

A HEARING is held by the Boiler Code Committee at least once in four years, at which all interested parties may be heard, in order that such revisions may be made as are found to be desirable, as the state of the art advances. The year 1922 becomes the period of the second revision, the first revised edition of the Boiler Code having been issued in 1918. The Boiler Code Committee plans to hold a public hearing in connection with the next annual meeting of the society in December, 1922, to which the membership of the society and everyone interested in the steam boiler industry will be invited and where they may present their views.

In the course of the Boiler Code Committee's work during the past four years, many suggestions have been received for revisions of the Power Boiler Section of the Code, as a result of the interpretations issued and also of the formulation of the Locomotive Boiler and Miniature Boiler Codes. In order that due consideration might be accorded to these recommendations, the committee began in the early part of 1921 to devote an extra day at each of its monthly meetings to the consideration of the proposed revisions. As a result of this many of the recommendations have been accepted and revisions of the paragraphs formulated.

The revisions which have met the approval of the Boiler Code Committee are here published. It is the request of the committee that these revisions be fully and freely discussed so that it may be possible for anyone to suggest changes before the rules are brought to final form and presented to the council for approval. Discussions should be mailed to C. W. Obert, secretary to the Boiler Code Committee, 29 West Thirty-ninth street, New York, N. Y., in order that they may be presented to the Boiler Code Committee for consideration.

The revisions here published are limited to the paragraphs appearing in the 1918 edition of the A. S. M. E. Boiler Code, and the paragraph numbers refer to the paragraphs of similar number in that edition. 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. 194 REVISED:

194 *Domes.* THE REQUIREMENTS OF PARAGRAPHS 187 AND 188 SHALL APPLY TO RIVETED LONGITUDINAL JOINTS OF DOMES EXCEPT THAT FOR DOMES 24 INCHES AND LESS IN DIAMETER FOR PRESSURES EXCEEDING 100 POUNDS, THE LONGITUDINAL JOINTS MAY BE LAP RIVETED IF THE FACTOR OF SAFETY IS NOT LESS THAN 8. [The longitudinal joint of a dome 24 inches or over in diameter shall be of butt and double-strap construction, irrespective of pressure. When the maximum allowable working pressure exceeds 100 pounds per square inch, the flange of a dome 24 inches or over in diameter shall be double-riveted to the boiler shell.]

THE FLANGE OF A DOME 24 INCHES OR OVER IN DIAMETER SHALL BE DOUBLE-RIVETED TO THE BOILER SHELL. WHERE THE FLANGE OF THE DOME IS USED FOR REINFORCING OR ATTACHING IT TO THE SHELL, THE DIAMETER OF THE DOME SHALL NOT EXCEED ONE-HALF THE DIAMETER OF THE SHELL OR BARREL OF THE BOILER. [The longitudinal joint of a dome less than 24 inches in diameter may be of the lap type, and its flange may be single-riveted to the boiler shell provided the maximum allowable working pressure on such a dome is computed with a factor of safety of not less than 8.]

The dome may be located on the barrel or over the fire-box on traction, portable or stationary boilers of the locomotive type. [Up to and including 48 inches barrel diameter. For larger barrel diameters, the dome shall be placed on the barrel.]

Flanges of domes shall be formed with a corner radius, measured on the inside, of at least twice the thickness of the plate for plates 1 inch thick or less, and at least three times the thickness of the plates for plates over 1 inch in thickness.

PAR. 244 REVISED:

244 The thickness of a corrugated or ribbed furnace shall be ascertained by actual measurement BY THE FURNACE MANUFACTURER BY GAGING THE THICKNESS OF THE CORRUGATED PORTIONS. IF A HOLE IS DRILLED THROUGH THE SHEET TO DETERMINE THE THICKNESS IT SHALL BE 3/8 INCH. WHEN THE FURNACE IS INSTALLED THE HOLE SHALL BE LOCATED BENEATH THE BOTTOM OF THE GRATE AND CLOSED BY A PLUG. The furnace shall be drilled for a 1/4-inch pipe tap and fitted with a screw plug that can be removed for the purpose of measurement. For the Brown and Purves furnaces, the holes shall be in the center of the second flat; for the Morison, Fox and other similar types, in the center of the top corrugation, at least as far in as the fourth corrugation from the end of the furnace.

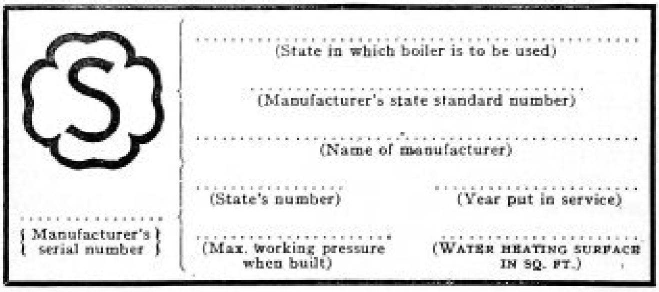



Fig 24.—Form of Stamping

PAR. 254 REVISED:

254 After drilling or reaming rivet holes the plates and butt straps OF LONGITUDINAL JOINTS shall be separated, the burrs and chips removed, the plates and butt straps reassembled metal to metal with barrel pins fitting the holes, and with tack bolts.

PAR. 265 CHANGE CENTER HEADING ABOVE THIS PARAGRAPH TO:

WASHOUT [HOLES] OPENINGS

PAR. 287 REVISED:

287 When the valve body is marked [with the letters A.S. M.E. Std.] as required by Paragraph 273, this shall be a guarantee by the manufacturer that the valve conforms to the details of construction herein specified.

PAR. 294 REVISED:

294 Each boiler shall have three or more gage cocks, located within the range of the visible length of the water glass, except when such boiler has two water glasses with independent connections to the boiler and located on the same horizontal line and not less than 2 feet apart. LOCOMOTIVE-TYPE BOILERS NOT OVER 36 INCHES IN DIAMETER NEED HAVE BUT TWO GAGE COCKS.

PAR. 303 REVISED:

303 When two or more boilers HAVING MANHOLE OPENINGS are connected to a common steam main, two stop valves, with an ample free-blow drain between them, shall be placed in the steam connection between each boiler and the steam main. The discharge of this drain valve must be visible to the operator while manipulating the valve. The stop valves shall consist preferably of one automatic non-return valve (set next the boiler) and a second valve of the outside-screw and yoke type; or, two valves of the outside screw and yoke type may be used.

Note—Matter deleted, in smaller type; matter added, in small capitals.

PAR. 315 REVISED:

315 In a horizontal [return] tubular EXTERNALLY FIRED FIRE-TUBE boiler the feedwater shall discharge ABOVE THE CENTER ROW OF TUBES at about three-fifths the length from the front head (except a horizontal [return] tubular boiler equipped with an auxiliary feed-water heating and circulating device), above the central rows of tubes OR FLUES, when the diameter of the boiler exceeds 36 inches. The feed pipe shall be carried through the FRONT head or shell [near the front end] in the manner specified for a surface blow-off in Paragraph 307, and be securely fastened inside the shell above the tubes.

In THESE AND other types of boilers where both internal and external pipes making a continuous passage are employed, the boiler bushing or its equivalent shall be used.

In Fig. 22 is illustrated a typical form of flange for use on boiler shells for passing through piping such as feed, surface, blow-off connections, etc., and which permits of the pipes being screwed in solid from both sides in addition to the reinforcing of the opening in the shell.

PAR. 318 REVISED:

A BOILER HAVING MORE THAN 500 SQUARE FEET OF WATER-HEATING SURFACE SHALL HAVE AT LEAST TWO MEANS OF FEEDING, ONE OF WHICH SHALL BE A PUMP, INSPIRATOR OR INJECTOR. WHERE A SOURCE OF FEED IS AVAILABLE AT A SUFFICIENT PRESSURE TO FEED THE BOILER AGAINST A PRESSURE 6 PERCENT HIGHER THAN THAT AT WHICH THE SAFETY VALVE IS SET TO BLOW, THIS MAY BE CONSIDERED ONE OF THE MEANS. [When a pump, inspirator or injector is required to supply feedwater to a boiler plant of over 50 horsepower, more than one such appliance shall be provided.]

PAR. 332 CHANGE TABULATION AT END OF PARAGRAPH AND FORM OF STAMPING AS FOLLOWS:

1 Manufacturer's serial number
2 State in which boiler is to be used
3 Manufacturer's state standard number
4 Name of manufacturer
5 State's number
6 Year put in service
7 Maximum working pressure when built
8 WATER HEATING SURFACE IN SQUARE FEET.

Items 1, 2, 3, 4, 7 AND 8 are to be stamped at the shop where built.

Items 5 and 6 are to be stamped by the proper authority at point of installation.

## Flange vs. Riveted Tank Bottom*

THE sub-committee appointed to investigate the construction of locomotive tenders with flanged bottom tanks, compared with the usual method of construction by the use of the angle irons and lap joints, has collected from various railroads, and has also made personal investigation. It is the opinion that the flanged tank possesses certain features of distinct merit, as enumerated below:

(1) The top and bottom sheets of the tank are flanged so that the rivets are horizontal. By this method the angle and tee irons are dispensed with.

(2) The design appears to prove more rigid construction and permits of better interior bracing. The interior parts are secured to the upturned edges of the sheets.

(3) There being no rivet holes through the bottom of the tank, the cost of repairs should be materially reduced, as it is unnecessary to lift the tank from the frame to repair leaks, which is frequently required with tank bottoms constructed with flat seams vertically riveted.

(4) The claim is made by certain railroads that the construction of the flanged bottom tanks is less expensive by 6 per cent than construction of tanks with lap joints. Locomotive builders, however, consider it would cost more to build the flanged tank. Much depends upon the number of tanks to be constructed at one time, and the proper tools for forming sheets. It would appear from the design that there may be some saving in labor and material, such as rivets, etc.

(5) There has been some question concerning the strength of the corners and difficulty in repairing them, if same become weakened by corrosion or cracking. Our best information, however, from the users of such tanks, indicates that corners are sufficiently strong and that no difficulty is experienced in repairs.

After careful consideration, your committee feels that the efficiency of the flanged tank should be equal to the old style of construction in every way. It is felt that ultimate life should be somewhat extended, and that the cost of construction should be no greater. Leaky tanks are Federal defects, and any design that will eliminate liability of such leaks is a desirable improvement.

*Section of locomotive construction committee report read at Atlantic City convention of the American Railway Association—Division V—mechanical, held June 14, 1922.

## Repairing Boilers by Welding

THE repair by welding of such parts as stays or shell plates which are wholly in tension and on the strength of which the safety of the boiler immediately depends is not generally advised.

There remain, of course, occasional instances where parts in tension are pitted or wasted but where the sound metal is still of such thickness as to be capable of satisfactorily carrying the load required. In such cases a repair is advisable, not with the object of reinforcing the wasted part but in order to arrest and prevent further deterioration. In such instances welding may be legitimately adopted but only with the express approval of the chief engineer after the proposition has been submitted for his consideration.

In boiler repairs, especially when thickening up plates or laps at or adjacent to a riveted seam, it is usually necessary to withdraw the rivets so as to allow the plates to expand freely, and a greater number of rivets must be withdrawn if the welding is to be done by flame than when an electric method is to be used.

In the second place boiler repairs have generally to be done inside the shell or furnace tubes where the heat and fumes given off from a blow pipe flame add to the difficulty and discomfort inseparable from such work.

After completion of repairs the parts at or adjacent to the welds should be well hammer tested and the boiler subjected to hydraulic test to make sure that all is sound and tight.

## Oil-Burning Firebox Design

IN oil-burning locomotives the question of draft or air admission is of utmost importance, according to *The Railway Gazette*. In a coal-burning locomotive the fuel lies in a mass on the bottom of the grate and, so long as air is drawn through, each particle of fuel sooner or later gets the required mass of oxygen to complete combustion and it is only the escaping gases due to incomplete combustion that have to be burned in the crown of the firebox. With oil fuel, however, which has to be carried into the firebox in the form of a spray of finely divided particles of floating carbon which are in constant motion, and whose time limit in the combustion area is of short duration, the problem of air distribution is somewhat different. Length and volume are the two main factors necessary in the firebox itself for there are not only the floating particles of oil requiring air but also the larger volume of hydro-carbon gases formed by liquid fuel requiring air to complete their combustion.

# The Boiler Maker

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Some confusion has been occasioned by the misuse on low pressure boilers of the official A. S. M. E. stamp or symbol shown in Fig. 23 on page 87 of the A. S. M. E. Boiler Code. This stamp or symbol is authorized for use on *power boilers only*. As stated in Paragraph 377 of the Code, all heating boilers built in accordance with the rules in the Code shall be marked "A. S. M. E. Standard," using letters and not the symbol. Misuse of the symbol constitutes a violation of the affidavit made at the time the stamp was issued and will serve as grounds for denying the further use of and for recalling the stamp.

Instructions to this effect have been sent by the secretary of the A. S. M. E. Boiler Code Committee to all manufacturers to whom the stamp has been supplied.

Final revision and correction of the "Rules for the Construction of Miniature Boilers," issued by the A. S. M. E. Boiler Code Committee, have been made and the "Miniature Code" is now completed. This Code was published in full on page 109 of our April issue and as the final corrections are of a minor character, consisting chiefly of slight changes in the wording of the rules, the Code will not be reprinted in our columns. In Paragraph M-1 the limit of pressure which must not be exceeded in fired pressure vessels to which the "Miniature Code" applies now reads as "100 pounds per square inch maximum allowable working pressure." In Paragraph M-14 it is stated that "the lowest, permissible water level shall be at a point one-third of the height of the shell except where boiler is equipped with internal furnace, when it shall be not less than one-third the length of the tubes above the top of the furnace." Paragraph M-19, covering the marking of the boilers, now reads, "all boilers referred to in this section shall be plainly marked with the manufacturer's name, maximum allowable working pressure, which shall be indicated in arabic numerals, followed by the letters 'lb.,' and serial number. All boilers built accordinging to these rules shall be marked 'A. S. M. E. Std.—Miniature.' Individual shop inspection is not required for miniature boilers." Following this, samples of the marking required on the boiler and of the data sheet which the manufacturer is required to fill out and sign for each boiler built are given. The form of marking finally adopted differs slightly from that first published and must be followed to the letter.

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With the continual improvement of autogenous welding processes, which has taken place in recent years, the Steamboat Inspection Service of the Department of Commerce has been giving more and more attention to the use of welding for repairing marine boilers. This is a field where the possibilities for savings are almost countless and, while the part that the Steamboat Inspection Service plays is that of a protector to insure the safety of the boilers in operation, nevertheless it can from time to time, by the revision of its rules and regulations in accordance with new mechanical developments in the boiler making industry, give greater latitude to the manufacturers and repair men in the application of these developments whenever they are found to be safe and practical. In this way it is within the power of the Inspection Service to encourage or dampen initiative in the development of new ways and means for perfecting the construction of boilers or for improving their upkeep. In the case of welding and reinforcing boilers by electric, oxy-acetylene or other processes, the latest rules and regulations of the Steamboat Inspection Service specify in detail just what repairs can be made by such processes but in no case can they be made until the operator has received a permit from the local inspectors after satisfactory evidence has been given that the applicant is competent and thoroughly understands the process by which the repairs are to be made. Furthermore, this permit will be canceled whenever satisfactory evidence is produced of poor workmanship or the use of improper material or flux. With such restrictions, welding is now being successfully applied with marked economy in a vast number of marine boiler repairs.

# Engineering Specialties for Boiler Making

**New Tools, Machinery, Appliances and Supplies for the Boiler Shop and Improved Fittings for Boilers**

## Mammoth Hydraulic Flanging Press

A 42-ton hydraulic flanging press, capable of exerting 435 tons of pressure, has recently been designed and built by The Hydraulic Press Manufacturing Company, Mount Gilead, O., for the Merchants Dispatch Transportation Company of Rochester, N. Y. This machine is to be used for flanging the plates for Murphy car ends. It will flange cold steel 5/16 inch thick by 10 feet long.

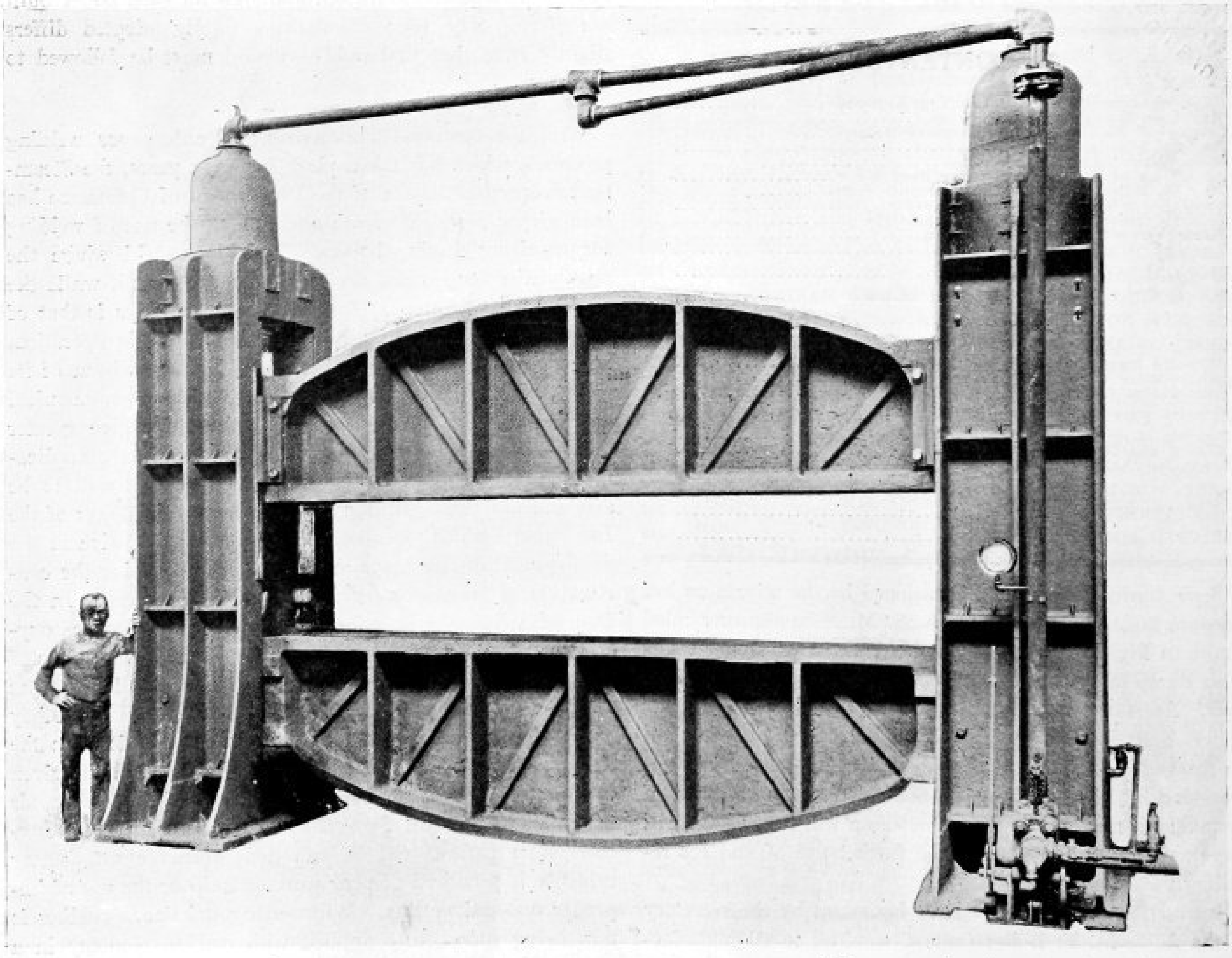
The press is equipped with two 20 inch rams. Two 5½ inch auxiliary cylinders are used for returning the platen. The entire press is made of cast steel (cylinders, platens, housings, etc.). The press has a stroke of 24 inches and the maximum distance between platens (daylight space) is 36 inches.

H-P-M hydraulic valves and fittings are used in connecting up the press. A three way poppet type H-P-M high pressure hydraulic valve controls all the movements of the press by the manipulation of one hand lever.

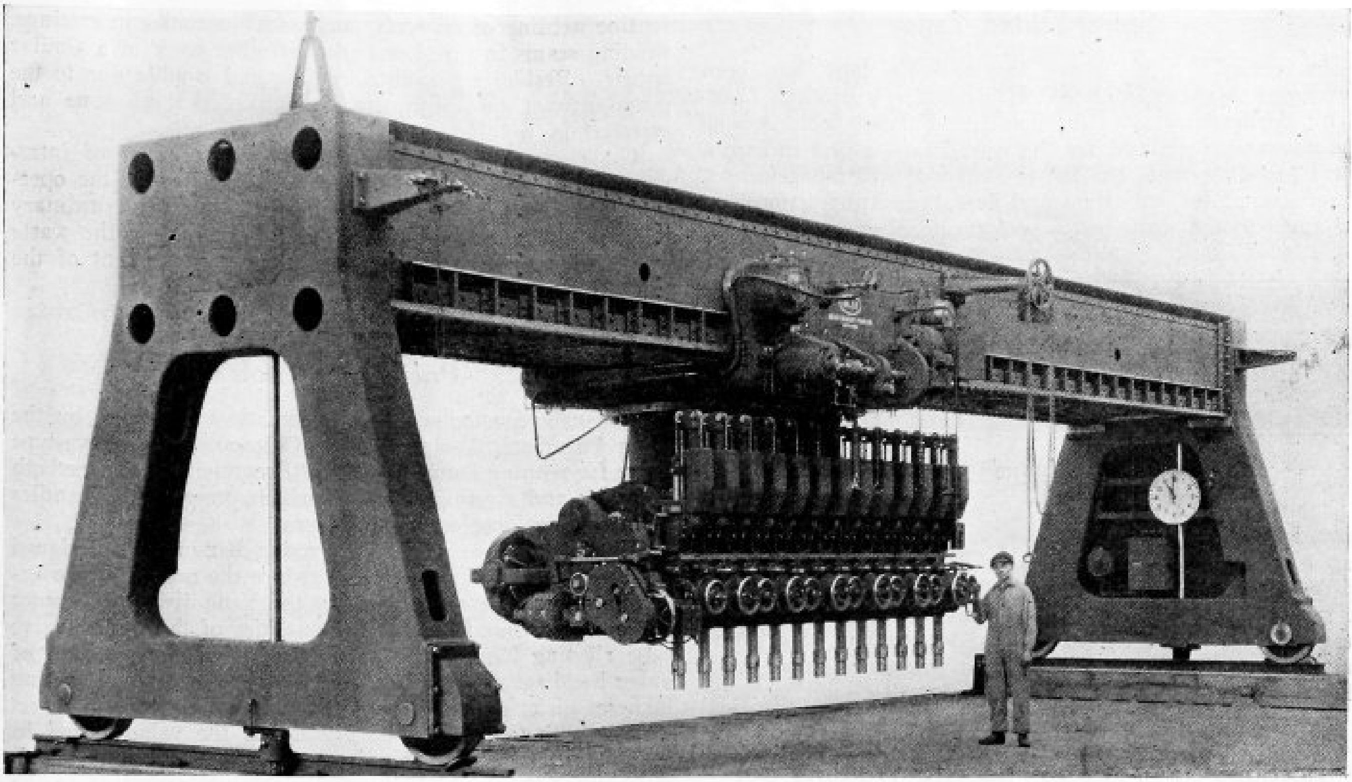
## Edna Water Column

A water column for locomotive service which can be relied upon to indicate the actual water level in the boiler was shown by The Edna Brass Manufacturing Company, Cincinnati, Ohio, at the recent Atlantic City convention. As will be noted from the drawing, the upper part of the column is connected to the top of the boiler by a U-shaped piece of copper pipe, at least 1½ inches in diameter, while the bottom of the column is connected to the water space. The distance from the lower gage cock and the bottom of the Reflex water gage glass is at least 7¼ inches and may be longer to suit conditions.

The bottom connection of the column is provided with a drain or blow-off cock and a ¾-inch plug, the removal of which permits inspection and cleaning of the water connection. In addition to the three gage cocks the column is regularly fitted with a type M Reflex water gage although a tubular water glass may be substituted if desired. This

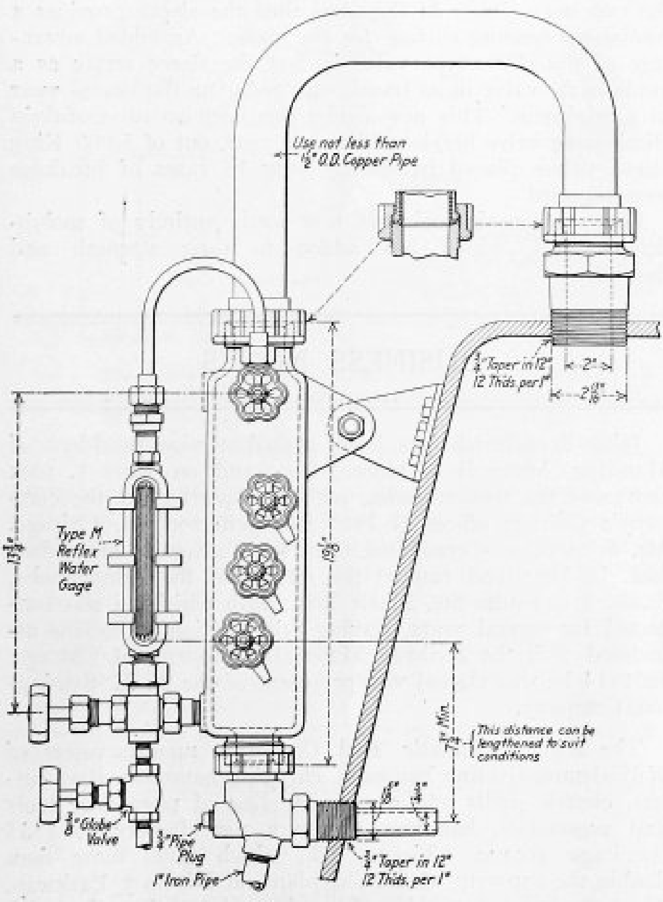


Hydraulic Flanging Press Capable of Exerting 435 Tons Pressure



Niles-Bement-Pond Machine for Drilling, Counterboring and Tapping Steel Plates

column meets all of the safety requirements desired by the Bureau of Locomotive Inspection.




Edna Water Column Insures Accurate Reading of Water Level

## Special Type Multiple Drill for Plates

The accompanying illustration shows a special multiple drilling machine recently built by the Niles-Bement-Pond Company, 111 Broadway, New York, for the drilling, counterboring and tapping of steel plates.

The machine is made up of two double-webbed steel plate girders supported 8 feet 10 inches above the floor by cast-iron housings placed 44 feet apart. A carriage on wheels, suspended as shown, is arranged to travel the length of the girders, and carries a cross-rail having 13 adjustable drill heads. The machine is mounted on wheels and travels on tracks on the shop floor, being driven by means of a 10 horsepower motor.

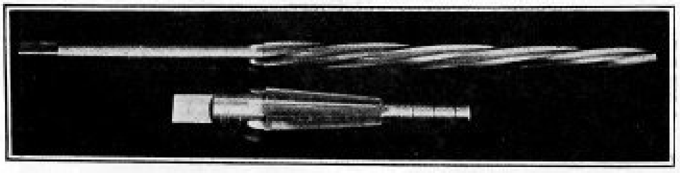
The spindles are driven by a 50 horsepower direct current motor mounted on the carriage. Spindle speeds from 120 to 360 revolutions per minute for drilling are provided and, by means of suitable gearing, speeds from 35 to 105 revolutions per minute for tapping. The spindles are 2 inches in diameter at the driving point and have No. 5 Morse sockets. They have a vertical adjustment of 13 inches. The center distances between consecutive spindles are 8 inches minimum, the maximum distance between the outside spindles being 12 feet 8 inches. Suitable spindle feeds are provided and each spindle has an independent feed clutch to permit disengaging one or more of the drills while the others are in operation.

The cross rail in which the 13 drill heads are mounted is pivoted on the carriage which permits swiveling a full revolution, a feature intended to enable the drilling of holes along the edges of plates, in any direction. A constant-speed reversible motor is provided for revolving the cross rail on the carriage and traveling the carriage on the girders, hand movement by ratchet being also provided for the cross rail and carriage.

Graduated scales for setting the drill heads are included and also adequate clamping facilities for the carriage and cross rail. All controls are placed in a position convenient for the operator.

## Spiral Fluted Taps

An entirely new feature in staybolts taps has been developed this year by the W. L. Brubaker & Brothers Company, Millersburg, Pa., in their spiral fluted tap. Among the advantages claimed for the spiral flute is that in case a thread tooth becomes broken, the tap will still tap a hole of exact size. Also, with the spiral flute, the cutting action is at an angle to the work being performed; hence, metal is removed with less resistance, thus increasing the life of the tap to a noticeable extent.

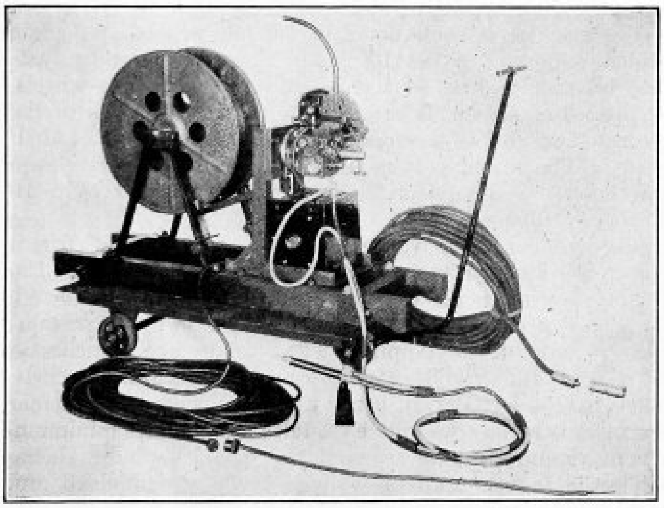


Brubaker Spiral Fluted Tap

Welding or closing in of old staybolt holes has placed a severe test on the threading tool and the spiral fluted staybolt tap was developed and tested out for this severe work. The results are so satisfactory on this difficult work that the spiral flute is being adopted for all classes of work.

## Portable Semi-Automatic Arc Welding Set

In order to increase the applicability of its semi-automatic arc welding apparatus, and adapt it for use in any place where current for welding is available, the General Electric Company is now building a portable set. This comprises a complete semi-automatic equipment, with support for a wire reel, mounted on a small truck that can be pulled over the shop floor by hand, or lifted by a crane. The complete outfit weighs about 400 pounds.



The Set Can Be Used Wherever Welding Current Is Available

The welding equipment consists of a semi-automatic lead, an automatic welding head, with control, and a standard for holding a reel of electrode wire. Power is supplied to the arc through a flexible cable with a plug for attaching it to the nearest welding circuit. The reel carrier is equipped with a brake and designed to take any size reel up to 2½ ft. in diameter.

The portable outfit should be valuable in repairing parts of machines in place when these parts are too bulky, inconvenient, or otherwise impractical to move, and for doing routine welding of all sorts, such as filling holes in castings, welding seams in pipes or tanks, or other work of a similar nature. Besides the saving in time and trouble due to the portability of the outfit, its use will save both time and material in welding.

The electrode is fed continuously, the number of interruptions are reduced and less skill is required by the operator to make a good weld than is the case with ordinary hand welding. Material is saved by eliminating the waste ends which usually amount to at least ten per cent of the total amount of electrode wire used.

## Pneumatic Tools

Two new developments in pneumatic tools made by the King Pneumatic Tool Company, Chicago, are a sleeve-type valve for riveting hammers and a "Progressive" lock for both chipping and riveting hammers which prevents the handles from coming loose on the cylinders.

The King sleeve valve for riveting hammers is designed to eliminate valve breakage and reduce the necessity of oversizing valves to a minimum. In the King riveting hammer valve the hard and fast hitting qualities of the hollow-valve type riveting hammer are maintained and the question of valve breakage is claimed to be solved. Formerly a riveting hammer piston in hollow-valve type hammers came in direct contact with the valve; the piston and the valve moved in opposite directions and the piston came in direct contact with the valve 1,050 to 1,720 times per minute, according to the length of stroke of the hammer. This constant contact between piston and valve resulted in fatigue of the metal in the valve itself, with resulting valve breakage.

In the King sleeve-type valve the sleeve is interposed between the valve and the piston, making any contract between the two impossible. At the same time the sleeve provides a continuous bearing surface for the piston. An added advantage of the sleeve-type valve is that the sleeve serves as a guide to the valve in its travel, thus reducing the lateral wear to a minimum. This new device has been so successful in eliminating valve breakage that last year, out of 5,000 King sleeve valves placed in service, only 15 cases of breakage were reported.

King pneumatic tools are now made entirely of molybdenum steel, which has added to their strength and durability.

## BUSINESS NOTES

John F. Schurch has been elected a vice president of Manning, Maxwell & Moore, Inc., and on June 1, took charge of the western sales, with headquarters at the company's Chicago office, 27-29 North Jefferson St., Chicago. Mr. Schurch was graduated from the University of Minnesota, in 1893 and entered the service of the Minneapolis, St. Paul & Saulte Ste. Marie R.R., with which he was connected for several years, leaving this position to become associated with the Railway Materials Company of Chicago. In 1914 he was elected vice president of the T. H. Symington Company.

The King Pneumatic Tool Company, manufacturers of molybdenum riveting hammers, chipping hammers, rivet cutters, electric drills and a complete line of pneumatic tools and accessories, has moved into a new factory at 1735 Armitage avenue, Chicago, Ill., which gives more than double the capacity of the old plant on Diversey Parkway. The company has purchased considerable additional equipment to expedite production.

# Questions and Answers for Boiler Makers

## Information for Those Who Design, Construct, Erect, Inspect and Repair Boilers—Practical Boiler Shop Problems

**Conducted by C. B. Lindstrom**

*This department is open to subscribers of* THE BOILER MAKER *for the purpose of helping those who desire assistance on practical boiler shop problems. All questions should be definitely stated and clearly written in ink, or typewritten, on one side of the paper, and sketches furnished if necessary.*

*Address your communication to the Editor of the Question and Answer Department of* THE BOILER MAKER, *Woolworth Building, New York City.*

## Allowable Pressure on a Stayed Head

Q.—I am a subscriber to your magazine, THE BOILER MAKER, and would like to have answered through its columns the following question with attached sketch: Was I right in cutting the pressure from 200 pounds to 180 pounds on the head, as shown in Fig. 1? The diagonal braces are fastened to tee irons and the tee irons are fastened to the tube sheet with 7/8-inch rivets. Lugs on the barrel are also fastened with 7/8-inch rivets.—A. McD.

A.—As you have not shown in Fig. 1 the complete details of the tee irons fastened to the head and boiler shell, the strength of these parts cannot be determined. The stay

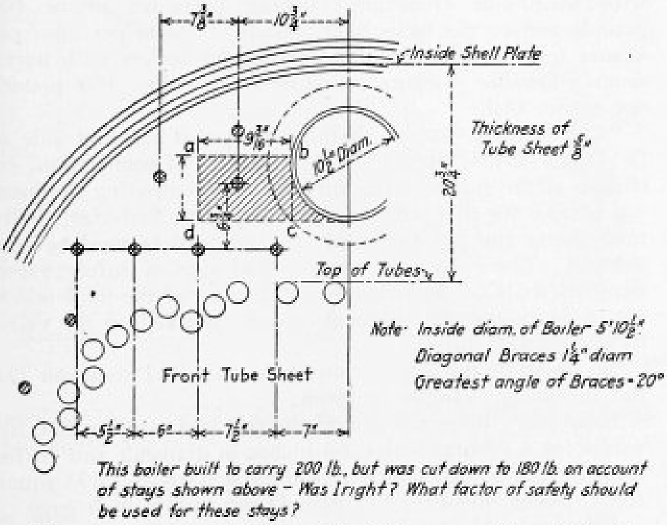



Fig. 1.—Sketch Outlining Conditions on Stayed Head

strength and pressure on the segment of the flanged head is covered as follows: The head being flanged is to some extent reinforced by the flange and hence that portion of the head adjacent to the flange does not require staying. The A. S. M. E. Code gives the following rule on staying a segment:

*Areas of Heads to Be Stayed.*—The area of a segment of a head to be stayed shall be the area enclosed by lines drawn 2 inches from the tubes and at a distance $d$ from the shell, as shown in Fig. 2. The value of $d$ may be the larger of the following values:

(1) $d$ = the outer radius of the flange, not exceeding 8 times the thickness of head.

$$(2)\quad d = \frac{5 \times T}{\sqrt{P}}$$

where; $d$ = unstayed distance from the shell, inches.
$T$ = thickness of head in sixteenths of an inch.
$P$ = maximum allowable working pressure in pounds per square inch.

Using the values in the example and substituting them in formula (2) the unstayed distance $d$ equals

$$\frac{5 \times 10}{\sqrt{200}} = 3\tfrac{1}{2}$$

The area of the segment to be stayed is that shown within the dotted lines, Fig. 2. The height of the segment equals

$$20\tfrac{3}{4} - (3\tfrac{1}{2} + 2) = 15\tfrac{1}{4} \text{ inches.}$$

The area of the segment may be determined by the A. S. M. E. formula:

$$A = \frac{4\,(H - d - 2)^2}{3} \sqrt{\frac{2\,(R - d)}{H - d - 2} - .608}$$

where; $A$ = area of segment to be stayed in square inches.
$H$ = height of segment, inches.
$R$ = radius of boiler head, inches.
$d$ = unstayed distance from shell, inches.

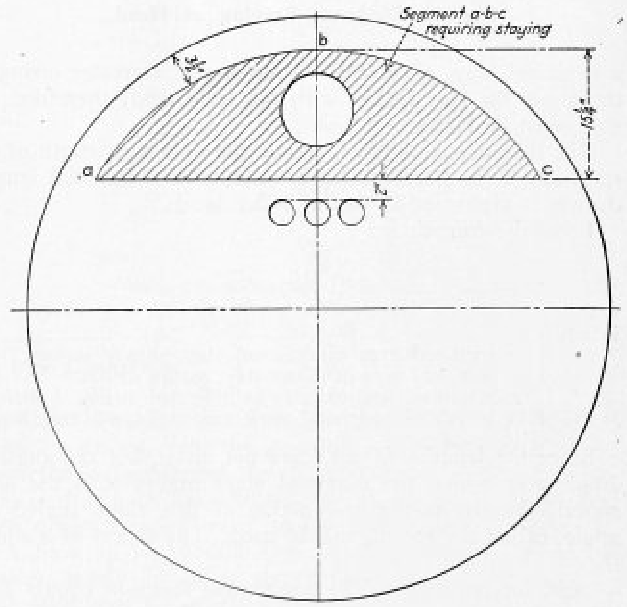



Fig. 2.—Boiler Code Ruling on Area of Head to Be Stayed

Using the values of the example in the formula:

$$A = \frac{4\,(15\tfrac{1}{4} - 3\tfrac{1}{2} - 2)^2}{3} \sqrt{\frac{2\,(35\tfrac{1}{4} - 3\tfrac{1}{2})}{(15\tfrac{1}{4} - 3\tfrac{1}{2} - 2)} - 0.608} =$$

683.44 square inches.

The area of the circle $10\tfrac{1}{2}$ inches in diameter equals

$$(10\tfrac{1}{2})^2 \times 0.7854 = 86.59 \text{ square inches.}$$

$683.44 - 86.59 = 596.85$ square inches, net area to be stayed.

There are 14 stays 1¼ inches in diameter employed to stay the segment, but their arrangement is such that the load is not uniformly distributed. They could be more uniformly arranged so that the metal around the 10½-inch circular opening would be stayed to better advantage. In Fig. 1 is indicated a shaded section *a-b-c-d*, which is the maximum area supported. On this area the allowable working pressure would be based. The size of the section in question measures 9 3/16 inches by 6 inches, nearly, or 55⅛ square inches in area. The total pressure on this area equals 55⅛ × 200 equals 11,025 pounds.

According to the A. S. M. E. Code the allowable stress for unwelded stays and staybolts is 9,500 pounds per square inch when the lengths between supports does not exceed 120 diameters. Using this value (9,500 pounds) the cross-sectional area of a stay to support a pressure of 11,025 pounds equals 11,025 ÷ 9,500 = 1.16 square inches. This is for a stay when the pressure is direct, that is, when the stay is at right angles to the section or area it supports. In

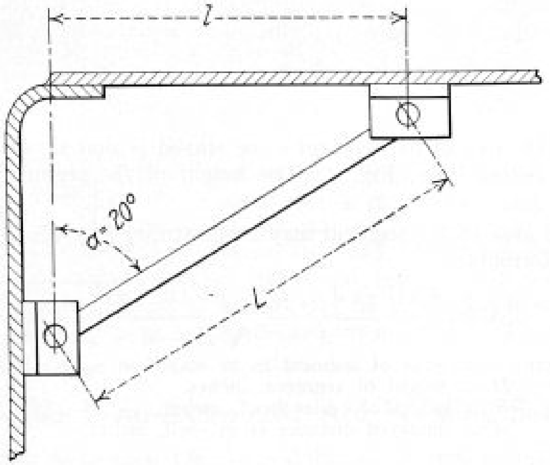



Fig. 3.—Diagonal Staying of Head

a diagonal stay, as in Fig. 3, the stress is greater owing to the angle the stay makes with the horizontal; therefore, the stay must be larger.

The distance, $L$, Fig. 3, equals the diagonal length of the stay, and $l$ the horizontal projection of the diagonal length, drawn at right angles to the boiler head.

From the formula:

$$A = \frac{a \times L}{l},$$

in which;

$A$ = sectional area of diagonal stay, square inches.
$a$ = sectional area of direct stay, square inches.
$L$ = length of diagonal stay as indicated in Fig. 3, inches.
$l$ = length of horizontal projection of diagonal stay, inches.

Since the lengths $L$ and $l$ are not given, but the angle of 20 degrees which the diagonal stays makes with the horizontal, the trigonometric function of this right angled triangle, called the secant, will be used. The secant of $a$ equals $\frac{L}{l}$ and for an angle of 20 degrees the function equals 1.06. Using this as a multiplier, the sectional area of the diagonal stay equals 1.16 × 1.06 = 1.23 square inches, which is the area of a stay 1¼ inches in diameter, nearly.

If the allowable stress per square inch is less than 9,500 pounds, a larger stay would be required. Thus, if a welded stay is employed, a stress of 6,000 pounds per square inch is allowed.

Then, 11,025 ÷ 6,000 = 1.83 square inches area of direct stay.
1.83 × 1.06 = 1.9398 square inches, area of diagonal stay, which is a stay approximately 1⅝ inches in diameter.

The A. S. M. E. Code gives values of from 49,000 to 53,000 pounds per square inch tensile strength for stays. With an allowable stress of 9,500 pounds on a solid stay without welds, and, if the bar withstands the 49,000 pounds tensile strength, the factor of safety equals 49,000 ÷ 9,500 equals 5.15.

## Safety Valve Calculations

Q.—I would like to ask if you will give me a rule for finding the size of a spring loaded safety valve (in a boiler) as I soon expect to take the examination for boiler inspector at Harrisburg, Pa. I have worked as boiler inspector for the last twenty years for different railroads. Can you help me, or let me know of anything that will help me? I have studied the Boiler Code and am fair at figures.—J. D. B.

A.—The A. S. M. E. rules cover the requirements in determining the capacity and size of safety valves. These rules have been adopted by the Industrial Board, Pennsylvania Department of Labor and Industry. Paragraphs 270, 271 and 274 are herewith given on safety valve capacity.

Par. 270.—"The safety valve capacity for each boiler shall be such that the safety valve or valves will discharge all the steam that can be generated by the boiler without allowing the pressure to rise more than 6 percent above the maximum allowable working pressure, or more than 6 percent above the highest pressure to which any valve is set."

Par. 271.—"One or more safety valves on every boiler shall be set at or below the maximum allowable working pressure. The remaining valves may be set within a range of 3 percent above the maximum allowable working pressure, but the range of setting of all of the valves on a boiler shall not exceed 10 percent of the highest pressure to which any valve is set."

Par. 274.—"The total relieving capacity of the safety valve, or valves required on a boiler shall be determined on the basis of 6 pounds of steam per hour per square foot of boiler heating surface for watertube boilers. For all other types of power boilers, the minimum allowable relieving capacity shall be determined on the basis of 5 pounds of steam per hour per square foot of boiler heating surface for boilers with maximum allowable working pressures above 100 pounds and on the basis of 3 pounds of steam per hour per square foot of boiler heating surface for boilers with maximum allowable working pressure at or below 100 pounds per square inch.

"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. The minimum number and size of safety valves required shall be determined on the basis of the total relieving capacity and the relieving capacity marked on the valves by the manufacturer."

To illustrate the application of the data in Paragraph 274, the following example is given:

*Example:* Required to find the size and number of safety valves for a tubular boiler, 66 inches in diameter and 16 feet long, having a total effective heating surface of 1,293 square feet. Boiler pressure, 125 pounds per square inch gage.

*Solution:* The total relieving capacity of the safety valves required in this case is based on a capacity of 5 pounds of steam per square foot of heating surface; thus, 1,293 × 5 = 6,465 pounds weight of steam per hour that the valves must be able to relieve.

The minimum number of valves required shall be determined on the basis of the total relieving capacity and the relieving capacity indicated on the valves by the manufacturer. On pages 117 to 119 of the appendix, given in the A. S. M. E. Code, are tabulated the discharge capacities for direct spring loaded *pop safety valves* with 45-degree bevel seats. The discharge capacity of a flat seated safety valve may be obtained by multiplying the discharge capacity given in the table for a 45-degree bevel seat valve of the same diameter and lift by 1.4.

Further, according to Paragraph 269, each boiler shall have two or more safety valves, except a boiler for which one safety valve having a capacity of 2,000 pounds per hour or less is required by the rules.

Safety valve capacity may be checked, according to paragraph 275 in three different ways:

(a) By making an accumulation test; that is, by shutting off all other steam discharge outlets from the boiler and forcing the fires to the maximum. The safety valve equipment shall be sufficient to prevent an excess pressure beyond that specified in Paragraph 270.

(b) By measuring the maximum amount of fuel that can be burned and computing the corresponding evaporative capacity upon the heating value of the fuel. Explained in paragraphs 420 to 426 of the appendix.

(c) By determining the maximum evaporative capacity by measuring the feed water. The sum of the safety valve capacities marked on the safety valves shall be equal to or greater than the maximum evaporative capacity of the boiler.

The amount of steam that a valve will discharge in pounds per hour may be found from the formula given in Paragraph 420 of the appendix.

$$W = 110 \times P \times D \times L \text{ for bevel seats at 45 degrees.}$$
$$W = 155 \times P \times D \times L \text{ for flat seats}$$

in which;

$W$ = Quantity of steam that a safety valve will handle per hour, pounds.
$P$ = Absolute pressure = gage pressure + 14.7 pounds atmospheric pressure.
$D$ = Inside diameter of valve seat, inches.
$L$ = Vertical lift of valve disk, measured with 3 percent excess pressure, inches.

Assuming in the solution that two safety valves are to be used having a lift of 0.08 inch, each safety valve thus must have a relieving capacity of 6,465 ÷ 2 = 3,232.5 pounds per hour.

Substituting these values in the formula given for the bevel seated valve and transposing to find the diameter of the safety valve

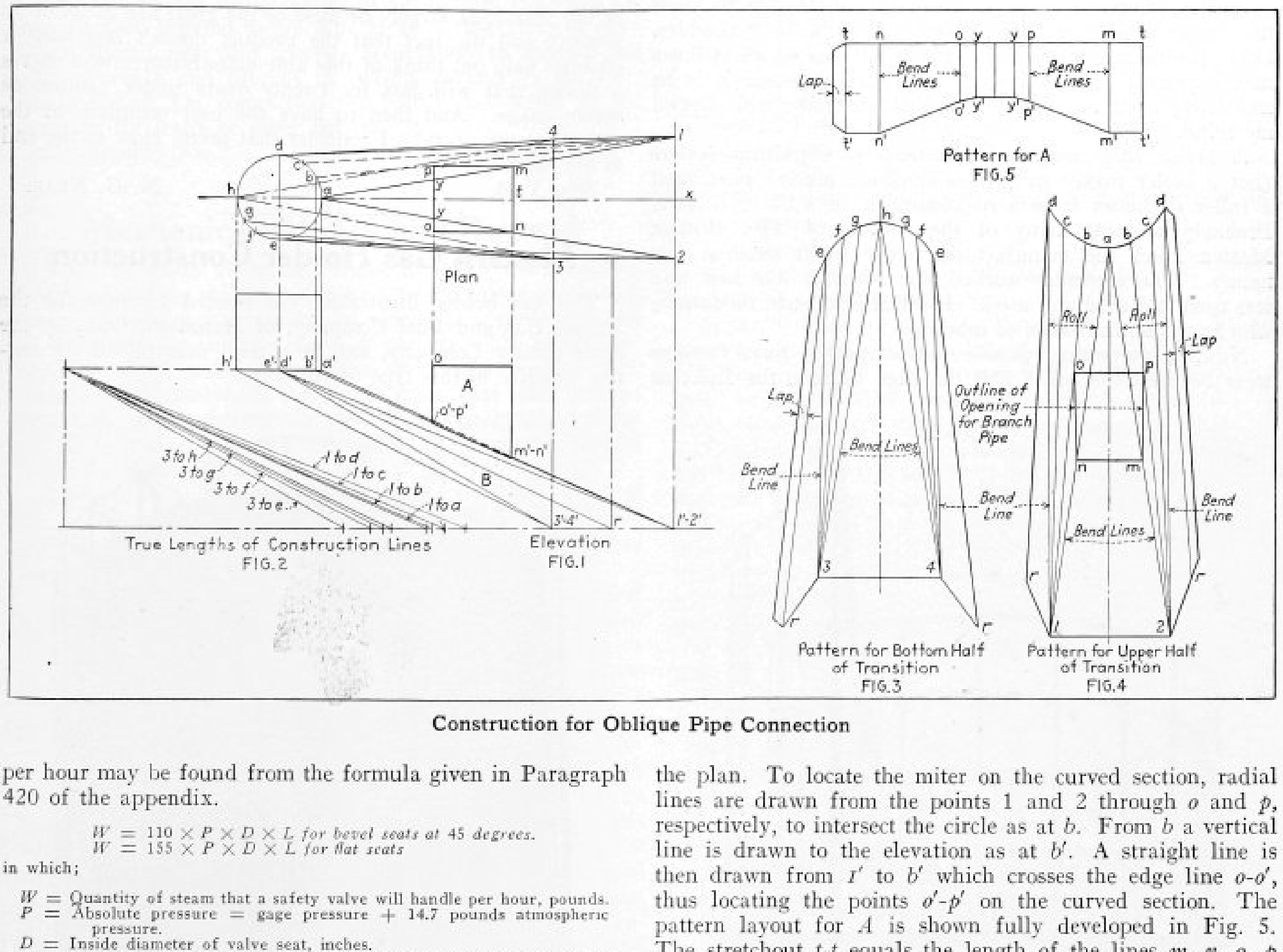
$$D = \frac{3232.5}{110 \times (125 + 14.7) \times .08} = 3 \text{ inches, nearly.}$$

From the table given in the code, a 3-inch safety valve marked with 0.08-inch lift and a working pressure of 125 pounds per square inch, the relieving capacity = 3,677 pounds per hour. Hence 2 safety valves of this size will amply take care of the boiler capacity of 6,465 pounds steam per hour.

# Oblique Pipe Connections Forming Transition Pieces

Q.—Would you please show me how to lay out pipe *A*, Fig. 1, when it is on center; also when the top is not parallel with the front elevation.—W. F.

A.—In the construction of Fig. 1 it is first necessary to find the line of intersection between the oblique transition pipe *B* and the rectangular pipe *A*. Since the pipe *B* tapers from a square section at the base to a round at the top, there will be four triangular shaped sides as *1-2-a* and *3-4-h* on the top and bottom, respectively, as shown by their outlines in the plan and *2′-3′-e′* and *1′-4′-d* shown in the elevation. Where the side *m-n* of the rectangular pipe intersects the lines *a-1* and *a-2* establishes two points on the miter line in the plan. To locate the miter on the curved section, radial lines are drawn from the points 1 and 2 through *o* and *p*, respectively, to intersect the circle as at *b*. From *b* a vertical line is drawn to the elevation as at *b′*. A straight line is then drawn from *1′* to *b′* which crosses the edge line *o-o′*, thus locating the points *o′-p′* on the curved section. The pattern layout for *A* is shown fully developed in Fig. 5. The stretchout *t-t* equals the length of the lines *m, n, o, p* of the plan. The lengths of the lines *t-t*, *n-n′*, *o-o′* are transferred from the elevation of *A*.




**Construction for Oblique Pipe Connection**

The development of the transition piece *B* is made by the triangulation method. The curved sections of the pipe are divided into a number of radial sections running from the circular section of the plan as from *a-b-c-d* terminating in point *1* and *2* for the upper half of the pipe; and from *e-f-g-h* to points *3* and *4* for the bottom half. The true lengths of these lines are determined as in Fig. 2 by the usual method of developing right triangles; in which the bases are equal to the radial lengths in the plan. Since the upper and lower bases are parallel the height is the same for all of the triangles. The patterns are laid off as in Figs. 3 and 4, using the diagonal lines or true lengths of the right angled triangles. By noting the reference letters in both figures, the assembly of the respective lines will be better understood.

# Letters from Practical Boiler Makers

**This Department Is Open to All Readers of the Magazine —All Letters Published Are Paid for at Regular Rates**

## Troubles of the Manufacturer of Boiler Maker's Tools

It may interest readers of THE BOILER MAKER to know that boiler makers are not the only ones who have troubles. Other people have them too. I will tell you of an instance that happened some ten years ago but I presume it is as true today as it was then. The incident had about slipped my mind.

A boiler shop making a business of repairing boilers (not a boiler maker in this case, please notice) purchased a roller expander from a manufacturer of such expanders. Probably a great many of the readers of THE BOILER MAKER know the manufacturer but I won't mention any names. The expander worked fine when it was new and was used and used and used. It rolled hundreds, thousands, who knows but millions, of tubes.

Now, in the rolling process, unfortunately, there is some wear between the roller and the cage because the function of the cage is to hold the roller in position and in holding it there, during the rolling process, friction results. Friction, naturally, begets wear.

After a time (I was told twenty years) the cage became so badly worn that it wouldn't hold the roller in place any more. The roller insisted on coming out.

Did the owner buy a new one? No. He straightway sent the cage to the manufacturer, told the manufacturer of the cage that it was "No good" and demanded a new one in its place.

It may be that this is a common occurrence with some manufacturers of boiler maker's tools but I doubt it. It is a record breaker for me.

On reading this morning that a certain manufacturer of a device that wears out quickly made $20,000,000 profit in the year 1921 largely because of the great use made of its product and the fact that the product doesn't last long, I couldn't help but think of this able manufacturer who makes a device that will last for twenty years under continuous severe usage. And then to have the user complain at the end of twenty years! I consider that pretty close to the end of the limit.

New York N. G. NEAR.

## Modern Gas Holder Construction

The gas holder illustrated was erected recently for the United Gas and Fuel Company, of Hamilton, Ont., by the Riter-Conley Company, and is a good example of present-day practice in this type of structure.

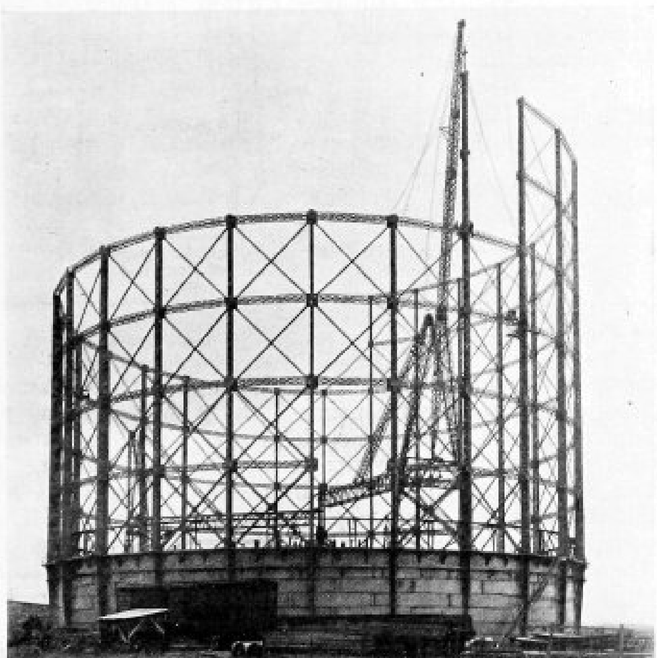


Fig. 1.—Erection of 6,000,000 Cubic Foot Gas Holder

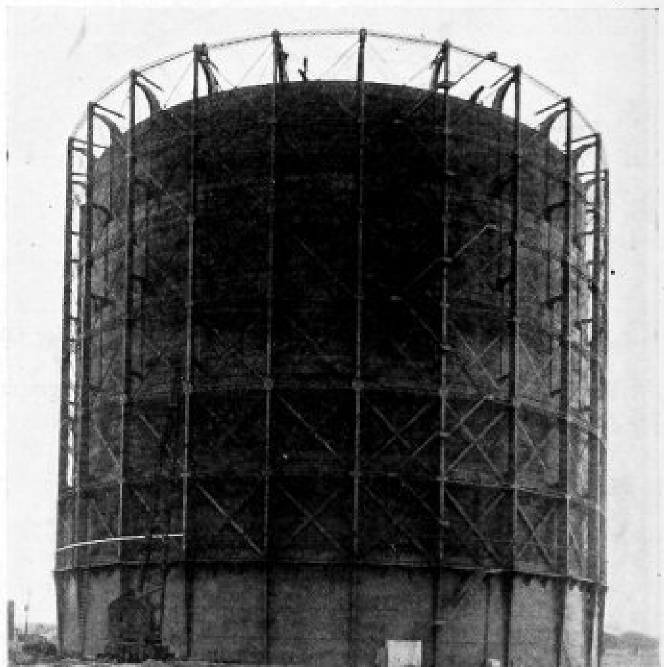


Fig. 2.—6,000,000-Cubic Foot Gas Holder Completed

The nominal capacity of the holder is six million cubic feet of gas, and its principal dimensions are as follows:

| | Diameter | Height |
|---|---|---|
| Inner lift | 200 feet 0 inches | 30 feet 10 inches |
| Second lift | 202 feet 9 inches | 31 feet 6 inches |
| Third lift | 205 feet 6 inches | 31 feet 6 inches |
| Fourth lift | 208 feet 3 inches | 31 feet 6 inches |
| Fifth lift | 211 feet 0 inches | 32 feet 0 inches |

The height over all from the surface of the ground is approximately 200 feet. The annular space between the shells is practically 16½ inches, and each shell is provided with its own set of goosenecks and guide rollers bearing on the backs of the columns.

The construction of gas holders is attended by a number of special problems and in consequence this class of work is undertaken by but a comparatively small number of steel construction firms, and only by those possessing the requisite experience and equipment. It will be seen, however, that after the special questions of stability, economical use of metal and durability in service have been provided for, there is considerable opportunity for duplication of parts, and the shop fabrication approaches pretty closely to a manufacturing proposition, so that the main problems are those of design and erection.

The method of preparation of the site and the general scheme of erection are clearly shown by the photographs. As is customary in large tank construction, the bottom of the holder was riveted while supported about three feet from the ground, then lowered to place by jacks, a thin layer of sand being spread over the concrete foundation to support the bottom evenly and prevent the weight resting on the rivet heads alone. On completion the holder was tested by air pressure for leaks or other defects.

Sherbrooke, Que. DONALD M. MCLEAN.

## Mechanical Ability and Reward

Remarks made at various times in the writer's hearing were summed up the other day by a friend in the words that many first rate capable mechanics worthy of advancement had been unfortunate in their choice of parents. The belief is so general in the trade that means and social position lead directly of themselves to the higher posts, that some ventilation of the matter seems desirable. No generally held opinion voiced as it is in many different ways by men not in contact is devoid of foundation.

The individuals who are loudest in their expression of the opinions cited at the beginning are often to the impartial onlooker lacking in a number of ways which lead directly to want of the success they reckon their due.

First of all it is conceded that academic success is in itself no criterion of value; every practical man, including those who grumble at their own ill luck, will readily cite instances to prove this contention. On the other hand there is the unrealized fact that practical qualifications of real merit are of value only in practical applications. Unfortunately for the individual as qualified there is no lack of capable, intelligent and highly trained mechanics. It is also well known that good time keeping, sobriety and diligence do not in themselves make a first rate workman. For proof of this witness the usual reference furnished with an application for employment. Emphasis is laid upon just these points, and ability, if mentioned, is in general and unspecified terms. The length of service is given instead, the understanding implied is that qualification is assumed as being a usual and ordinary possession. The assumption made is that no employer is foolish enough to retain a proved incompetent. A new man is always a speculation until tried out. Emphasis is laid upon time keeping, sobriety and diligence, while ability is left to the new employer to discover. The mere fact that a man is honest and has for a given length of time been in receipt of normal wages may prove him a decent citizen, but is certainly no proof of superior capacity either present or latent. Stress is laid upon just these matters because skill is a common commodity while the man will show by appearance and under cross examination whether he is otherwise qualified or not. In any case a trying out process discovers his limitations. It is therefore a reasonable deduction from the usual reference that skill is more apparent than character or conduct.

At the same time it assumes that a works manager is a trained psychologist and thought reader, for men are so diverse and the shyest at an interview is apt to prove first class under test.

The reverse to the practical—for under this head are included draftsman, designer, works manager and the man in overalls—is the commercial. The practical man hardly realizes that he is an economist, that unless his product saves the public purse, adds to its convenience or renders the otherwise impossible a practical matter, there would certainly be no engineering trade as at present.

While any attempt to catalogue the qualities needed for advancement is certain to meet with criticism, the following is put forward as a fairly comprehensive list.

*Individual characteristics.*
Personality. Temperament. Character.
Common sense. Manners. Character.

*Educational characteristics.*
Correspondence. General culture. Reading.

*Technical characteristics.*
Practical and theoretical ability.
Academic success. Experience.

*Instinctive characteristics.*
Adaptation to environment.
Mechanical, commercial, executive ability.
Development under responsibility. Non-technical exposition.
Judgment.

The qualities may be sorted out into tangible and intangible or apparent and latent.

Apparent qualities include means and influence, but also character, experience, education, culture qualifications.

Latent qualities include unrealized personal possessions such as adaptability, executive ability, commercial and mechanical instincts, development under responsibility.

Apparent qualities are realizable and can be assessed by another. Latent characteristics are quite another story and can only be proved after, not before, the event.

The lack of the first rate mechanic is not in technical and practical abilities but in those business aspects of at least equal moment. Latent ability no one can diagnose, but ability to dictate a clear letter on a complex matter, non-technical exposition to a layman, manners, speech and general education are apparent matters which count for a great deal.

Three qualities indispensable for any real success are common sense, executive ability and commercial instinct.

Now it is not in ability and intelligence that the lack is most apparent but in general education, speech, manners and business and commercial ability. Taking education first. There is in all education, whether gained directly as tuition or in the larger and more important field of experience, a want of elasticity and suppression of original thought. The stricture applies more directly, however, to academic training. Some men having had the largest opportunity for experience and considerable tuition are found lacking when left to do their own thinking without precedent to guide them. It may be broadly stated that the more the individual is spoon-fed on predigested food the greater the probability of dyspepsia, mental or moral.

The question of instinctive qualities may be reasoned on the basis of color or musical senses. A color-blind man, whatever training may be applied, can scarcely become a reliable art critic. The non-musical can never be trained to become a pleasing exponent of musical art even if trained in theory, harmony, or the obscure canons underlying the work of great composers. In a similar manner numbers of people are distinctly lacking in commercial instinct, money and value have to them no meaning. Many first rate technical and scientific men are nearly destitute of commercial faculty, indeed, it is rare to find acute ability in both directions in a single individual.

Mechanical instinct of supreme importance is found in many unlikely quarters. There are quite efficient mechanics who lack, and numbers of amateurs who possess the quality indicated. The patent office might be cited as a witness but the man who makes a hobby of mechanical things is common enough, and as he works for pure affection only he is perhaps the better example.

Certain platitudes are obvious enough:

Instinct is valueless without training.

Academic scholarship is no proof of creative ability.

Technical and commercial faculties demand two distinct facets of intelligence.

Executive ability minus commercial instinct is apt to prove a snare.

Adaptability is valueless without judgment.

Commercial instinct destitute of ethics defeats its own ends.

Common sense combined with judgment rarely misleads.

In a properly organized staff, subdivision into compartments is the rule; the end desired is that each unit plays a part fitted to his capacities. It is useless to argue that in a successful business all concerned are misfits. Obviously some prove less capable in their allotted tasks than others.

To take directly the case of the ambitious mechanic. His latent abilities are unknown. These can only be developed under responsibility. While highly skilled and perfectly competent, he may lack in several directions apparent enough to the impartial observer. General education as apart from technical ability is the direction most often evident. Too often he concentrates absolutely upon the things pertaining to his craft, and neglects the broad general knowledge, without which he is oblique in his vision and onesided in his views. This excepts any moralizing as to how the industrious apprentice should spend his spare time and scant leisure. There are competent mechanics whose reading is confined to the news of the day; others, and the case is unfortunately not exceptional, who read literally nothing at all.

We all needs must make sacrifice in becoming a specialist and the limitations of the operator of a single machine are apparent and realized by any trained man. Yet the trained man is penalized in turn if he neglect the broader world around him, for exactly the same reason and in the same manner.

Neglect of the art of expression, of correspondence ability, of due appreciation of the wider aspect of his work has spoiled many a career open to the man at the bench. It has placed the distinctively commercial and clerical staff in a relatively false position both as to salary and appreciation. Those who depend upon the technical man for their facts and their own mental acumen to sift the pertinent from the valueless; whose understanding of the business is limited but sufficient contrive to float at the higher end of most enterprises of considerable size.

Few mechanics are competent to perform similar functions, hence the belief they are unfairly penalized in the organization. There is again the disinclination of the man in the shop to tackle distinctively clerical work, confidential and necessary though it may be.

There is commendable independence on the part of the mechanic. It may, however, if he be entrusted with other duties, show itself as insolence to customers. It is a common enough fallacy to assume that tact and good manners show servility.

It is not disputed that means and social position do not give their possessor a considerable start. But it is actually the education and intangible qualities such possessions bring which have the greater value. Of themselves alone such qualities go for little against experience, proven merit, technical ability and the qualities previously indicated; the balance must be in favor of one whose abilities are recognized but whose circumstances are less enviable.

The trouble is that the man in the shop is unwilling to realize his limitations, or allow merit for the things he lacks; nor does he take steps to rectify the omissions of his training.

Life as a mechanic has its own compensations. There are more nets about the feet of those who organize and control. Certain is it that the reliable and competent mechanic has the respect of all in the business.

It is enough simply to mention that literally thousands of men without the advantages of social position or higher education have risen from the ranks in what after all is possibly the most democratic industry.

It must be recognized as a fact that in no other trade is the general level of intelligence so high, the training more severe, the rewards for equal mentality so meagre.

There are few if any reputed millionaires whose money was wholly made in engineering manufacture.

The man lacking capital, destined to be an employee, is therefore doomed to disappointment if he embraces at once the most interesting and poorly paid of all the professions in the hope of securing what is known as a lucrative appointment.

London, England. A. L. Haas.

## TRADE PUBLICATIONS

Pneumatic Drills.—Pigmy pneumatic drills for light work are described and illustrated in a four-page leaflet recently issued by the Independent Pneumatic Tool Co., Chicago, Ill.

Flue Gas Analysis.—A new type gas filter for preparing flue gases for analysis, known as the double disk "Pyroporus" filter, is described in a bulletin recently issued by the Uehling Instrument Company, Paterson, N. J. In addition to the details of the filter, an outline of its installation and uses are given together with illustrations showing its position in relation to the gas sampling pipe and boiler.

Armstrong Stocks and Dies.—Catalogue No. 17 has just been published by the Armstrong Manufacturing Company, Bridgeport, Conn., giving detailed descriptions and prices for Armstrong stocks and dies, water, gas and steam fitters' tools and pipe threading machines. A special section of the catalogue is devoted to details of new machines for threading and cutting pipe. These are built in various sizes for both hand and power drive.

Boiler Blow-off Valves.—A catalogue, describing a variety of valves for general service but with special attention given to valves in boiler blow-off service, has been sent out by the Everlasting Valve Company, Jersey City, New Jersey. Descriptions and illustrations of the various type valves are given in the catalogue together with their application to a number of different services. In each case, specifications and price lists are included.

"Bringing the Van Dorn Plant Home to You."—The cover of a unique and attractive folder just issued under the above title by the Van Dorn and Dutton Company, Cleveland, Ohio, gear manufacturers, portrays a mailman with the plant in his arms delivering it to the addressed. The inside is a complete story, profusely illustrated, of the entire "Van Dorn" plant, department after department, just as one would see it on an inspection trip or following the various operations necessary in the manufacture of gears. A copy will be sent to any interested party.

Pneumatic Tools.—Two folders (special publication No. 686) have been sent out by the Chicago Pneumatic Tool Company, Chicago, Ill., showing by illustration and description the great number of possible applications of the company's pneumatic and electric tools. These bulletins constitute a general review of riveting and chipping hammers, grinders, drills, air hoists, compressors, semi-Diesel oil engines and other products with interesting notes on the history and development of the company and its devices together with statements on the performance of many of them.

The Taylor Stoker.—A book made up of illustrations and descriptions showing the installations of Taylor Stokers in the central station field has been sent out by the American Engineering Company, Philadelphia. The book indicates that the Taylor Stoker has been thoroughly introduced all over the country with good, bad and indifferent fuel supplies. The plants in which these stokers are installed are called upon to perform duties of supplying power and light under all manner of operating conditions and their service records show that the Taylor Stokers installed have performed their functions satisfactorily at all times.

Heating and Power Plant Specialties.—The McAlear Manufacturing Company, 1901-7 South Western avenue, Chicago, Ill., has ready for distribution a new 128 page catalogue, known as No. 27, which illustrates many new devices, including an individual temperature control valve, specialties for all power plants, vacuum and vapor heating systems, oil refining and water works plants, plumbing systems and marine service, together with illustrations showing their application and use. The individual temperature control valve is self contained and can be applied to any radiator, old or new, without additional piping other than the supply and return. When the thermostatic member is set for the desired room temperature, it automatically controls the opening and closing of the valve.

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### Bureau of Locomotive Inspection of the Interstate Commerce Commission

Chief Inspector—A. G. Pack, Washington, D. C.

Assistant Chief Inspector—J. M. Hall, Washington, D. C.

### Steamboat Inspection Service of the Department of Commerce

Supervising Inspector General—George Uhler, Washington, D. C.

Deputy 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—John A. Stevens, Lowell, Mass.

Vice-Chairman—D. S. Jacobus, New York.

Secretary—C. W. Obert, 29 West 39th Street, New York.

### National Board of Boiler and Pressure Vessel Inspectors

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Secretary-Treasurer—C. O. Myers, State House, Columbus, Ohio.

Vice-Chairman—R. L. Hemingway, San Francisco, Cal.

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### International Brotherhood of Boiler Makers, Iron Ship Builders and Helpers of America

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William Atkinson, Assistant International President, suite 522, Brotherhood Block, Kansas City, Kansas.

Joseph Flynn, International Secretary-Treasurer, suite 504, Brotherhood Block, Kansas City, Kansas.

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# SELECTED BOILER PATENTS

Compiled by
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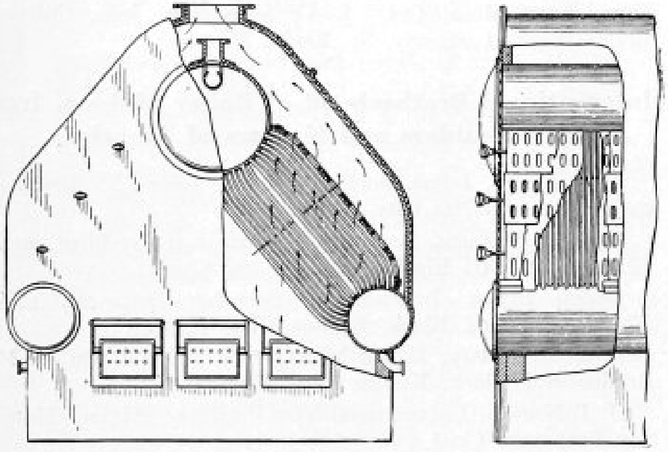
Washington Loan and Trust Building,
Washington, D. C.

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

1,394,969. STEAM BOILER. JAMES M. COLVEN, OF YONKERS, NEW YORK, ASSIGNOR TO NEW YORK ENGINEERING COMPANY, A CORPORATION OF NEW YORK.

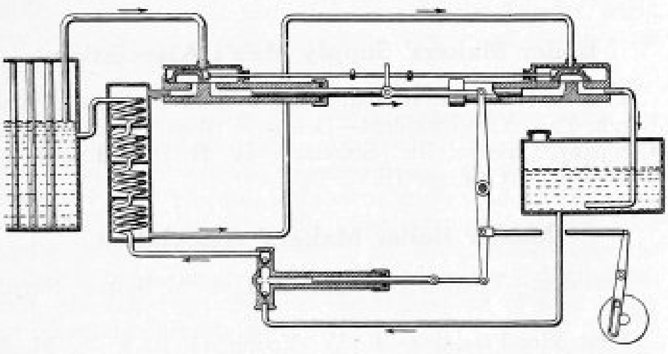
*Claim* 1.—In combination with a boiler having upper and lower drums and having a bank of tubes connecting said drums, baffling means extending from the upper toward the lower drum comprising a baffle adjacent a



row of tubes and slidable transversely of the tubes, said baffle having rows of perforations spaced so as to register with the tubes when the baffle is in one position, and to register with the spaces between the tubes when the baffle is in another position. Three claims.

1,401,894. WATERLEVEL REGULATOR FOR STEAM-BOILERS. FRANCIS I. DU PONT, OF WILMINGTON, DELAWARE ASSIGNOR TO DELAWARE CHEMICAL ENGINEERING COMPANY, OF WILMINGTON, DELAWARE, A CORPORATION OF DELAWARE.

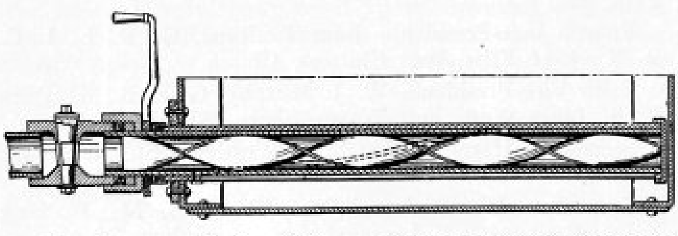
*Claim* 1.—In an apparatus for regulating the water level in a steam boiler, means to deliver an excess supply of water to the boiler, a discharge from the



boiler at the desired water level, a heat interchanger interposed in the delivery and discharge connections, and means for removing the discharged water from the interchanger at the rate delivered thereto. Ten claims.

1,416,207. STEAM-BOILER CLEANOUT DEVICE. MIKE HUFFMAN, OF DES MOINES, IOWA.

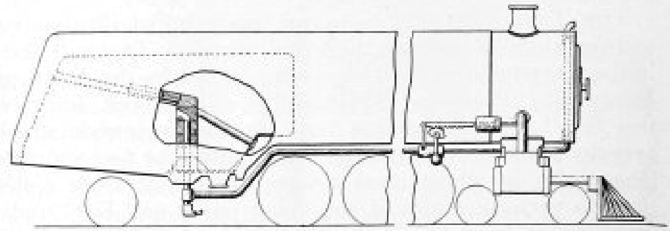
*Claim* 1.—In a device of the class described, the combination of an outer stationary tube and an inner rotatable tube, said tubes being provided with



openings that are capable of registering or coinciding at different parts of the tubes during the time that the inner tube is rotated, and means connected to the said inner tube, to be acted on by the water escaping through the said inner tube, for causing said inner tube to rotate. Five claims.

1,402,163. LOCOMOTIVE FIREBOX. RALEIGH J. HIMMELRIGHT, OF NEW YORK, N. Y., ASSIGNOR TO AMERICAN ARCH COMPANY, OF NEW YORK, N. Y., A CORPORATION OF DELAWARE.

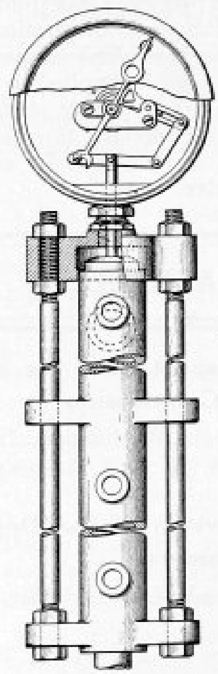
*Claim* 1.—A locomotive firebox construction comprising a substantially vertically disposed supplemental air inlet passage, a transversely extending conduit for supplying the air, which opens into the vertically

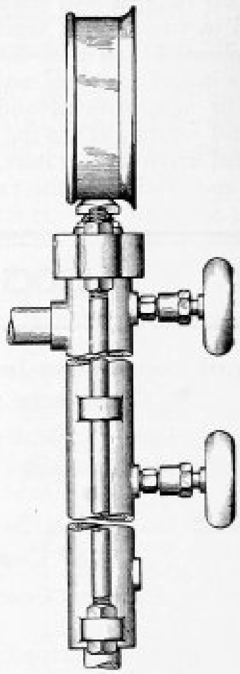


disposed passage at a point intermediate its ends, and a pivoted damper normally closing the lower end of the vertical passage and adapted to automatically open a discharge accumulated deposit when the weight of such deposit reaches a predetermined point whereby choking of the transverse supply conduit is prevented. Three claims.

1,405,832. WATER-LEVEL INDICATOR FOR BOILERS. PERRY H. GENTZEL, OF NEWTON, MASSACHUSETTS.

*Claim* 1.—A water level indicator for steam boilers, comprising a metal tube, means whereby said tube is attached to the side of the boiler to communicate therewith and with the steam drum indicator mechanism, said tube

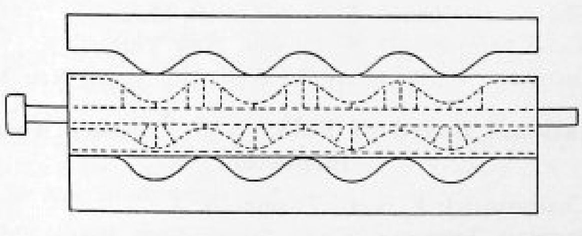




being rigidly mounted at one end and being free to move at the other end, and being connected at its movable end to the indicator mechanism by means which operates said indicator mechanism through the expansion and contraction of the tube, substantially as set forth. Four claims.

1,415,706. METHOD OF AND MEANS FOR BLOCKING OR CORRUGATING HEADERS FOR STEAM BOILERS. REES REES, OF KAPUNDA, SOUTH AUSTRALIA, AUSTRALIA.

*Claim* 1.—The method of blocking or corrugating a plain rectangular tube to form a header for a steam boiler which consists in:—assembling a num-



ber of specially shaped blocks and an intermediate draw-bar with the aid of several approximately semicircular plugs in an open-topped box to form as it were a core; inserting the assembled blocks and draw-bar in a heated tube, then pressing the same between top and bottom dies; and then withdrawing first the draw-bar and then the blocks. Three claims.

# THE BOILER MAKER

SEPTEMBER, 1922

Fig. 1.—Side Bay of Federal Boiler Shop with Combustion Chambers Under Fabrication

# Federal Shipyard Building Nine 80-Ton Scotch Boilers

**Largest Marine Boilers Constructed in New York District to Operate at 225 Pounds Working Pressure**

MANY special features of construction, due to their size, and the weight of materials used, have been incorporated in the nine single ended Scotch marine boilers which are now under construction for the Luckenbach Steamship Company at the Federal Shipbuilding Company's plant, Kearny, N. J. These boilers, which have a diameter of 17 feet 6 inches and a length of 13 feet, are intended for installation in ships of the Luckenbach fleet, which are being reconditioned at the Baltimore plant of the Bethlehem Shipbuilding Corporation. The boilers will be used to replace watertube boilers which were removed from the vessel.

Construction of the very highest quality has been maintained to meet the requirements of the United States Steamboat Inspection Service, the American Bureau of Shipping and Lloyd's Register of Shipping. The boilers are designed to burn oil under the heated forced draft system. The fact that the dry weight of each boiler will be approximately 80 tons gives an excellent idea of their unusual size. The weight of the shell alone with butt straps is about 67,000 pounds, while 3½ tons of rivets are used in each boiler. In the case of the butt straps, the rivets used are 8⅝ inches long and weigh 8¼ pounds each. The largest shell plate is 243⅛ inches by 144¼ inches by 2 inches and weighs 10 tons while the bottom heads are cut from plates 232⅛ inches by 164¼ inches by 1-3/32 inches and weigh 6 tons. The shell is made in one course and three plates are used in the circumference. The longitudinal seams are of double butt strap construction with both the inside and outside straps of equal width. The outside strap is 2 inches thick, as in the case of the shell plate, while the inside strap is 1¾ inches thick. Rivets 1⅞ inches in diameter are driven through holes drilled to 1-15/16 inches diameter. The efficiency of the plate used in the straps is 82.5 percent; the rivet efficiency 107.8 percent; and the combined plate and rivet efficiency 86.3 percent.

### General Characteristics

In order to increase the life and efficiency of the boilers in service, the scantlings have been kept well in excess of the requirements of the classification societies. Special attention in this connection is called to the thickness of the outer butt strap, mentioned above, which was made 2 inches thick to conform with the specifications and is 23 percent

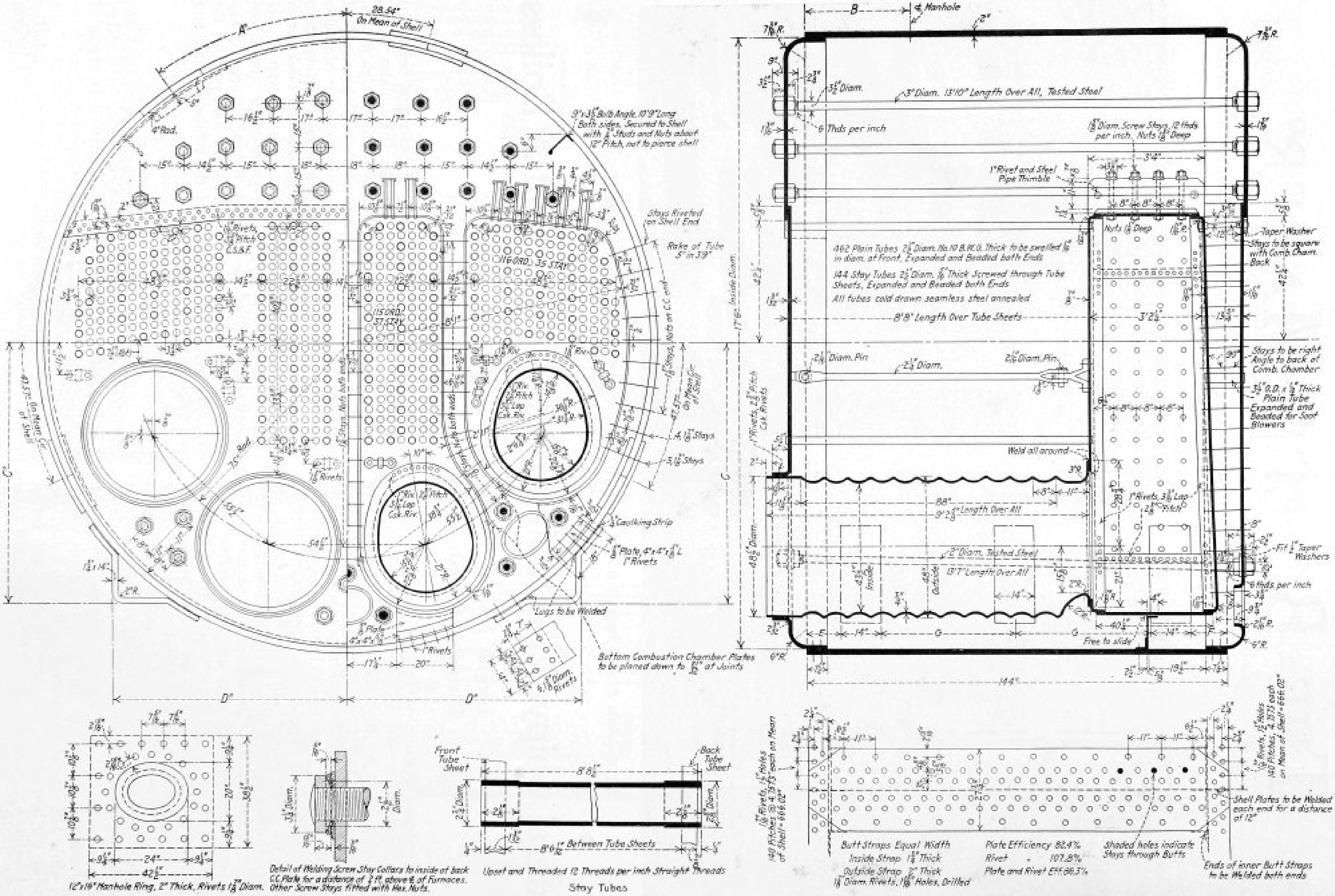



Fig. 2.—Structural Arrangement of New Marine Boilers with Details of Longitudinal Seams, Manholes, Tubes and the Like

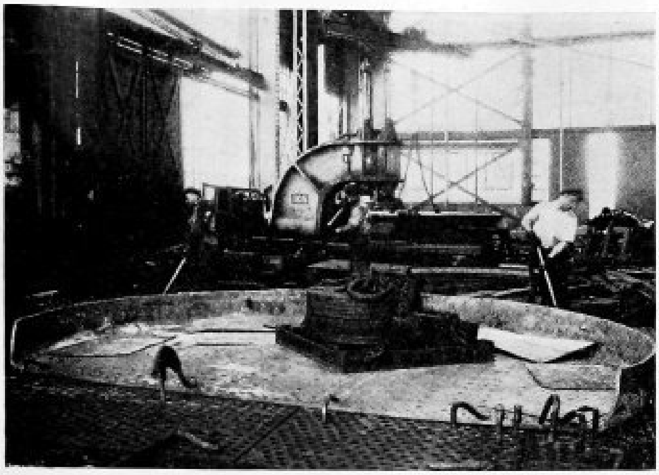


Fig. 3.—Furnacing and Annealing Boiler Head

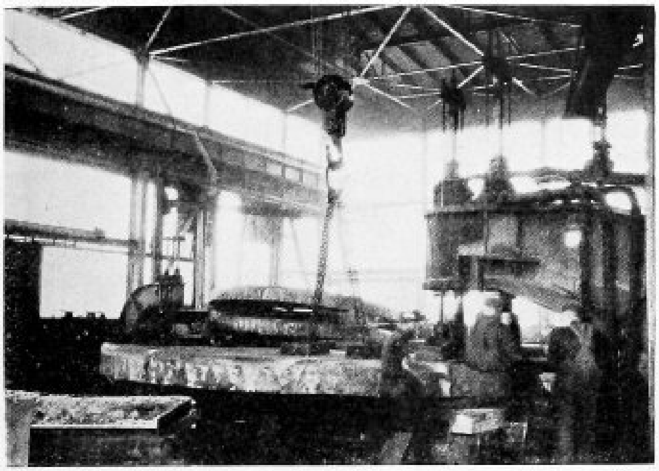


Fig. 5.—Flanging Lower Head

in excess of the requirements. Because of the extreme proportions thus provided, ample space has been available for a wide spacing of tubes and an unusually wide space between the lower banks of tubes and the furnaces. This feature, because of the possibility of adequate maintenance and cleaning facilities, will insure a high operating efficiency of the boilers at all times. The steam space ratio of 0.29, especially for a boiler of this size, gives a very large steam space and will tend to insure against priming. As a further preventative against priming in case of the ship rolling, two swash plates are provided by the installation of a 9-inch by 3½-inch bulb angle on each side of the shell above the waterline.

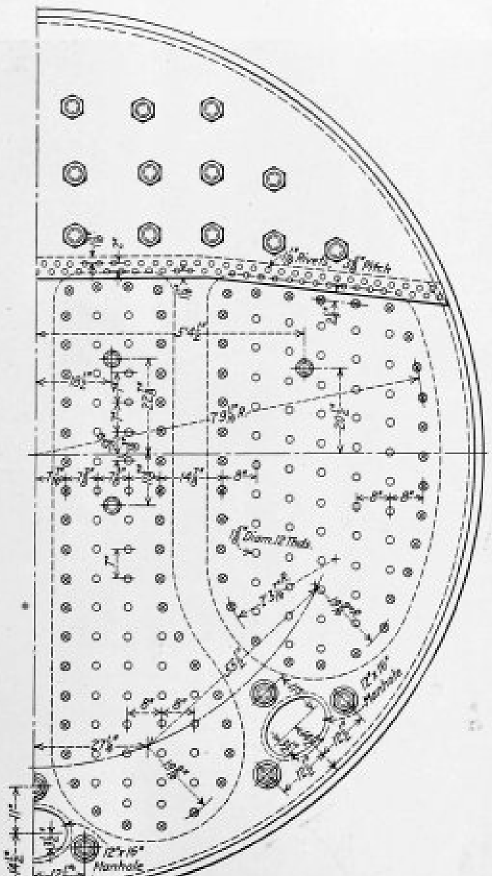



Fig. 4.—Details of Back Head of 80-ton Boiler

Each combustion chamber is supported from below by a stool or saddle riveted to the shell plate. These saddles are built up of 2½-inch by 2½-inch angles and steel webs of ⅝-inch plate so installed as not to interfere with access from the manholes and so that the combustion chamber is free to move.

All flange plates have large radii, those of the main heads being about 5 inches inside of the plate. Care in all cases has been taken that the shell plates and butt straps are circular in form and that the top of the back connections are well rounded at the corners.

There are three 12-inch by 16-inch manholes located in the lower back head between the furnaces and one near the top of the back head in the shell. The top heads are well braced with twenty-four 3-inch steel stays and the wide spaces in the lower heads and combustion chamber tube sheets are supported with eight 2½-inch crowfoot stays.

All tubes are of cold drawn seamless steel annealed and are 2½ inches outside diameter. The ordinary tubes, of which there are four hundred and sixty-two, are of No. 10 B. W. G. material, while the one hundred and forty-four stay tubes installed are 5/16-inch thick. The ordinary tubes are swelled 1/16 inch in diameter on the front end and the stay tubes upset and threaded on both ends. The tubes have a length of 8 feet 8 inches over tube sheets and are expanded and beaded over on both ends.

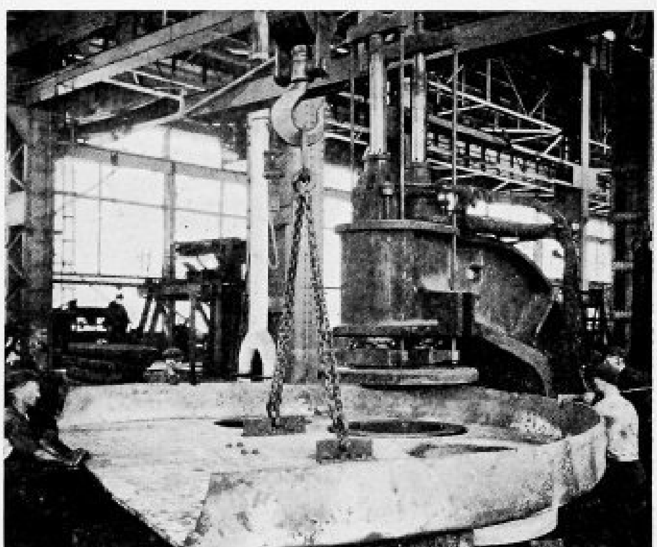


Fig. 6.—Flanging Furnace Holes in Front Head

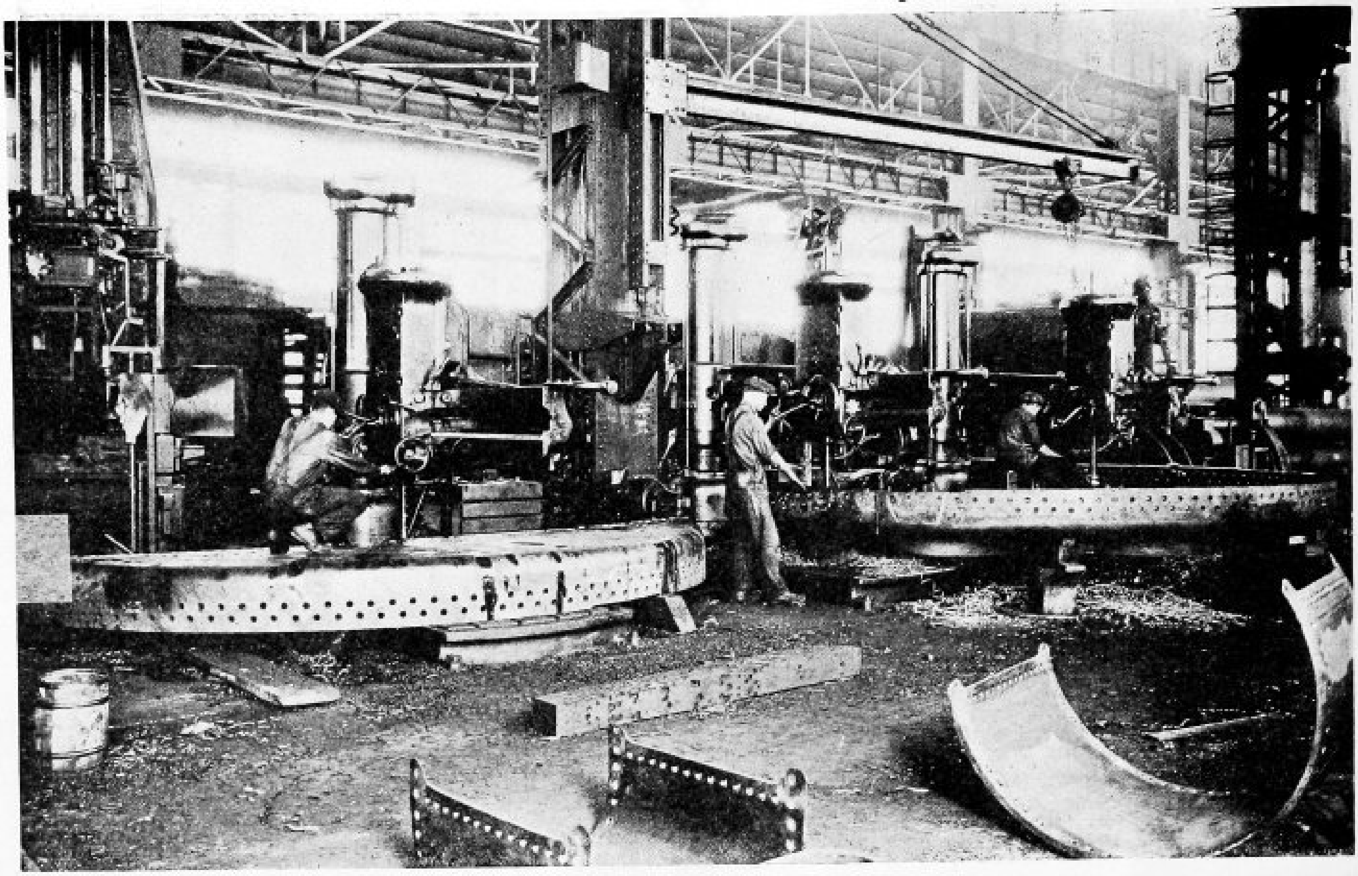


Fig. 7.—Cutting Tube Holes and Stayholes in Boiler Heads

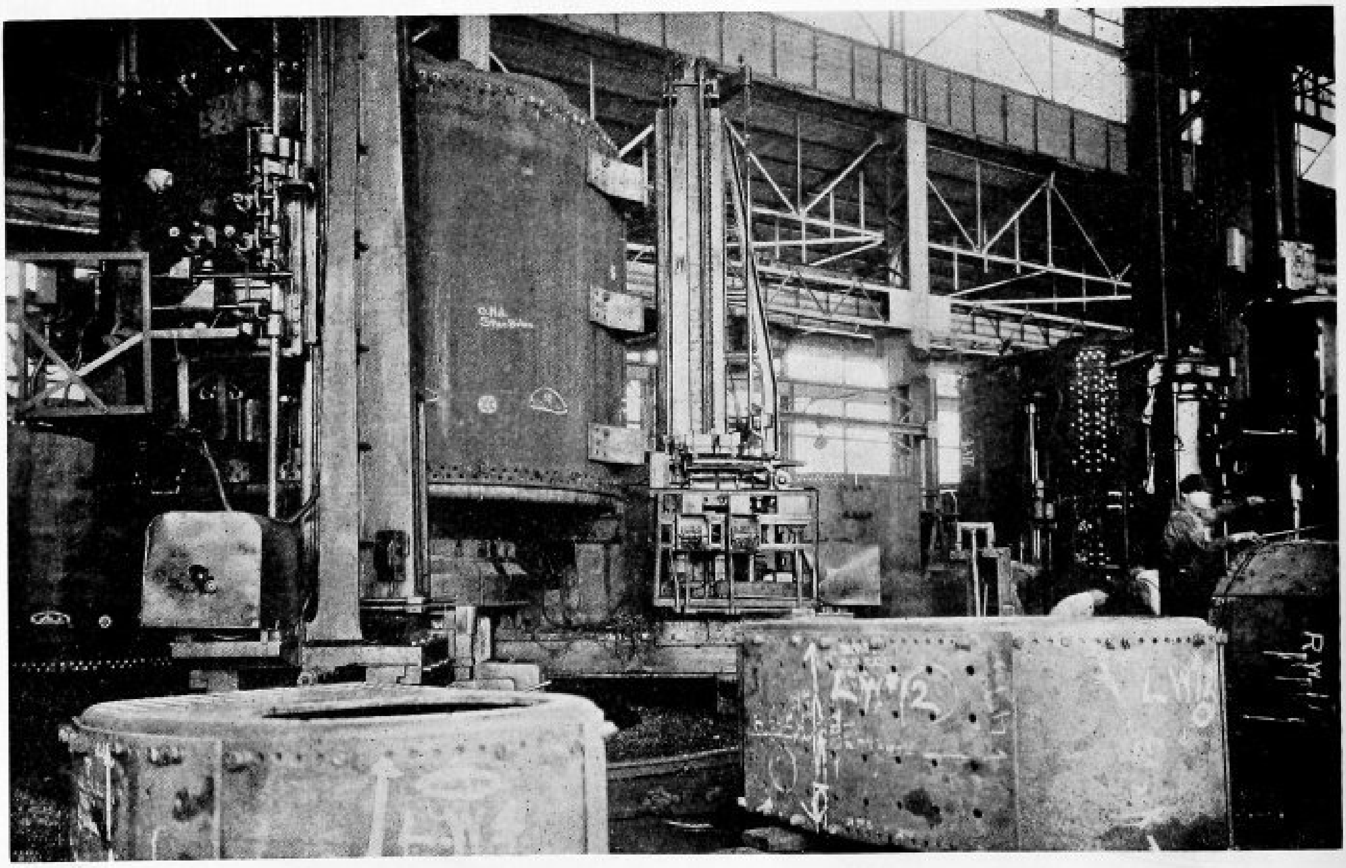


Fig. 8.—Drilling Holes in Boiler Shell

### Combustion Chambers

There are four separate combustion chambers in each boiler, each chamber being made up of ⅞-inch thick tube sheet and 11/16-inch thick back sheet and four wrapper plates. The top and side wrapper plates are 21/32-inch thick and the bottom plate 1 1/16-inches thick. All seams are single lap riveted with 1-inch countersunk rivets.

The backs of the combustion chambers have a 4-inch slope while the tops of the wing combustion chambers slope down toward the shell 5 inches from the center. All screw stays connecting the back sheets with the back head of the boiler are set in normal to the combustion chamber sheet. The screw stays are finished smooth between the plates to a diameter equal to the root of the threads.

Four furnaces of the Morison corrugated suspension type are fitted in each boiler and these have an inside diameter of 43½ inches. These furnaces have horse-collar connections to the combustion chamber with enlarged front ends to permit withdrawal.

Each boiler has six supporting saddles, three on each side, made of 1¾-inch plate 14 inches long. These saddles are secured to the shell with twelve 1⅝-inch rivets and a calking strip ¼-inch thick inserted between the shell and the saddles.

A perforated dry pipe 7 inches in diameter is fitted the full length of the shell with a cap on the end and securely fastened to the shell.

### Large Amount of Welding Used

In order to insure a tight boiler at all times, under adverse operating conditions and the difficulty of maintaining boilers at sea, an unusual amount of electric arc welding has been done on all the boilers. The seams and stay nuts in the combustion chambers are welded up to a point 2 feet above the centerline of the furnace. The inside butt straps are beveled down on the ends to the thickness of the boiler head flanges and welded across the ends at that point and for a distance of 6 inches along the head flange and the same distance along the butt straps from the flange. Where the shell plates butt together they are beveled and welded for a distance of 12 inches from each end. The saddle lugs, which are fitted with a ¼-inch calking strip, as indicated before, are welded on the inside of the lugs to the shell.

All seams of the combustion chambers in contact with flame are welded inside and out to protect the edges of the plates and insure against any possible leaks. This welding is carried to a point 2 feet above the centerline of the furnaces. All screw stays up to a point 2 feet above the centerline of the furnaces are fitted with special round collar nuts which are welded after being screwed on the stays.

All welding is built up of several layers to the required amount, each layer being thoroughly wire brushed and hammered before the succeeding layer of welding material is added. The finished weld in all cases is then peaned with pneumatic hammers.

### Fittings and Mountings

Six Diamond rear end soot blowers are fitted to each boiler; one in each wing combustion chamber and two in each inboard combustion chamber to enable all tubes being thoroughly swept by as near a direct jet of steam as possible.

All connections to the boiler heads and shell are fitted to nozzles of open hearth steel forgings which are riveted to the boiler. These nozzles are made of sufficient length to allow removal of valves without disturbing the lagging to get at the nuts and bolts. The main and auxiliary feed nozzles have necks extending through the head of the boiler and are fitted with a flange securely screwed on from the inside of the boiler. The zincs are supported by hooks on straps suspended down between the nests of tubes from the

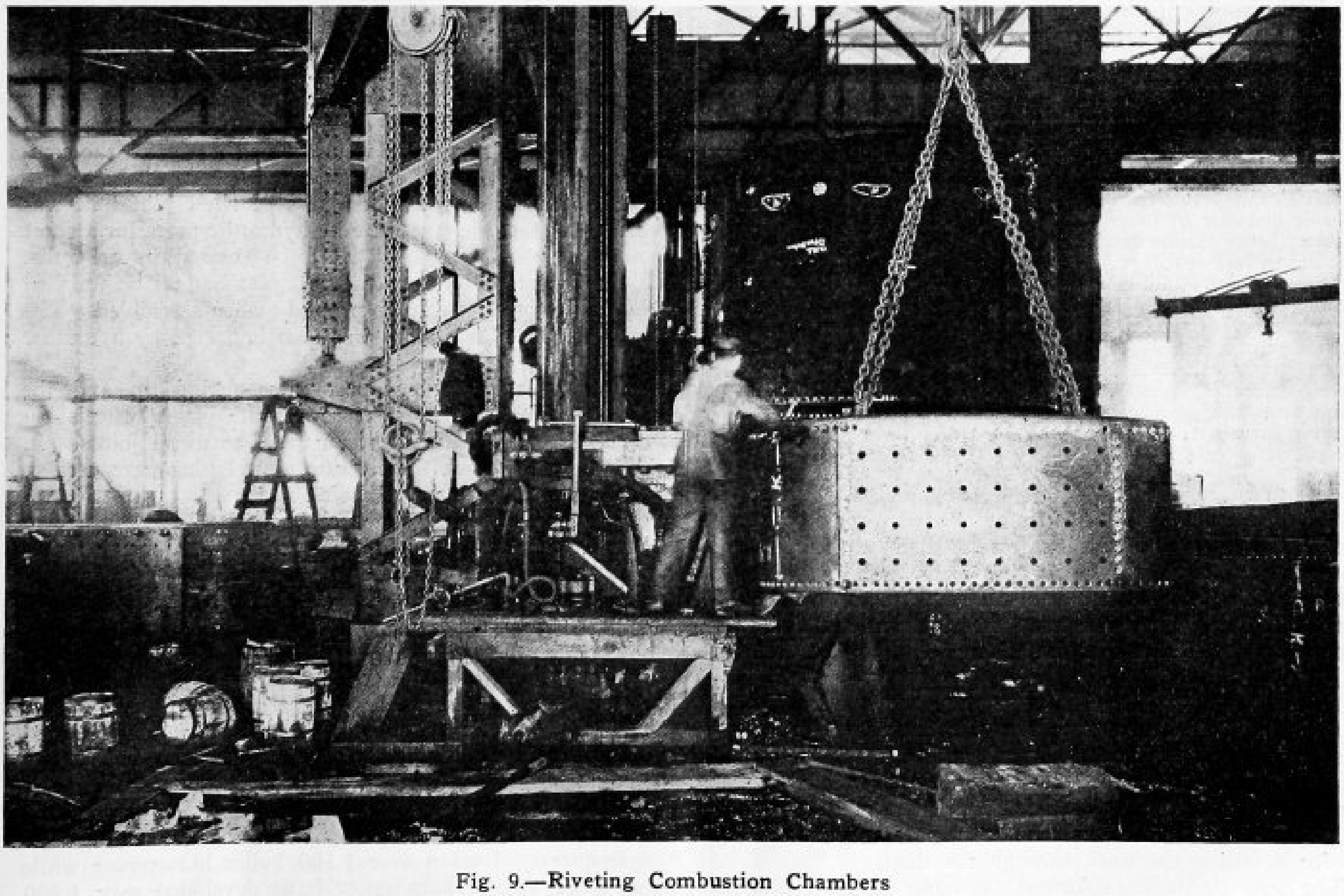


Fig. 9.—Riveting Combustion Chambers

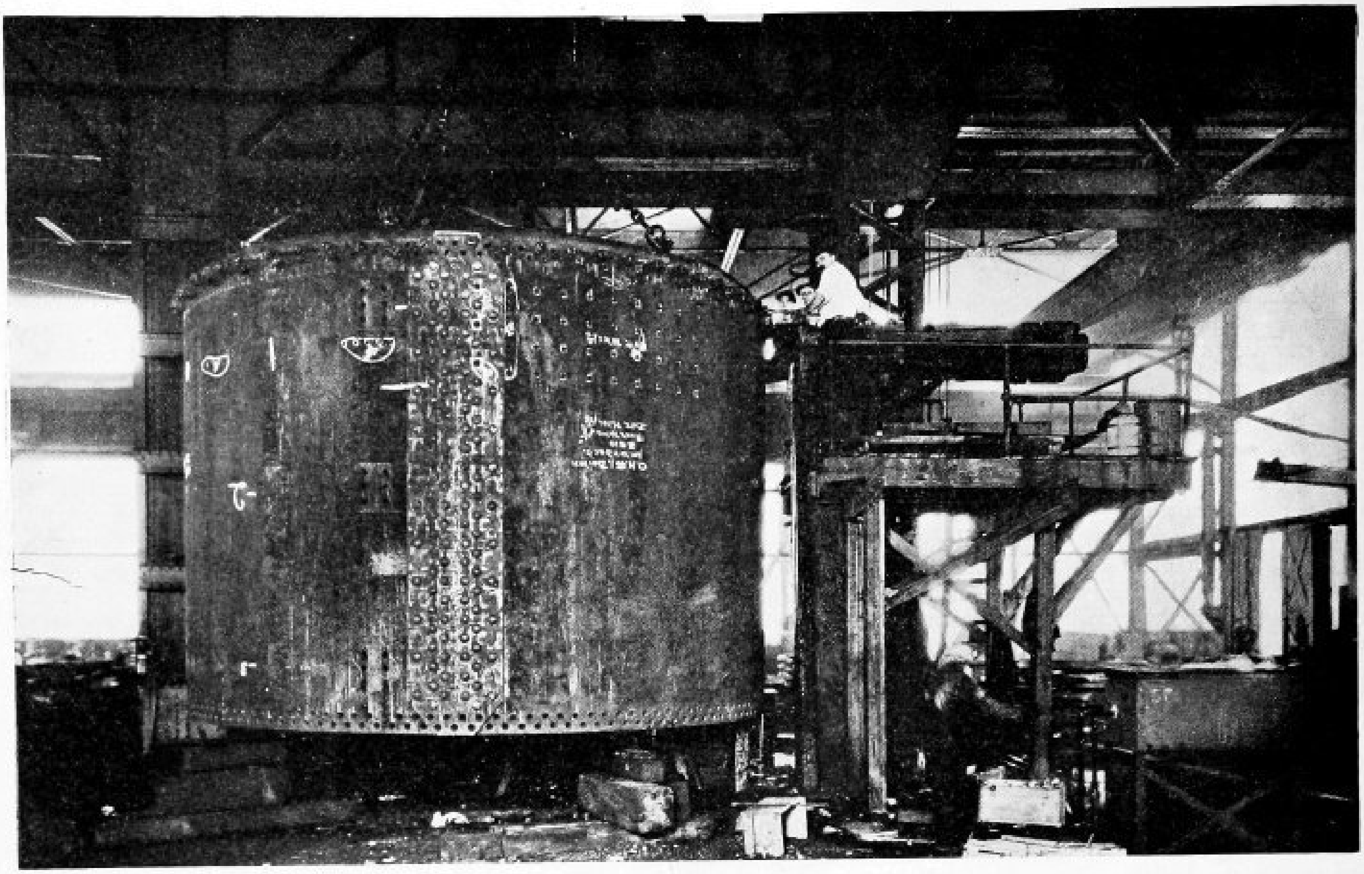


Fig. 10.—Fitting Up Head in Marine Boiler Shell

main stays. Thirty-six zinc slabs 12 inches by 6 inches by ½ inch are fitted.

### General Details of Boilers

| | |
|---|---|
| Diameter of boilers (inside) | 17 feet 6 inches |
| Length (over bottom heads) | 13 feet 0 inches |
| Thickness of shell | 2 inches |
| Number of furnaces | 4 |
| Inside diameter of furnaces | 43½ inches |
| Number of plain tubes | 462 |
| Number of stay tubes | 144 |
| Outside diameter of tubes | 2½ inches |
| Distance between tube sheets | 8 feet 6 1/32 inches |
| Heating surface of tubes | 3,370 square feet |
| Heating surface of furnaces | 425 square feet |
| Heating surface of combustion chambers | 465 square feet |
| Total heating surface | 4,260 square feet |
| Net area through tubes | 15.4 |
| Steam pressure | 225 pounds |
| Steam space | 0.29 |
| Equivalent grate area with 5-foot 6-inch grate | 79.75 |
| Heating surface ÷ grate area | 53.4 |
| Weight of boiler, dry | 80 tons |

The main steam connection is seven inches in diameter and is fitted with a wrought iron slotted dry pipe. A 1¼-inch Weir hydrokineter is fitted on the shell between inboard and wing furnaces for circulating water when starting to get up steam. A scum pan and salinometer cock are fitted to head of boiler. There are two water columns and three try cocks fitted to the head of the boiler.

### Methods of Manufacture

All work of manufacture from the flat plates to testing has been done in the boiler shop of the Federal Shipbuilding Company which is one of the best equipped marine boiler shops in the country. On account of the great size and weight of the boilers special and extra equipment was made up for handling the work through the shop.

The butt straps were formed to shape under a 200-ton hydraulic press. The 1⅞-inch rivets in the butt straps were driven by a 200-ton hydraulic riveter. Rivets in the circumferential seam of the back head were driven by a 150-ton hydraulic bull, while the rivets in the straight seams of the heads and the combustion chamber seams were driven by a 75-ton bull. In the circumferential seam of the front head the rivets were hand driven with pneumatic riveting hammers. Special riveters of 80 tons pressure were used for the seam at the furnace mouth which is riveted the complete circumference of the furnace.

Because of the extreme thickness of shell plates, it was necessary to start the curvature by hydraulic press for a short distance, so that the plates could be entered in the rolls. The outer edge of the longitudinal joint had to be finished by hydraulic press to fair up properly when assembled. The curvature of the butt straps was also imparted by hydraulic press.

All plates were taken apart after fitting up and the surfaces cleaned and burrs removed with emery wheels before reassembling to insure clean metal to metal joints. In reassembling the work for riveting, dowel pins were used to insure perfect alinement of holes.

These boilers in general represent the last word in Scotch marine boiler design and construction and their service records will serve to uphold the reputation for reliability under adverse conditions that this type boiler has gained in its years of powering the merchant ships of the world.

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Locomotive Boiler Horsepower.—Experiments conducted under D. F. Crawford while general superintendent of motive power for the Pennsylvania system indicate that to obtain average and maximum power from a locomotive, fuel must be burned at a rate of from 100 to in excess of 150 pounds per square foot of grate per hour. For example, boilers rated at 320 horsepower according to heating surface frequently develop over 1,500 boiler horsepower while others rated at 400 horsepower have developed over 1,900 boiler horsepower.

# Relative Value of Steel and Copper Fireboxes*

## Tests of Locomotive Boilers on European Railroads Indicate That Steel Fireboxes Give Longer Service

**By Paul Conté**

IT can be said, in general, that the fireboxes of the boilers of locomotives are made of steel in the United States, whereas almost everywhere else they are made of copper, particularly in Europe. It cannot be given as a reason for the greater use of copper that this metal is a better conductor of heat. The trials made by the Pennsylvania Railroad, at Altoona, with locomotives equipped with steel fireboxes showed that the heating surface gave forth as much heat in the case of these fireboxes as with the fireboxes of the boilers made of copper and it is, moreover, a well known fact that the power of the boilers was not diminished when copper tubes were replaced by steel. As far as the ease of making repairs is concerned, this is about the same with the steel as with the copper fireboxes and it can even be said that, since the practical use of autogenous welding, repairing is easier with the steel than with the copper fireboxes.

In Europe extensive trials at replacing copper fireboxes with steel have failed because the steel fireboxes suddenly cracked either in the middle of the plates or else fissures appeared radiating from the rivet holes, and these accidents appeared to be the result of the rapid cooling of the plates.

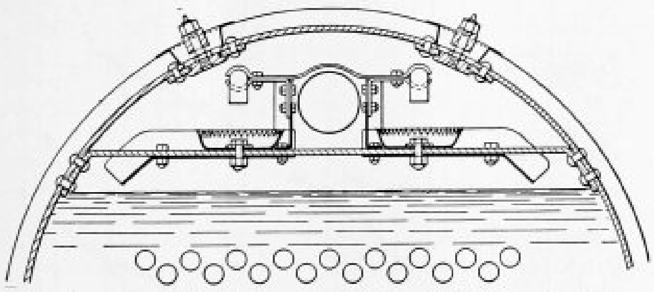

**Fig. 1.—"Trick Feed" Used on Locomotives of the Paris-Orleans**

We were, therefore, led to conclude that, in order to maintain the steel fireboxes in good condition, it was necessary to avoid submitting them to any rapid change in temperatures and the reason the Americans were able to continue to use steel fireboxes was because of the special precautions which they must have taken to avoid these rapid changes and which we in Europe knew nothing about. During a trip for study to the United States, we were able to examine these precautions closely and we found that they could be summed up in two definite rules:

1. The boiler should never be washed except with hot water and it should also never be filled except with hot water.
2. The formation of scale on the lining of the firebox should be avoided as much as possible.

The washing and the filling with hot water is now performed in the large American terminals by using fixed pipes fed by special boilers. In terminals of lesser importance, the injector of an engine under steam is used. It was therefore necessary before renewing the trials of the steel firebox on the Orleans railroad, to begin by spreading the practice of washing and filling the boilers with hot water, either by employing the injector of a locomotive under steam, or by some other means. It was only when this custom had been generally adopted on the railroad that we were able to again take up the trials of the steel fireboxes.

These trials began in 1907. In order to carry them out under the best conditions, the 12 fireboxes put into service from 1907 to 1908 were ordered in the United States, and delivered completely erected. The staybolts were also made from charcoal iron bars from the United States. Furthermore, in order to avoid as far as possible the formation of scale on the lining of the firebox, it was decided to use in connection with the trial boilers a special system of steam feeding which allows the water employed for filling to be heated by the steam of the boiler to a temperature near that of the saturated steam.

### Heating the Boiler Feed Water

This very simple system, called on the Orleans railroad "Trick Feeds," is composed merely of a tray placed inside the body of the boiler shell above the normal level of the water, and on which the water for filling the boiler falls. (See Fig. 1.) The water spreads out in a thin layer on the tray before running into the boiler, is heated by the contact with the steam and the scale falls off in small particles which drop on the tray or run along the walls of the barrel to its bottom. The crystallizing of the scale on the walls of the boiler and particularly on those of the firebox is thus avoided. It is naturally necessary to place a handhole outside the cylinder and above the tray in order to allow the complete cleaning of the tray.

These "Trick Feeds" have been placed on all the locomotives of the Orleans railroad constructed since 1906 with copper or steel fireboxes and have never been the cause of any trouble. The boilers show a minimum amount of scale. Furthermore, by heating the supply water to the temperature of the water of the boiler, an equal temperature is obtained at all points of the boiler and in this way the formation of colder zones is avoided in the bottom of the barrel and in the water legs. We also noticed that with the engines equipped with "Trick Feeds" the lapse of time between heavy boiler repairs, such as the replacing of the tube sheet or the firebox, was noticeably longer than with the locomotives of the series constructed before that time and which were not so equipped; but as different types of locomotives were concerned we were unable to draw definite conclusions.

### Engines Equipped with Steel Fireboxes

The first use of steel fireboxes was made in 1907 and 1908 on 12 locomotives, six of which were of the 2-4-6 type with a grate surface of 18.4 square feet, and six of the 0-8-0 type with a grate surface of 18 square feet. As this trial gave good results it was continued, and in 1909 and 1910 steel fireboxes were placed on 27 boilers, 16 on 2-4-2 type locomotives and 11 on 0-8-0 type locomotives of the same sort as previously. In 1914, 40 more were added. In 1915, it was decided to replace with composite fireboxes (rear plate only of copper) the copper fireboxes of the old locomotives which had reached the limit of their service. Finally in 1918 and 1919 the Orleans railroad put into service 150 Mikado locomotives constructed in the United States with fireboxes entirely of steel. At the end of 1917 the Orleans

*Abstract of an article appearing in the Revue Generale des Chemins de Fer. Mr. Conté is a naval constructing engineer and also assistant chief engineer of the Central Office for the study of French railway equipment.

railroad had in service nine tube plates or composite fireboxes on the four-cylinder compound engines and 160 fireboxes of steel or composite on the old locomotives.

### Results of the Trials

As regards heat transmission, it was found that there was no difference between similar locomotives, whether the fireboxes were of steel or of copper. From the point of view of upkeep, the trials showed a noticeable advantage in favor of the steel fireboxes. In general the steel fireboxes gave very good results. The locomotives of the 2-4-2 and 0-8-0 types had the door frames and the frames of the openings of solid forged iron which were retained. The result of this was that

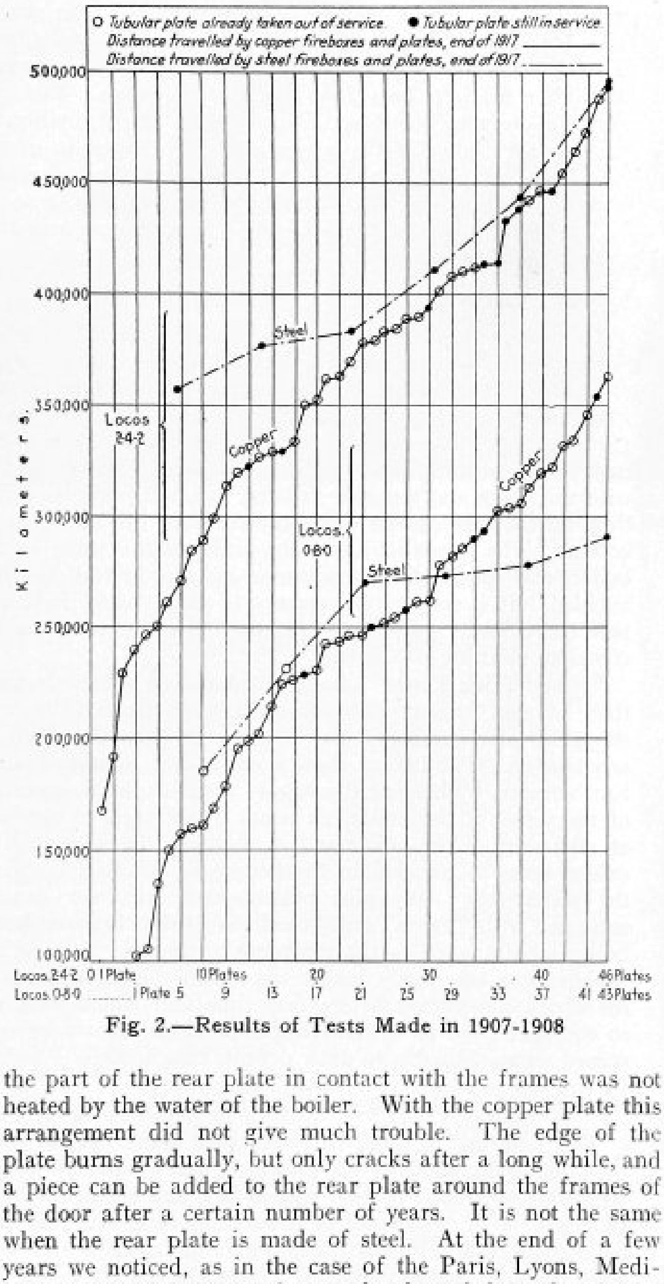


**Fig. 2.—Results of Tests Made in 1907-1908**

the part of the rear plate in contact with the frames was not heated by the water of the boiler. With the copper plate this arrangement did not give much trouble. The edge of the plate burns gradually, but only cracks after a long while, and a piece can be added to the rear plate around the frames of the door after a certain number of years. It is not the same when the rear plate is made of steel. At the end of a few years we noticed, as in the case of the Paris, Lyons, Mediterranean trials in 1893, that cracks showed themselves in the part of the plate in contact with the frame. These tests extending over a period of 11 years showed that in cases where solid frames were used for the door openings, it was preferable to make the rear plate of copper, and since 1914 all the steel fireboxes installed in our locomotives under these conditions were composite fireboxes. We have not, however, abandoned the idea of constructing complete fireboxes of steel and in the new spare boilers for locomotives of the 0-6-0 type put into service in 1918, as well as in the 150 Mikado engines in 1917 we constructed the firebox entirely of steel, taking the precaution, however, to protect the part of the plate in contact with the door by a flame-shield and abolishing the small openings of this door. As the boilers were new, we took advantage of this fact to adopt a type of door opening in towards the firebox which made it easier to install a proper flame-shield as mentioned above.

As regards the 40 composite fireboxes installed in 1914, at the end of 1918, we found trouble only in the case of three fireboxes of locomotives of the 0-8-0 type resulting from circumstances which are worth while relating in order to show the ease with which steel fireboxes are affected by cold. In these three locomotives from the Tessonnieres Terminal, with composite fireboxes, cracks were found at the same time in 1916, in their sides and in one of them in the tube plate, opposite the handholes for the washing of the outside envelope. An examination was made and it was found that, in order to easily do the washing, it was necessary to move the engines out of the terminal and that the prevailing wind, which is very strong in that region, came from such a direction when the locomotive was at the wash-stand that it blew directly through the holes for washing and struck the plate opposite as soon as the cover was detached. As these

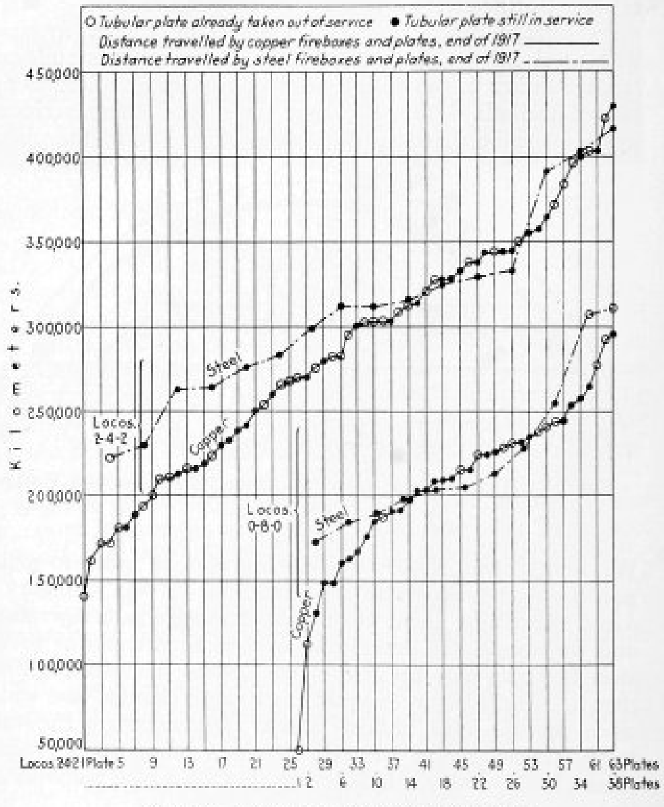


**Fig. 3.—Results of 1909-1910 Tests**

cracks only occurred on one side of the engine and always the same, it was proved that it was certainly the action of the wind which caused the cracks.

### Lasting Qualities of Steel and Copper Fireboxes

The criterion for judging the wearing qualities of a firebox is the distance traveled by the locomotive between the time the firebox is installed and when it is replaced. As this distance is very great, both for the copper and for the steel fireboxes, we have had to limit ourselves to comparing the distance traveled between the time of putting into service and the replacing of the tube plate, this plate being usually the first part which has to be replaced in a firebox.

Six steel fireboxes were installed in 1907 and 1908 on passenger engines of the 2-4-2 type. Up to the present time no tube plate has been replaced. The average distance traveled by the six engines was 257,375 miles at the end of 1917. During the same period, 1907 and 1908, 46 copper fireboxes or tubular plates were installed on the other locomotives of the same series. Out of the 46 plates, 38 had been replaced and the average distance traveled by these 46 engines, at the end of 1917, with the fireboxes or tube plates installed in 1907 and 1908, was 225,000 miles. Out of the six steel fireboxes placed on the locomotives of the 0-8-0 type, two tube plates were replaced after traveling an average distance of 130,000 miles. The average distance traveled by the six fireboxes was 159,375 miles at the end of 1917. During the same period, 1907 and 1908, 43 copper fireboxes or tube plates had been installed on locomotives of the same series. Thirty-seven have been replaced at the present time and the average distance traveled by these 43 fireboxes or plates was 153,750 miles at the end of 1917.

The curves (Fig. 2), which show the distance traveled at the end of 1917 by all the plates, furnish an idea of the service given by the copper and by the steel plates.

Sixteen steel fireboxes were installed in 1909 and 1910 on engines of the 2-4-2 type . Up to the present time only one tube plate had been replaced after traveling 138,750 miles. The average distance for these 16 fireboxes was 194,375 miles at the end of 1917. During this same period —1909 and 1910—63 copper plates or fireboxes had been placed on locomotives of the same series. At the present time 34 plates have been replaced and the average distance traveled at the end of 1917, by the 63 plates or fireboxes was 179,375 miles.

Eleven steel fireboxes were replaced during the same period on locomotives of the 0-8-0 type. Two fireboxes were replaced after making an average of 194,375 miles. The average mileage made by the 11 fireboxes was 136,250 miles at the end of 1917. During this same period, 1909 to 1910, 38 copper plates or fireboxes were installed on engines of the same series. Fourteen tube plates have already been replaced and the average distance of the 58 tube plates or fireboxes at the end of 1917 was 129,375 miles.

The curves in Fig. 3 show the comparative mileage made by the copper and the steel plates.

### Effect of Scale on Steel and Copper Fireboxes

Contrary to what might have been expected at first thought, we noticed no particular effect on the steel fireboxes caused by the nature of the water. We found no corrosion in the case of the fireboxes filled with water of a nature likely to corrode the tubes. Furthermore, in the case of the steel or composite fireboxes in service in the terminals of the railroad, particularly at Etampes and Capdenac where the water is very calcareous and contains a large percentage of calcareous salts, we noticed no formation of scale and no difficulty arose while in service, whereas the copper fireboxes, fed with the same water, showed abnormal wear and cracks between the holes of the tubular plates. We must add that, during the war, a certain number of engines of the 0-8-0 type were used in the field service, particularly on the Nord railroad where the water is very calcareous. In spite of the special conditions under which these locomotives were used, no trouble with the fireboxes has been brought to our attention.

It should be stated in connection with these tests that the steel fireboxes were installed under the same conditions as the copper ones, without taking any special precautions. The rods were riveted at the two ends and given a head slightly reduced in size, without receiving the usual finish of the copper rods. The assembling of the tubes in the tube plates was done by the American method; that is to say, by inserting a thin plate of copper between the tube and the plate and then expanding the tubes, driving them into the plate and turning down the edges.

This method gave the best of results and when the work is well done it is unnecessary to touch it again.

### Conclusions

As a result of the very thorough trials which we have just described, we are convinced that by using the special precautions, which we have mentioned in this article, steel or composite fireboxes can be substituted for copper ones. It would even seem that the length of service of steel fireboxes was greater than that of the copper ones. Moreover, as the steel fireboxes are much lighter and cheaper than those of copper, this conclusion is of the greatest importance. We draw attention again, however, to the absolute necessity, before making a trial or installing a large number of steel or composite fireboxes on a railroad, of beginning by making it a general custom to do the washing and the filling of the boilers with hot water, in order that this may be the general practice, before putting the steel fireboxes into service. A locomotive, as a matter of fact, has to go to several terminals of the railroad. The washing and filling with hot water should therefore be a general custom at all points. Otherwise one would run the risk of putting the firebox out of service by one single washing with cold water done under bad conditions.

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## Mechanical Design of Locomotives

Before the advent of the heavy modern locomotive, the mechanical features of the locomotive design did not demand very careful attention. In most cases the parts were light, clearance was not a limiting factor and stresses and pressures were well within the allowable limits for ordinary material. In the locomotive of today, conditions are entirely different. So many restrictions hamper the designer that it is often impossible to keep within the limits of good practice. As a result, the maintenance of machinery is becoming more and more troublesome. It is interesting to compare the designs of early locomotives with those of the present day. Such a comparison soon makes it evident that many locomotive parts as commonly constructed are merely overgrown specimens of designs that were in use when the prevailing type for passenger and freight service was the eight-wheel locomotive. Many of these designs have the merits of being simple and easily made, but has not too high a value been placed on simplicity and low cost in the design of motive power? There are opportunities for refinements that save weight, reduce the cost of upkeep and increase the proportion of time the locomotive spends on the road. There is a field for improved material that will give longer service between repairs. Such refinements can more than pay their cost, especially under present labor conditions.

It is natural to ask where refinements in the design of machinery should begin. The logical method would be to start with those parts which cause the heaviest expense for repairs and time out of service.

A few of the more important features of the newer locomotives, feed water heaters, the use of superheated steam for the auxiliaries, the use of water circulating devices, double arches, thermic syphons, and the like, as part of the boiler design, combined with improvements in the mechanical details, should be considered in the construction of future locomotives. Simple, straightforward construction will not give results on modern locomotives and today further refinements are essential. In the past simplicity has been almost an end in itself, but it is well to bear in mind that refined designs are not necessarily complicated designs, and that complicated designs are not necessarily expensive to maintain.—*Railway Mechanical Engineer.*

# Increasing Locomotive Boiler Efficiency by Proper Circulation of Water*

By F. G. Lister†

THE benefits to be derived from positive circulation of water on heat transfer in steam boilers has in years past been quite neglected in steam boiler design, and only in these later years has the subject been given meritorious study.

Circulation of the water in the boiler is its flow caused by the density differing in various parts of the boiler due, in part, to the difference in temperature and also to the formation of steam bubbles. The rate of the circulation depends upon the rate that the steam bubbles are formed from the heating surfaces and their unrestricted liberation and rising to the top forcing the colder or heavier water to settle to the bottom.

Positive circulation, in addition to mixing the hot and cold water together, materially increases the effectiveness of all of the heating surfaces by bringing the moving currents directly in contact with the radiant surfaces, thus adding to the ability of the water to take up heat. It also prevents in a large measure the accumulation of scale forming deposits in the boiler, and as such impurities are prevalent in most waters, and when the water is evaporated remain to incrust the surfaces of the boiler, circulation should without any question of doubt play a very important part in cleaning the boiler of them, as incrustation sometimes becomes quite serious, so much so that the transmission of heat through the metal is almost entirely prevented. Good circulation allows a hotter fire to be carried, which in turn boils away the water more rapidly, and at the same time reduces the liability to waste heat by what is technically known as priming.

An annoying condition in a locomotive boiler is the chemical action set up, especially in the belly of the shell, due no doubt to the very slow circulation or more likely lack of circulation of the water, which prevents the precipitated impurities from being carried out. Corrosion, which is a chemical action set up between the acids in the water and the metal, of course, varies quite materially, depending upon the composition of the metal in the sheets, and the nature of the acids in the water, but can to a great extent be overcome if the water can be kept moving.

### Early Design Horizontal Boilers

In the earlier designs of locomotives the vertical type of boiler seemed to prevail. The value in those days of circulation of the water in the boiler was not particularly realized, the principal desire having been to create more steam by adding as much heating surface as possible. This heating surface was increased in various ways, most of which did not seem to prove very effective.

The horizontal type of boiler succeeded the vertical type about 1840, and closely following this time British builders began to make modifications in them in order to secure additional heating surface. Some of the modifications consisted in what were termed "mid-feathers," some of these "mid-feathers" being placed crosswise and others lengthwise of the firebox. Others hung down from the crown sheet in the shape of pockets or channels, the construction being similar in some respects to the Nicholson thermic syphon of today, except that they had no connection with the tube sheet.

Tests conducted in 1920 by the Bureau of Locomotive Inspection, Interstate Commerce Commission, which terminated in the recommendation of the Chief Inspector that water columns equipped with water glasses and gage cocks be applied to locomotives, revealed without any question of doubt that there is a very swift movement of the water up the sides and back of the firebox, emerging onto the crown sheet in fountain or geyser-like effect, so that a true register of the height of the water in the boiler could not be depended on where the water glass and gage cocks were connected directly into the boiler.

The fact has for many years been recognized that the temperature of the water should be raised before it should come in contact with the water already in the boiler, and with this prevalent fact in mind many devices have been tried in an effort to put the water into the boiler at a high temperature in order that a uniform and constant thermal condition might be created in the boiler.

Aside from the supposition that the water traveled from the front end of the boiler along the bottom of the barrel, down the back tube sheet and up the sides and back of the firebox, little additional attention appears to have been devoted to the study of the true principles governing the proper heating of the water in the locomotive boiler and the events which caused the water to circulate.

Only since the subject has been given systematic study has it been considered that positive means should be provided to keep the water constantly traveling throught a "trodden path." Angus Sinclair in his "Development of the Locomotive Engine" says, in reference to forcing a boiler beyond its endurance: "The inability of the ordinary firebox to withstand the heat of the high combustion is due to the fact that natural circulation will not keep the heating surface covered with water as fast as it is evaporated." This same thought has, no doubt, occurred in the minds of a great many, and has possibly been the nucleus around which the various later methods and devices have been developed for stimulating better circulation.

### The Thermic Syphon

Among the various innovations in locomotive boiler construction probably none has created more attention than the thermic syphon. Results of tests conducted during the last four years on a number of railroads demonstrate that this device has passed the experimental stage, and will probably be one of the standard fixtures in the locomotive of the future, as is the arch tube at the present time. They are in service now on twenty-seven railroads.

The first pair of syphons went into service on the Chicago, Milwaukee & St. Paul Railroad in June, 1918, and at the present time they are still in service, apparently in approximately as good condition as when installed.

As with practically all new devices it had to pass through its experimental stage, but now it appears to have reached a final state of development. Located in the hottest part of the firebox, extending in triangular form from the crown sheet to the throat sheet, the additional radiant heating surface provided in the firebox must naturally increase the boiler efficiency proportionately, but the heating surface to be effective must be assisted by circulation of the water over same. The more rapid the circulation, the greater amount of heat will be transferred from the firebox and tubes to the water.

The water entering the boiler at the check being of a lower temperature than the water already in the boiler, falls to the

*Abstract of a paper presented before the meeting of the International Fuel Association recently held in Chicago.
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bottom, and through the partial vacuum set up by the mixture of steam and water traveling up through the syphon, sucks this water into the intake channels located in the belly of the boiler, and connecting with the throat of the syphon at the throat sheet carries it up into the syphons.

As the water in the syphon, which lies in the direct path of the hottest flames in the firebox, evaporates, steam bubbles rising to the surface, coupled with the difference in density of the water in the syphon and in the forward portion of the boiler, create an upward movement of the water through the syphon, syphoning it through the intake channels from the front end of the boiler backward to the syphon and up over the crown sheet and forward to the front tube sheet again. Its temperature by this time should neutralize with the other water, the temperature depending on the number of heat units in the water, the velocity of flow, the rate at which steam is taken from the boiler, and new water injected into the boiler.

The fuel economy, the manufacturers say, resulting from the water passing through the intake channels, adds to the saving effected by the syphon itself, due to the fact that tube heating surface is constantly swept by this flow of water, which increases the heat transfer by assisting in disengagement of steam bubbles from the tubes and sheets, thus freeing the surfaces of all accumulations of steam and allowing a close contact at all times between the water and heated surface. In locomotives equipped with the syphon, the mud deposits collect in the rear water leg, where they can be easily washed out.

Results of tests of locomotives equipped with the thermic syphon conducted on several railroads indicate an increase of from 10 per cent to 27 per cent in the water evaporated per pound of coal, with a corresponding increase in gross ton miles. As in the arch tube installations the brick arch serves its important part with the thermic syphon in increasing the firebox temperatures and in making the firebox heating surfaces absorb more heat.

### Harter Circulating Plate

The Harter circulating plate is one of the more recent developments for creating or inducing circulation in the locomotive boiler. It is the invention of Charles Harter, mechanical engineer of the Missouri Pacific Railroad. It consists of a curved plate extending horizontally from side to side of the barrel of the boiler between the tubes, reaching backward to within about 4 inches or 5 inches of the rear tube sheet and forward to within about 30 inches of the front tube sheet. Into the circulator plate are inserted a number of 2-inch tubes or pipes known as steam risers, which extend upward through the tubes and terminate close to the top of the boiler sheet. These tubes or pipes are provided for the purpose of carrying up into the steam space the steam generated below the plate.

The object of the circulator plate is to provide a definite circuit or path for the water from the sides and crown of the firebox forward over the plate, around the end and backward under the plate and around the firebox, from which the same course is repeated several times a minute. Its use, along with arch tubes, should increase its efficiency value very materially. It is stated by Mr. Harter that the impurities in the water are carried back into the water legs, where they can be washed out or blown out, and that the rapid travel of the water along the tubes and sheets retains a clean heating surface with a reduction in scale formation and the prevention of the adhesion of the steam to the metal.

From data furnished by him an engine of 50,000 to 60,000 tractive power equipped with the plate will raise steam to the required steam pressure in from 30 to 45 minutes less time than the same class of engine not so equipped, and that from a series of comparative tests conducted a saving of fuel consumption averaged 15 per cent.

While considering means for assisting circulation it should be worth while to consider the feed water heater. In addition to the saving of fuel accomplished by the use of exhaust steam for heating the water before entering the boiler the steaming capacity of the boiler is increased, due to the fact that the heating surfaces are relieved of some of their work when the feed water has received some of its heat before it enters the boiler. The boiler is able to generate more steam with the same heating surfaces.

### Washout and Refilling System

While possibly not considered as directly responsible for assisting in the circulation of water in the locomotive boiler, there is no other one apparatus that does more to make circulation easier and more effective than the locomotive washing and refilling system, which is now quite universally used.

Its particular advantage (aside from the time and fuel saved in washing the boiler and getting up steam again) is in the even temperatures maintained in the boiler.

The longer it takes to fire an engine up the harder it is on the boiler. The washout and refilling system not only protects the boiler against undue strains caused by rapid change of temperature, but on account of supplying water to the boiler at close to boiling point the pressure is quickly raised.

A difficulty that must be overcome in rapid circulation in bad water localities, where water is not treated before or after it enters the boiler, is the foaming caused by the rapid movement of the water, thereby carrying the impurities along and holding them in suspension, not allowing them an opportunity to precipitate and be deposited at the mud ring, where they may be easily blown out.

It may be difficult for a locomotive to make a round trip under such conditions without the necessity of changing the water in the boiler at each terminal.

Circulation holds an important place in the safety of the boiler in preventing unequal strains due to the expansion and contraction. It should also prevent the crown sheet from becoming overheated in case the water level should drop below it. Most explosions of locomotive boilers are the result of strains set up by unequal expansion.

The advantages to be derived from proper circulation may briefly be summed up as follows:

A cleaner boiler, which means higher heat transfer and more water evaporation per pound of fuel, which is conducive to fuel economy or a higher boiler horsepower; elimination of pitting, and elimination of strains due to unnecessary expansion and contraction; a lower maintenance cost and longer life.

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## Advertising Statement Inserted in Reprint from The Boiler Maker Without Authority

A REPRINT of the report "Defective Staybolts Cause Locomotive Disaster" which appeared in the April issue of THE BOILER MAKER, made by the Falls Hollow Staybolt Company, Cuyahoga Falls, Ohio, and now being distributed, contains a statement under the author's name which did not appear in the original article and should not have been used as a part of the reprint.

This statement, which reads: "Note—Do staybolts break at the inside sheet? This accident proves that they do—and proves the necessity of Falls Hollow Staybolts in lieu of telltale holes in the outer end only," if used at all should have been entirely distinct from the article, appearing either above the credit line or at the end of the Bulletin, so that there should be no question but that the company was wholly responsible for the statement.

Neither the author nor THE BOILER MAKER were informed as to the manner in which this statement would appear and are in no way responsible for its publication.

# 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, C. W. Obert, 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.

Below are given the interpretations of the committee in cases Nos. 365 and 396 to 405 inclusive, as formulated at the meeting of June 29, 1922, and approved by the Council. In accordance with the Committee's practice, the names of inquirers have been omitted.

CASE No. 365. *Inquiry*: Is it permissible, under the requirements of the Boiler Code, to weld together the outwardly projecting edges of furnace door hole flanges by the autogenous process, provided the form of the circular door opening and the autogenous or fusion welding is as shown in Fig. 1, and the staybolting around the opening does not exceed the permissible staybolt pitch as given in Par. 199?

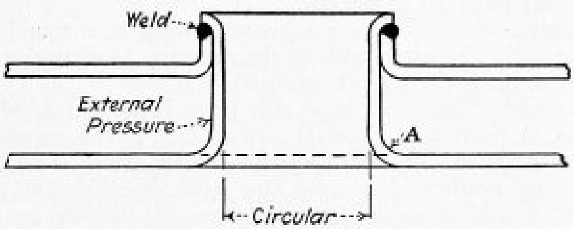



**Fig. 1.—Construction of Furnace Door Opening with Projecting Edges Flanged and Welded**

*Reply:* It is the opinion of the committee that a circular door opening, of the form shown, in which the projecting cylindrical portion of the inside sheet is provided with an outwardly turned flange, at its extreme edge, to form an abutment for the edge of the circular projecting flange of the outside sheet and is made leak-proof by autogenously filling the space between these two flanges, will meet the requirements of the Boiler Code, provided the circumference of the outwardly turned flange on the cylindrical projection of the inside sheet exceeds the outer circumference of the flange of the outside sheet, and provided that the thickness of this cylindrical projection of the inside sheet conforms to the requirements of the following formula:

$$P = \frac{5000 \times t}{R}$$

where:

$P$ = maximum allowable working pressure in pounds per square inch.

$t$ = minimum thickness of the plate forming the circular door opening in inches.

$R$ = the radius of the outer surface of the circular door opening in inches.

CASE No. 396. *Inquiry*: Is it permissible, under the requirements of paragraph 257, to calk the heads of rivets? If so, how shall it be done and with what type of tools? Is it permissible to cut the plate or butt strap underneath the head and force the projecting metal up under the head?

*Reply*: It is the opinion of the Committee that it is permissible to calk the head of a rivet, if the rivet is not loose, provided the number of rivets requiring calking is not objected to by the inspector as indicating improper workmanship. Such calking must be done with a round-nosed or other type of tool which will not score or damage the plate under the head. The plate under the head should not be cut in order to force the metal up and make the head tight.

CASE No. 397. *Inquiry*: Was it the intent, in paragraph 199, to permit a value of 175 for $C$ where copper washers were used as described in the definition for $C$?

*Reply*: It is the opinion of the Committee that the washers should be of steel to permit the use of 175 for $C$. Copper washers may be used provided no increase is assumed in the value of $C$ for the strength of the washer.

CASE No. 398. *Inquiry*: Is it permissible, under the requirements of the Boiler Code, to use a single-piece dome, with the shell drawn or pressed out of one piece, eliminating the lap seam and riveting of dome head to dome shell?

*Reply*: It is the opinion of the Committee that it was not the intent of the Code to prohibit the use of seamless construction otherwise built in accordance with the rules.

CASE No. 399. *Inquiry*: Is it permissible, under paragraph 199 of the Code, to use a value of 175 for the constant $C$ in the formula when the outside washer is omitted and instead an inside doubler plate securely riveted to the plate is used?

*Reply*: It is the opinion of the Committee that if three-fourths of the combined thickness of the boiler plate and doubler plate is used for the value of $T$ in the formula, the value of 175 for $C$ cannot be used unless outside washers are employed. It is the opinion of the Committee that if the thickness of the boiler plate is used for the value of $T$ in the formula without adding anything for the thickness of the doubler plate, the doubler plate may be considered as the equivalent of the outside washer and the value of 175 may be used for $C$.

CASE *No.* 400. *Inquiry*: Is it the intent of the Code that paragraph 183, specifying the distance from centers of rivet holes to edges of plates, shall apply only to longitudinal joints, or is it applicable also to girth joints, manhole frames and other riveted attachments?

*Reply*: Paragraph 183 refers only to longitudinal joints.

CASE No. 401. *Inquiry*: In paragraph L-31, is it the intent that the area to be stayed is calculated from the maximum pitch squared, or the product of the actual pitches of the area supported by the stay under consideration?

*Reply*: The formula cited is based on the use of flat and not curved plates. In the absence of authentic data as to the reduction in stress that may be obtained due to curving the sheets, stayed curved sheets were made subject to the rules for staying flat plates. In the revision of the Code which is now under way, such allowances will be made for stayed curved plates in conformity with rules which have been developed since the last printing of the Code. For calculating the stress in staybolts the area of surface supported can of course be used. However, for spacing of stays or estimating stresses in stayed sheets, it will not be admissible to substitute the area of surface supported for $p^2$.

CASE No. 402. *Inquiry*: Is it necessary, under paragraph 195, where more than one manhole opening is inserted in a dished head, to increase the thickness of the head by more than 1/8 inch?

*Reply*: It is opinion of the Committee that it is not necessary to increase the thickness of the head more than 1/8 inch if more than one manhole opening is inserted, provided the minimum distance between the manhole openings is not less than one-fourth of the outside diameter of the head.

Case No. 403. *Inquiry*: Where a steam drum or dome is attached to a boiler, is this drum or dome to be considered a part of the boiler in applying the requirements of paragraphs 277 and 278 for the attachment of safety valves?

*Reply*: It is the opinion of the Committee that where a steam drum or steam dome is attached to a boiler, the safety valve or valves, under ordinary conditions, may be located on this drum or dome. The area of the connection between the boiler shell and the drum or dome shall conform to the requirements in paragraph 290.

Case No. 404. *Inquiry*: If a dished head is formed with a flattened spot or surface for the attachment of a connection or flange, is there any limit to the size of the plane or flattened spot on the head?

*Reply*: It is the opinion of the Committee that the diameter of the flat spot formed in the head should not exceed the value of $p$ as given in the formula in paragraph 199 or in Table 4, for the pressure and thickness of head involved.

Case No. 405. *Inquiry*: If a boiler constructed to the requirements of the A.S.M.E. Code for boilers of locomotives, is removed from the locomotive and operated for stationary or portable service, will the rules under which the boiler was constructed still apply?

*Reply*: The rules for the Construction of boilers of locomotives do not apply to portable locomotive-type boilers, such as are used for steam shovels, steam cranes, road rollers, and portable boilers used for threshing grain or cutting lumber.

If a locomotive boiler is removed from the locomotive for stationary or portable service, it shall be treated in accordance with Parts I or II of the Code for Stationary Boilers.

# Renewing Fireboxes in Lehigh Valley Shops

The method of renewing fireboxes at the Sayre shops of the Lehigh Valley, while not particularly new, effects a material saving in repair costs. Briefly the operation, as shown in Fig. 1, consists of cutting the rivets along the throat sheet, mud ring and up over the wrapper sheet so that the entire back of the boiler can be removed and sent to the boiler shop for application of a new firebox. It is comparatively easy to strip the cab and fittings which would have to be removed in any case, and little time is required to cut off and punch out the rivets. Then the work of applying a new firebox, being performed in the boiler shop, is conveniently located for workers and supervisors. When the new firebox is applied, the back end of the boiler is sent back to the erecting shop and fitted in place, new rivets being driven in the old holes as shown in Fig. 2.

This method of renewing fireboxes has a big advantage, both as regards labor and material costs, over the former method of disconnecting and removing the entire boiler from the engine frames. In that case it is necessary to strip the jacket, lagging and fittings from the entire boiler, all running boards and brackets also being removed. Cylinder saddle bolts and expansion pads must be removed.

It takes two men about 16 hours to disconnect and remove the back of the boiler, as shown in Fig. 1, and about 20 hours are required to put it back in place and rivet it, as shown in Fig. 2. The old method of removing the entire boiler would probably take four men about 24 hours and approximately twice as long to put it back on again, including the time required to ream saddle bolt holes and drive new bolts.

### Crown Bolt Drilling Device

In connection with applying new fireboxes, a device has been developed at Sayre, as shown in Fig. 3, for drilling, tapping, facing off and driving crown bolts. These operations formerly required a staging built in the firebox and the boiler maker who operated the standard air motor was obliged to work in cramped quarters, feeding the drill or other tool upward by means of the motor feed screw. To facilitate performing this work, the device shown in Fig. 3 was made, consisting essentially of one section of 2½-inch pipe *A* (to which is attached the air motor *M*) turned down at the lower end and packed to make a sliding, air tight fit in a similar pipe section *B*. This lower section of pipe acts as a cylinder so that when the air pressure is turned on through valve *V* pipe section *A* together with motor *M* is forced upward. The combined length of pipes *A* and *B* is sufficient to reach from the level of the grate bars to the top of the firebox and pipe

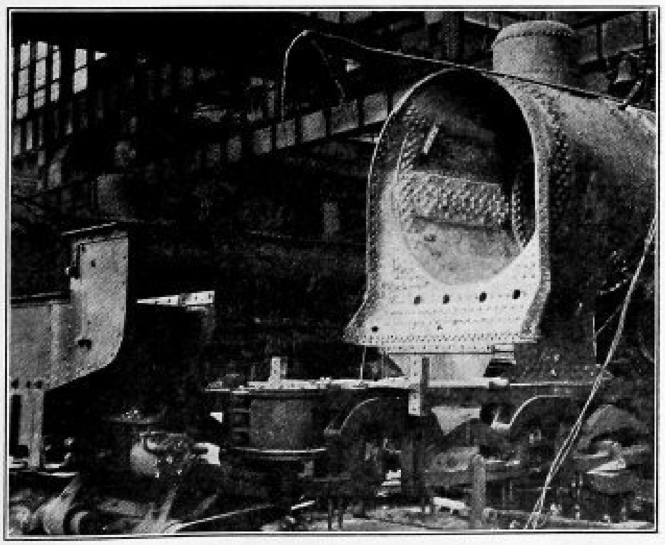


Fig. 1.—View Showing Boiler Back End Removed for Application of New Firebox

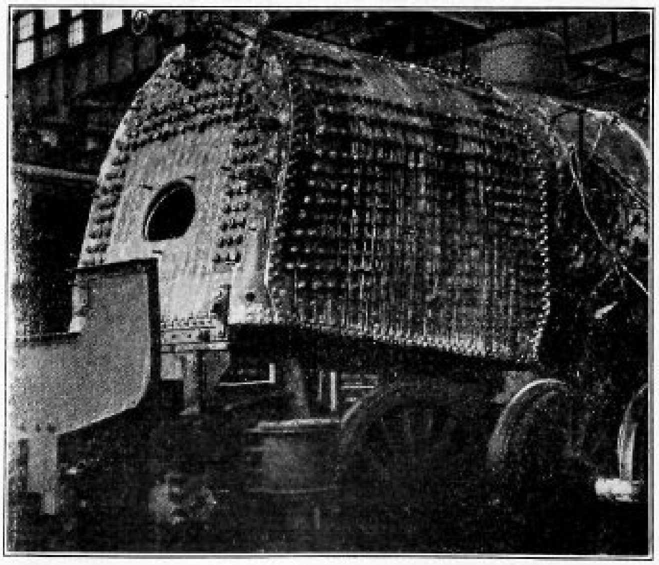


Fig. 2.—View of Boiler with New Firebox Applied to the Back End

*A* has sufficient travel in *B* to accommodate variations in this distance. The lower end of *B* (not shown in the illustration) is provided with a ball joint, and two handles *HH* facilitate handling.

In operation the device is set up under a crown bolt to be drilled and the air pressure turned on. This forces the

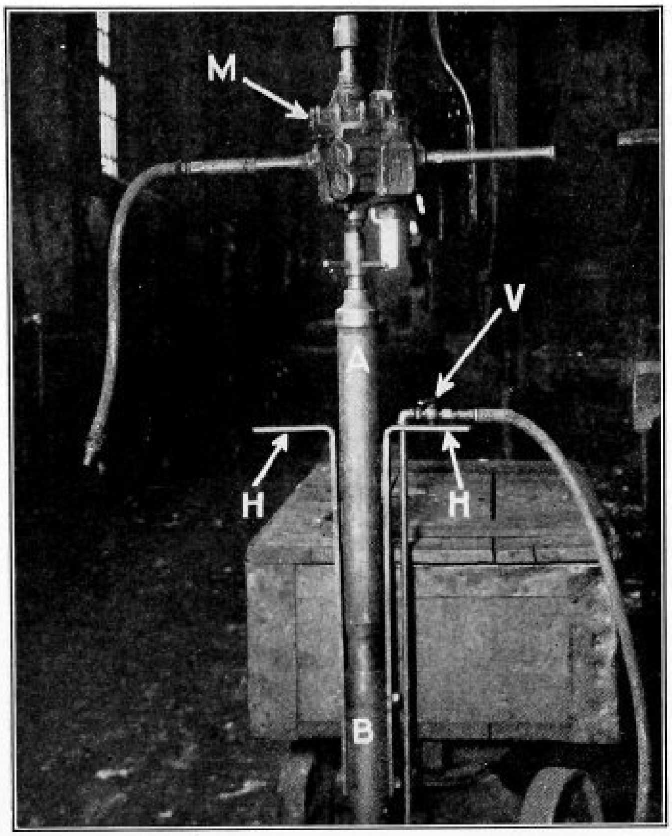



Fig. 3.—Device for Drilling Crown Bolts

pipe section *A* and air motor *M* against the crown bolt and when the air motor is started, provides automatic feed. Much less time is required for drilling crown bolts with this device than by former methods.

## Boiler Explodes on Lake Steamer

ATTENDING a funeral is not generally classed among hazardous occupations, but a recent occurrence forcibly illustrated how near danger is even when least expected. A funeral service was being conducted in a chapel in Port Huron, Mich., when, without warning, a heavy steam heating radiator crashed into the midst of the two hundred people present and flying glass and timbers were thrown about the place. A woman was struck by a beam which fractured her collar bone and three ribs. Another woman lost an eye as the result of flying glass. Five others also were injured.

The flight of the radiator was one of several results caused by the explosion of a steam boiler on board the ferry steamer, *Omar D. Conger*, at Port Huron on Sunday afternoon, March 26, 1922. The scene of the accident was on the Black River about 200 feet east of Military Street bridge, Port Huron's principal street and in the center of the downtown section.

The explosion sent the hull of the steamer to the bottom of the river, which was not, however, deep enough to completely submerge it. Two other ferry steamers nearby were damaged and the force of the explosion was felt over a wide area, plate glass windows three blocks away being shattered by the blast.

The engineer, firemen and two deck hands were killed, seven persons were injured and the property loss which resulted was said to be in excess of $100,000.

The main portion of the boiler was thrown 250 feet across a dock and over Quay street on a small frame house, which was crushed like an eggshell by the impact. Fortunately, the occupants of the house were away at the time. Fire, following the landing of the boiler, completed the destruction of this house.

The *Conger* was owned by the Port Huron and Sarnia Ferry Company. It was built in 1882 and was rated at 196 gross tons, 92 feet long and 26 feet beam. The boiler which exploded was installed in 1904, so that it was eighteen years old.

The steamer had been in dry dock in February and was supposed to be in perfect condition. At the time the explosion occurred, it was tied up to a dock adjoining the ferry landing, taking on coal preparatory to making its first trip of the season. If the explosion had taken place a half hour later, after ferry passengers had gone on board, the loss of life would undoubtedly have been appalling.

The boiler, a sketch of which is given in Fig. 1, was of the compact marine type made up of a cylindrical shaped

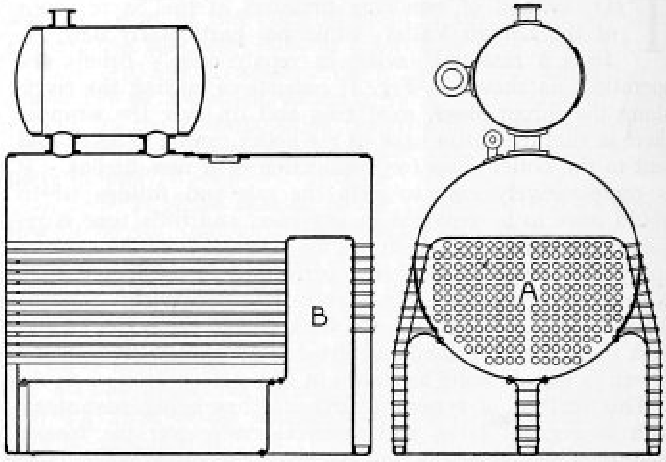



Fig. 1.—Details of Compact Type Marine Boiler Which Failed

upper section (*A* in Fig. 1), to which was riveted two outside and one middle waterleg. The combustion space *B* back of the grate was also enclosed at the rear by a waterleg. The boiler was internally fired in two furnaces.

The force of the explosion ruptured the rear tube sheet, tore the rear waterleg away from the side waterlegs and pulled away braces and staybolts at the rear end of the boiler. —*The Locomotive.*

## Baldwin Locomotive Works Issues Quarterly Magazine

UNDER the title "Baldwin Locomotives," the Baldwin Locomotive Works has published the first issue of a periodical devoted to the interest of transportation and motive power problems. It is intended to illustrate from time to time the newest types of locomotives constructed at the Baldwin Works and to present articles on technical or commercial subjects allied to transportation. The first issue, date July, 1922, contains articles on the first uniform gage transcontinental railway in South America, on the lubrication of railway car journals, and on South American business. The locomotives described include the Consolidation type built for the Western Maryland, Santa Fe and Pacific types built for the Argentine state railways and also logging and tank locomotives. The interests of foreign readers have not been overlooked as some of the articles are published in both English and Spanish and the locomotive specifications are given also in French and Portuguese.

# Applying the Right Angle Rule to Hood Construction

**By Phil Nesser**

FOR various reasons, particularly as a material and labor saver, the right angle rule has been found peculiarly adaptable to the layout of steel plates to be used in the construction of hoods and hoppers of the type made up with straight sides and flanged corners. Using other methods of layout, material is wasted at the corners of the plates where triangular sections have to be trimmed in providing for flanges at the corners of the finished assembly.

In the following layout, the hood construction has been used as typical of the general method. Exactly the same principles apply to the hopper construction, however, for when the hood is erected with the small end uppermost it becomes a hopper.

Fig. 1 shows the plan of the hood, Fig. 2 the end elevation, and in order to make it an odd problem, the bases are out of center and are not perfectly square. To use the rule described it is necessary that all corners should be right angles in the plan and elevation.

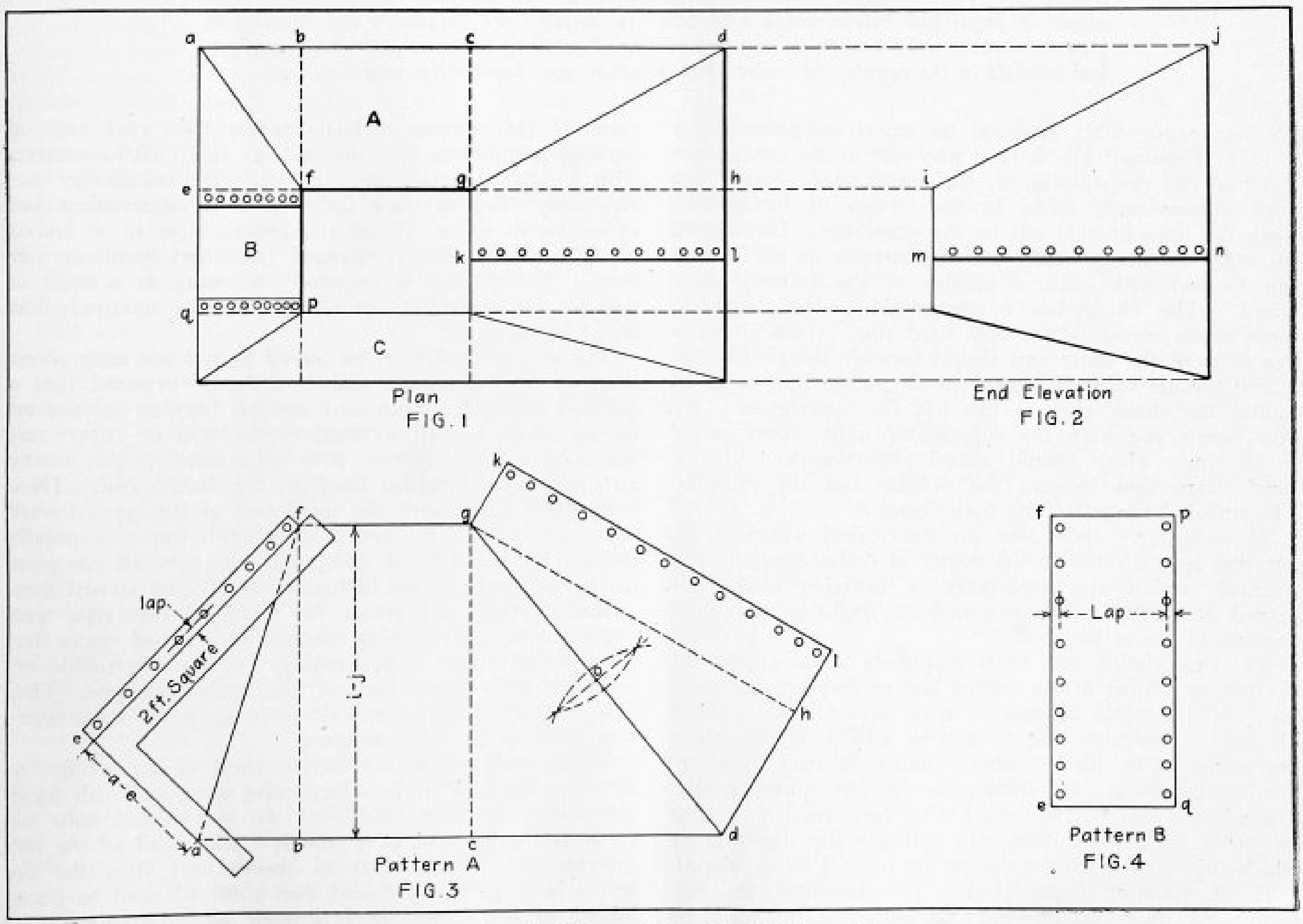
There are two ways of lapping the sheets; one is the center line lap as on line *k-l*, shown in Fig. 1, and the other is the top corner lap, as shown on lines *e-f* and *p-q*, Fig. 1. We have made this difference so that both methods may be explained. It will be noticed that it takes a much wider sheet to make the pattern when using the center line lap, but a few rivets and holes are saved. Nevertheless, it seems cheaper to make it with an end piece, as *B* in Fig. 1, unless the sheet happens to be wide enough by chance, which is often the case. Sometimes they are made using both kinds as in this instance, according to the way the material figures out.

Whenever the corners show right angled in both plan and elevation, then there can be nothing else but right angles in the pattern and this is the theory that is introduced in this article. The layout is given as follows:

Draw the plan, Fig. 1, to the required dimensions. Draw dotted lines through the sides of the small base and thus locate points *c*, *d*, *e*, *h* and *q*, then draw the end elevation, squared over from the corners. The straight height is then introduced between the bases, as upon the line *m-n*, Fig. 2. Join the bases by diagonal lines shown at *i-j*, Fig. 2, and proceed to make the pattern, Fig. 3.

We use a strip of iron, 1/8 inch by 3/4 inch to carry the points *a*, *b*, *c* and *d*. By marking these graduations upon the strip, transfer them from the plan Fig. 1, to the pattern Fig. 3, marking the points *a*, *b*, *c* and *d* upon the flange line if it is to be flanged, or upon the near edge of the sheet if no flange is needed. Carry the perpendicular lines up from the points *c* and *b*, taking for their length the diagonal line *i-j*, Fig. 2, thus locating points *f* and *g* in Fig. 3.

Join *f* and *g*, Fig. 3, and draw the diagonal lines *f-a* and *g-d*, completing the side *a*, *d*, *f*, *g*. Now to join on a part of another side, consider that the point *e* is to be on one side




**Triangulation Applied to Sheet Metal Hopper Layout**

of a right angle; take upon the tongue of a two-foot square, the length of the line *a-e*. In the plan, Fig. 1, mark the point *a* holding the corner upon the point *e*. Then *e* in the pattern, Fig. 3, will automatically form the triangle *a-e-f*, if the mark is at *a* is held at point *a*, and the side of the blade swung so that it will pass through the point *f*. This reasoning is only given to explain the principle of the system. Most problems are too large to use a square in the way explained, but after the principle is made clear we can bring out the method of procedure when the square is not used.

The holes are placed upon a parallel line set off from *f* and *e* and the lap added to this finishes the end where the square has been used.

The pattern *B*, Fig. 4, is taken from lengths *f-p* and *e-q* in the plan and transferred to Fig. 4 from Fig. 1. These lengths are placed upon the flange or edge lines as stated before. The length *e-f* is taken from Fig. 3, and transferred to Fig. 4.

Try to keep the point *a* in Fig. 3 just far enough away from the edge to make point *e* stay on the sheet. Shift it or lay it out over, which will not take long, before starting on the other end, as it may run off the sheet at this end, besides saving the stuff for the end *B*.

Let us suppose the other triangle *d-g-h*, Fig. 3, is too large to use a square. As stated before, we simply bisect the line *d-g*, that is, find the middle of the line as shown at *o*, Fig 3, and with *o* as a center, and *o-d* as a radius, scribe an arc to pass through the point *h*. With *d* as a center and *d-h* taken from *d-h* in the plan, Fig. 1, as a radius, step off *d-h* upon the arc described before in Fig. 3, thus locating point *h*, which is bound to be a right angle if the work is done as explained.

To lay out half the end piece as shown, take *g-k* from the plan, draw a parallel line *k-l*, Fig. 3, parallel to *g-h*, locating the point *l* by extending the line *d-h* to *l*, and making *k-l* equal to *g-h*.

The holes are put on the line *k-l* and the lap added to suit; flanges are added if necessary. The rivet holes in the pattern *B* are set in equal to the same lap as was allowed for in Fig. 3. The whole row of holes can be transferred along with the length of the piece. Once we get familiar with its application, this rule will be found very simple.

After mastering this method of making hoods, it can be seen that most of the laying out can be done even without drawing the plan, by taking the lengths from a rough sketch and the length of any diagonal side as *i-j* can be determined by scaling on a two-foot square.

# Design and Maintenance of Locomotive Boilers

*On page 223 and succeeding pages of the August issue of* THE BOILER MAKER *appeared an abstract of a report read at the Atlantic City convention of the American Railway Association, Division V, Mechanical. A complete discussion of this report is published below which will serve to amplify the details of the report and give our readers the benefit of the experience of many of the most prominent mechanical officials in the country in boiler shop practice and locomotive maintenance.*

IN the absence of Mr. Emerson, the report was presented by O. C. Cromwell (B. & O.), who said at the conclusion: Since the preparation of the report there have been some improvements made in the design of locomotives along the lines brought out by the committee. Locomotive No. 8000 has been recently put in operation on the Michigan Central with quite a number of the features mentioned. The circulation is improved by introducing a large radius corner in the back mud ring. This allows a free entry of the water and should increase the circulation.

The throttle valve is located in the smoke box, so as to control the steam after it has left the superheater. By that means you keep the superheater units under steam at all times which should afford protection and give a short steam area between the throttle and the cylinder. The outside by-pass is fully under control.

These features show that the mechanical world is interesting the railroads in the matter of boiler design. The railroads realize the importance of bringing about improved circulation and steam generating qualities; also more economical use of the steam.

As to circulation you know that there are a number of circulating devices in the market but as they are patented, no specific mention is made of them in the report. They all tend to improve the circulation and I believe there are going to be further improvements in that direction. Feed water heaters are coming to the fore quite rapidly, a number of different designs having been tried out which no doubt in a short time will indicate the direction in which this very much sought-for device will be developed.

H. H. Lanning (Santa Fe): The committee has recommended that button-head staybolts be adopted as standard practice for crown sheets of other than oil fired boilers. On railroads which operate both coal and oil burning locomotives, it is desirable to equip all locomotives with a type of crown stay that will give satisfactory service with either of these fuels, as it is inconvenient and expensive to renew all of the crown stays in a firebox when the locomotive is changed from coal to oil or vice versa. This change is frequently necessary as a result of transfer of locomotives or changes in the relative prices of oil and coal.

The service conditions on an oil burner are more severe than on a coal burner and it is to be expected that a railroad which has both coal and oil burning locomotives should adopt for all locomotives the type of crown stay which gives best service with oil; namely, one having an upset taper threaded head on the firebox end. These bolts are applied with the small end of the taper toward the water side of the crown sheet. The taper is usually about 1 1/2 in. in 12 in. and, after being screwed into place the firebox ends of the bolts are cut off and riveted over.

Radial stays and crown bar bolts of this type were developed on oil burning locomotives in bad water territory as a means of overcoming very serious trouble experienced with crown sheets of the button-head type. They have been in successful and extensive use under these severe conditions for 15 years or more.

When subjected to the extreme heat of an oil fire or to a very hot coal fire in a locomotive using bad scale forming water, the round heads of the button-head bolts became overheated and gave trouble. The head of the bolt presents an enlarged area to absorb heat from the fire and a large part of the heat thus absorbed must be transmitted to the crown sheet through an intervening layer of dirt and scale and to the water, through an accumulation of mud or scale adhering to the bolt and to the sheet. The result is that, in an oil burning engine and sometimes in the hottest part of the firebox on a coal burner, the button heads become overheated and leak.

The taper head type of crown stay presents a smaller area to the fire and does not absorb so much heat. The contact between the bolt and the sheet is more intimate and the transference of heat from the bolt through the sheet to the water takes place with less interference. The taper head bolt has a further advantage that in case it does show a tendency to leak, it can be restored to a perfectly tight condition by a small amount of hammering and working.

On coal burning locomotives using certain kinds of coal the taper head radial stay accumulates practically no honeycomb or clinker, while under the same conditions crown stays of the button-head type would collect considerable quantities of this material.

Fifteen years or more experience with crown stays of the taper head type in oil burning service and about seven years' experience with this type of stay bolt in coal burning service on a railroad, having over 2100 locomotives, has demonstrated that the taper head crown is fully as safe under favorable conditions and is safer under conditions of extreme firebox temperatures than the button-head type of crown stay. Taper head bolts have also been found to give better and more satisfactory service than button-head stays on coal burning locomotives as well as on oil burners.

I feel that the committee should be requested to give consideration to crown stays of the taper head type for both oil and coal burning locomotives and include this type of stay among those recommended for adoption by this body.

C. A. Seley: I was under the impression that the success of the taper head radial as developed for oil burners would set the pace for its use in coal burners as well, because of its manifest advantages in cost, application and maintenance. The great difficulty in making the thread of a button-head bolt fit tight in the sheet simultaneously with a fit of the button against the sheet leads to much imperfect work and subsequent leakage and calking that strains the section under the head. The heating of the projecting head tends to break the calking joint and has an affinity for some products of combustion that form clinker.

That I am not alone in my opinion was shown by the 1921 report of the Master Boiler Makers' Association which strongly endorsed the taper head radial for all classes of service after making tests and comparing results of service. The Boiler Makers at their recent convention of 1922 supported the report of the committee.

In the interest of economy of material and reduction of boiler weight at the most advantageous point I would question the body diameters as shown in this report. The I. C. C. rule for 7,500 lb. maximum stress of stays applies to radials as well as water space stays and this figure is supported in the Boiler Code of the A. S. M. E. With 4 in. by 4 in. spacing the diameters named would carry 281.8 lb. for 15/16 in.; 323.5 lb. for 7/8 in. and 368 lb. for the 1 in. body, all of which seems excessive.

In his opening address at this convention, Chairman Tollerton forcefully urged consideration of fuel savings and other economies in operation, and in line with this the committee urges careful consideration of the design of boilers to the end of perfecting circulation of water. Just what and why is this circulation? A brief definition would be the movement of boiler water in its conversion to steam, and the perfecting called for is an implication that the present designs and state of the art are not perfect and need further consideration.

It is obvious that the circulation should be sufficient to do two things; to serve as a wiper-off and carrier of the steam bubbles as formed on the heating surfaces for prompt discharge into the steam space, so that the full value of these surfaces may be realized; also to so mingle and mix the boiler water as to have no extremes of temperature. The maintenance of a relatively large volume of highly and uniformly heated water will promote reduction in maintenance and increase the effectiveness in operation.

The arch tube came as a life saver when boilers were assuming lengths to accommodate wheel arrangements necessary for development of increased traction, and wonderfully stimulated the circulation of the increased volume of water. Its very extended use has certified to the correctness of the theory that getting close to the source, taking advantage of initial conditions, is the proper method of solving this important problem. What might have been regarded as an incidental advantage, aside from the use of the tubes as brick arch supports was, in my belief, the most important factor, not only in use of the tube but due to the tube being in the firebox and directly subject to the only motive power which can promote circulation aside from outside mechanical means.

For the actual production of steam, the firebox of the locomotive is a very vital feature in its arrangement and proportions. Each square foot of its surface is five or more times as valuable as flue heating surface, for the simple reason that there is conduction and radiation of heat from the combustion of the fuel imparted to all parts of the firebox, but these combustible gases are extinguished on entering the flues with a reduction of temperature below the point of ignition. There is now no radiant heat, simply that of convection or rubbing of the flue surfaces by hot gases, and notwithstanding the short travel through thin walls of the tubes as compared with firebox plate thicknesses, the results are not high in evaporative efficiency, particularly at the forward ends of long flues.

To obtain a further increase of circulation, as desired by this committee, let me call your attention to a device which has been through some years of development;—an American invention, of which mention was made at the recent convention of the International Railway Fuel Association as follows:

"Results of tests conducted during the last four years on a number of railroads demonstrate that this device has passed the experimental stage and will probably be one of the standard fixtures in the locomotive of the future, as is the arch tube at the present time."

The thermic syphon is fulfilling the requirement of the committee for a circulating medium of adequate promise. It is a further development of the arch tube principle, serving as an arch support and its capacity for increasing the water circulation is shown by the fact that the throat connection of two syphons has a waterway approximately three times as large as four 3 in. tubes; that the upper or discharge openings in the crown sheet are 3 in. wide by such a length as to give approximately ten times the areas of the lower connections, providing a quiet release of the upward circulation, and a direct upward path for steam bubbles, without chance for pocketing which would permit incrustation. The entire outer surface of the syphons are additional heating surfaces of highest value, due to their location in the hottest zone of the firebox, and by the generally increased water circulation effect of the syphon, the heating surfaces of the fireboxes and flues will be further stimulated to higher evaporative effect, facilitating deposit of boiler feed impurities to convenient washout points. Each syphon is in effect a double plate girder, longitudinally strengthening the crown sheet, dividing the stream of gases for more favorable absorption of radiant heat and subdividing crown sheet into limited zones, and preventing boiler explosions. This is proved in two cases of extreme low water.

Tests of syphon engines as against like engines not so equipped show coal savings running from 14 to 25 per cent per thousand ton miles; on oil burners 8 to 10 per cent.

J. A. Pilcher (N. & W.): I wish to speak simply with reference to Fig. 8, referring to crown stays and heads, reinforcing what has been said by the two previous speakers. We have eliminated the button-head stay bolts in favor of stays with a large taper. Our boiler repair people have found it entirely advantageous and I was wondering just how far the committee investigated this particular feature of boiler construction before making their recommendation for the use of the button-head stay throughout the firebox crown. I also notice the very decided recommendation of the crown sheet of the Belpaire type. On the road with which I was connected in the early days they used the Belpaire, but for some reason they deserted it. I wonder why? They have named many good points. I wonder if there are any bad points explaining why this type has not been more generally used.

J. Snowden Bell: Mr. Seley has given us a very interesting statement and a valuable one. I think there is nothing in it that I differ from in the least degree. There are one or two questions, however, I would like to ask. One is a good deal a matter of personal curiosity, I may say. He has referred to this device called the thermic syphon. I would like to know why they call that thing a syphon. As far as I understand it, it has not any syphonic action whatever. There is nothing resembling a syphon present there. I have no doubt that the results of tests will show that the advantages derived from an increase of firebox heating surface secure probably a better circulation with that device, but I do not know why that should happen any more than it would with the old style water legs that were introduced in 1837 in the British practice by McConnell and others. This, as I understand it, is simply a water leg or rather two water legs. They get an increase of fire box surface, the value of which we all know but you would get it with any longitudinal water wall in your firebox and so far as the circulation is concerned, I cannot see why the circulation of that device would be better than the improved circulation obtained by an ordinary mid-fellow or longitudinal water wall in the firebox. (That is what I would like to hear from Mr. Seley, if he can explain.)

H. T. Bentley: I was very surprised when I read the report of the Committee on this button-head staybolt, because I thought it was a thing of the past. For years we were having lots of trouble in oil burning service with button-head staybolts and we looked around to see what could be done to overcome that trouble. By going to the taper head our difficulties were entirely overcome and we thought if it was a good thing in oil-burning locomotives, it was not a bad thing in any other service. About 5 or 6 years ago we made it our standard and since then we have been entirely satisfied with the results obtained. The conclusions of the committee generally are in accordance with my idea of things, particularly in regard to the hot water washing out. It is unfortunate that financial conditions have prevented the extension of hot water washout plants, but apparently very little has been done in the last few years. I am also in favor of the installation of water treating plants. I think everybody will agree that there is always a difficulty, when business is good, in getting boiler makers. If you can get a supply of water that overcomes the necessity of using so many boiler makers, it is certainly a move in the right direction and I am sorry that conditions have been such that little has been done in treating water to save work in the boiler shop.

I know of some railroads which, unless something is done and done very quickly, will have to enlarge their boiler shops and put in more machinery and tools for handling boilers. It seems to me that we are a little shortsighted when we do not prevent the disease rather than to try to cure it after it has developed.

C. F. Giles (L. & N.): I note in the committee's report under the caption of water treatment that they strongly urge the serious consideration by the railroad managements of the installation of water treating plants. They make no mention of a practice in effect on a number of railroads of using the internal treatment. We all know that the installation of a water treating plant is a very expensive proposition and must necessarily be confined to a point where they are troubled with bad water. If they have bad water at more than one point on a division, they must necessarily install water treating plants at every point where the water is bad.

It is a well known fact that the water on a division, or a series of divisions running out of a given terminal, can be analyzed and proper chemical preparations will take care of the water as a whole, avoiding treatment of the water at each particular point. The internal treatment is being practiced on a great many railroads. We have made some experiments with it ourselves with splendid results. It is a much less expensive way of taking care of bad water in some cases than the wayside treating plants. Besides that, at times when the water is exceedingly bad resulting in foaming, you may necessarily have to resort to the internal treatment to overcome the external treatment of water. In my opinion the committee should during the next year give some consideration to the internal treatment of water.

J. Snowden Bell: I would like to ask whether there is anyone present, who knows about the application to the Lima locomotive of a throttle valve between the superheater and the cylinders. It was the consensus of opinion of the Committee that that was a proper location for the throttle valve, but I would like to know if any other road has made a similar application, and if so, with what results.

C. E. Fuller (V. P.) There seems to be a difference of opinion here this morning. It is said that doctors never agree and I think in this case we are not agreeing.

The committee has recommended the adoption of button-head stays and I can fully endorse the Committee's recommendation from the results actually gained through experience in operating locomotives with button-head stays. I have not had experience operating locomotives with oil and I appreciate the difficulties that might be encountered in such cases but it is my opinion that the question of button-head stays, versus tapered, driven stays for the crown sheet is a matter of local conditions more than anything else.

We have had no trouble with button-head stays; that is, our standard form of stay. We have used them for years and if they are properly applied and maintained there is no trouble.

We do not have to resort to any calking of the button-head stays. I am inclined to the opinion that those who have had trouble with the button-head stay have not arrived at the cause of the trouble by a proper examination and inspection.

Mention is made of the button-head stay collecting scale and mud. It will do this. The committee, of which I am not a member, states that the bombarding of sheets to loosen the scale puts the locomotive into the shops for repairs quite frequently. I do not believe that there is any road which has done more bombarding than we have; I think that we were the original bombarders of crown sheets. We have many locomotives in certain sections, where, we would otherwise burn the crown sheet out in less than a year, but if they are bombarded, properly and frequently, there will not be any trouble. We have been doing it for years but with the proper tools and in the proper way and have been able to keep staybolts fairly free from mud even in a bad water district.

The committee in this report also mentions the treating of water. Before water is treated, it should be very carefully analyzed and an effort made to determine what is wrong with it; we have waters which are of such a character that they will not stand treatment; that is, in the tank. The condition of water requires careful study and I do not believe that the experience of any one railroad will be of much value with regard to treating of water on another road.

If I were selling water treating plants, I would probably tell you to treat your water but what I would personally advise is to investigate the matter and discover what is really the difficulty. There is no cure for all ills. When you find out what is the matter, you are in a better position to proceed to the question of water treatment. Then you can handle the subject of water treatment in the most intelligent way.

We can afford to spend a large amount of money to get good water and if we can get it, with or without any kind of treatment, we can close up our boiler shops to a very large extent and will have successful locomotive operation.

In the case of certain waters on our road, we have to put castor oil compounds in the water in order to keep the water down. We have our troubles keeping it in the boiler. We could not treat that water if we wanted to.

W. F. Kiesel, Jr. (Penn.): I would like to add something in connection with the button-head stays. We have used them for many years and we find them the safest stay to use. An engineer may at times disregard the condition of the water in his boiler and there will actually be low water in the boiler. The button-head stay, under such conditions, is the safest.

In the case of wagon-top boilers, objection is made to the use of the button-head stay because the stays will not go in at an angle and you cannot make a square seat very readily, but even in the wagon-top boilers the 3 or 4 rows in the center may be made of button-head stays to good advantage.

Mr. Pilcher asked what the advantages of the Belpaire boiler are: The committee recommended a Belpaire boiler and although I am not on the committee, I can readily see why—because the stays are normal to the sheet. You can use a stay with a head or you can use a stay such as proposed by some of these other members; furthermore, it is a more flexible job and expansion and contraction will put less stress in the sheets. Also you know more definitely what the stresses in the sheets are. It, of course, requires more time and the builders will be opposed to it on account of the increased cost of dies, but the Belpaire boiler is considered the safest both in Europe and in this country.

R. D. Hawkins (A. C. L.): The button-head staybolt does not seem to have very many friends here. While on the Atlantic Coast Line where we have used the taper head stay for many years I had experience with the Belpaire type of firebox. It is very easy to apply button-head stays and I must say that I favor button-head staybolts in this class of boiler. We are having some very satisfactory results with a taper stay but I do not like to see the committee turned down entirely on its recommendations of the button-head. I have also had some experience with button-head staybolts in oil burning engines. We had some difficulty where we used large heads and the heads started to burn. In this case we made a hollow tool and kept the button heads smoothed off thus getting very satisfactory results, even with oil.

C. E. Chambers: I have had experience for 20 years, at least, with button-head staybolts or crown bolts. With locomotives built recently we went to the use of the taper-head crown bolt, but not because of any trouble of leakage or being unable to keep button-head bolts tight. There was one reason that prompted me to do this. Possibly somebody else in the room has had a similar experience. We had a great many crown sheets equipped with button-head crown bolts which, while the sheets looked perfectly good, were badly grooved around the head of the bolt. Water conditions could not be blamed so I thought perhaps the heads of the bolts became overheated, or that the circulation from the water did not protect the sheet at that point as thoroughly as it would without the button-heads. That was really what prompted me to go to the taper crown bolts.

A. W. Kelly (National Tube Company): I just want to say a few words in connection with the dry pipes. We have had a great deal of trouble with the railroads because of filling orders for dry pipes as mentioned in No. 1 and No. 2. Many different orders come in and that means we have to change rolls, causing delays. Oftentimes we have had to substitute seamless dry pipe which costs more money. I think the committee's recommendations are right. They will allow the tube manufacturers to carry standard sizes of pipes in stock, so there won't be any delayed deliveries.

Mr. Seley: I would like to answer Mr. Bell's objection to the term "syphon." I rather think there is a syphon there. It may be inverted from the ordinary syphon; it may be upside down, but it seems to me there is a distinct analogy in that term. The water from the boiler barrel being drawn there by its greater weight displaces the lighter water, forms a syphon and assists in the circulation.

As regards the water leg idea, I haven't any reason to doubt that any water leg of the same heating surface measurement would be just as effective, but in the design which is under discussion, these are most advantageously arranged for meeting the direction of the flow. I think that the failure of most of these devices formerly used has been in the manner of making the proper connection to the sheets.

W. L. Robinson (B. & O.): It is very pleasing to note in the committee's conclusions that they have included items No. 4 and No. 5, which will bring about some fruitful results for something besides reduction of maintenance of equipment expenses. We ought to think about the C. T. saving obtained through carrying out recommendations No. 4 and 5, and increase the boiler washing periods from two or three days in certain districts to 10 or 20 days; also holding the fires longer, instead of knocking them out every trip for boiler wash or boiler work. The cost of fuel is a C. T. expense and so is roundhouse labor, boiler washing, etc. Your C. T. ratio may be affected two or three points by possible saving in fuel. If you have hot-water washout systems and water treatment it means a saving in C. T. expenses. I want to bring out the possibility of making savings in the C. T. expenses as well as the M. of E. expenses.

J. Kruttschnitt (So. P.): Apropos of feed water purification, there is a piece of apparatus in use on the government railroads in Hungary which is located on top of the boiler and its purpose is to purify the water. If there is anybody here who is informed respecting that I think the rest of us would like to hear him tell what he knows about it.

Mr. Greenough: I am very sorry I haven't anything on that of an official nature at all, but it is probable that the location of those feed water heaters has had some influence on some of the feed water heaters recently applied by the Locomotive Feed Water Company. The apparatus referred to is, I understand, a purifier and the apparatus, made in this country, is a feed water heater. I have not heard what the results of the purifier in Hungary amounted to.

Chairman Coleman: This is a very important paper, gentlemen, and in order for the committee to make some standard recommendation to you they must have the experience of all of the railways in the country. You are all operating your boilers under different conditions and the minute conditions change the committee must get an expression from each one of you. There is a great responsibility before you now in trying to economize in the operation of locomotives. The slogan is economy and efficiency and in order for your committee to draw up these papers and present them to you in an intelligent manner, covering the entire continent, they must have your experience.

Mr. Brooks: You are operating locomotives in the Canadian Northwest under the most extreme climatic conditions. The committee would like to know your experience.

C. E. Brooks: I hesitated to say anything about our experiences because they are evidently so diametrically opposite to the experiences of many others who have spoken here today. The first two speakers indicated that the button-head crown bolts had been abandoned for the reason that it could not be used with oil and that in order to standardize with one type of crown bolt for both coal and oil burning locomotives, it would be advisable to go to the sharp tapered type of crown bolt, which was mentioned. When we started oil burning about eight years ago, we had the idea, gathered from various oil-burning roads in the southern part of the country, that we had to have the tapered type of crown bolt. We installed this type of crown bolt in a large number of locomotives and our intention was to spread the use of this type of bolt throughout the coal-burning areas as well. The net result of the thing is that two years ago we had to abandon the tapered crown bolt and we are now using from coast to coast button-head bolts; not button-head, unfortunately, as per the recommendation of the committee, but with parallel thread button-heads. The reason we went to the use of parallel thread button-head bolt was that a tapered crown bolt of any kind can be made test proof without really being a good job; that is, it will meet a water test, whereas the parallel-thread crown bolt must be a fit in the thread in order to pass the water test of either the railroad shops or the manufacturers.

The second disadvantage that we found in the quick tapered crown bolt was the mechanical features in connection with the application of the bolt. That is the different type and sizes of taps required and the difficulties of alining the thread in any way between the inner and the outer sheet. The next disadvantage that we found was that the large water area of the quick tapered crown bolt gave much greater possibilities for scale accumulation than the smaller diameter button-head type bolt.

The next disadvantage that we found was in cases of low water. We have some very remarkable photographs of cases of low water in the bad water districts of Saskatchewan, where an entire firebox had pulled off the quick tapered bolts and simply turned the backs down in the form of a little ring, pulling off without destroying the bolt and without even rupturing the sheet, for the simple reason that, as the sheet started to corrugate, it lifted the thread. It got no support from the thread whatever and had nothing but the back. The photograph even showed the perfect thread on the quick taper. The reason for this is, we think, a succession of overheating of these bolts, due to what might be called ordinary low water conditions. That is, a condition where a man was working with water very low, as we do in certain areas, and as possibly caught a little. The bolt consequently was hammered up a little and in hammering on the back of a quick tapered bolt, your whole action is not an upsetting action. It is an action that destroys the thread in the sheet; that is, loosens it up and you depend upon nothing but the taper of the bolt to hold your sheet.

Now, with regard to two or three of the other items which have been mentioned here. We are not a Belpaire boiler road, but we are very much interested in the recommendations of this committee. We intend to be a Belpaire boiler road, as far as the big power is concerned, for the simple reason that the radial stay boiler, when we get into the large diameters and near our clearance limits, does not have the steam space for handling our light water. We figure we can get this from the Belpaire type of boiler and I believe it is going to be our standard throughout.

Regarding hot-water washout systems, we are opposed to ordinary practice, to such an extent that I do not like to mention it at this late hour. We are a cold-water washout road, and furthermore we intend to be, in the bad water districts, cold water absolutely. The reason for that is that we believe the hot-water washout system is, very often, hot water in name only. We cool our boilers down and know that they are cool; then wash them with water that the men can handle and wash them under conditions that give our men a possibility to inspect the boiler. At the same time, we figure that in reducing the temperature of the boiler we have some chance of keeping the scale accumulation in a condition where water pressure will remove it.

I have heard it mentioned today that item No. 5 is probably the greatest improvement that could be made. We are opposed to that, too, and for this reason: We believe that the solution of boiler trouble is by not using bad water. I can tell you of one case (and probably our friends south of the line can tell you of a great many more) where we were using terminal water in one of our busiest terminals that ran 25 grains of encrusted solids to the gallon. We abandoned that water which was well water, and by heavy expenditure it is true, we have impounded storage of 300,000,000 gallons of surface water, reducing our encrusting solids to probably 15 per cent of what they were in the well water. We intend to follow that principle of impounding water absolutely, abandoning wells and figuring on well water supply as a last resort.

E. Wanamaker (Rock Island): I do not think I am in a position to make any remarks but I have been a very interested listener. Some years ago we began to study the water supply on the Rock Island and water treatment in connection with our firebox maintenance work. I am inclined to agree with Mr. Brooks and with the gentleman who spoke preceding him. If it is possible to secure a good water supply you have reached the ideal solution. In a few instances, at a considerable expenditure, we were able to do that; in others it was practically impossible. Then it became a question of treatment and we found then that we had mistreated more water than we had treated. Furthermore, when we treated the water situation at one water point, it made more trouble with the water supply at some other point, due to the fact that you take your water supply from various points. We have started a progressive or systematic method of handling our locomotive feed water supply in an endeavor to secure uniformity. By so doing, we have greatly decreased our M. of E. in many instances, and at the same time, reduced the C. T. charges, making an indirect saving in that respect.

As regards the hot-water washout and fill up system, no doubt Mr. Brooks' statement is very true. If you have sufficient motive power to permit such practice in times of heavy business. In our case we have been able so to do and we feel that the hot-water washout and fill up systems, when properly used and supervised, result in a tremendous saving in C. T. charges as well as M. of E. Occasionally we get a letter from somebody wanting to know how much

(*Continued on page 274*)

# The Boiler Maker

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Nine of the largest single ended Scotch marine boilers ever built are now under construction at the Kearny plant of the Federal Shipbuilding Company. Details of the work as described elsewhere in this issue indicate the possibility of introducing many refinements in marine boiler fabrication that will tend to increase the economy of this type boiler in merchant ship operation.

The extreme proportions of these boilers have permitted wide spaces between tubes and above the furnaces which make possible easy accessibility for cleaning and maintenance. If advantage is properly taken of this fact after the boilers are put in service, it will insure long life and the economies which result from clean heating surfaces.

However, the points of greatest interest occur in the actual construction of the boilers which, because of their size and the weight of materials used, required special methods of fabrication. It is interesting to note that a great deal of electric welding has been employed in the construction in order that tightness might be maintained at all seams under stress of service. Wherever racking strains might tend to separate the joints, or where seams would be exposed to flame action, the reinforcement of welding has been incorporated.

Care has been taken as well in the selection of fittings and mountings, so that in every way these boilers represent the last word in Scotch marine boiler construction.

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Probably the point of greatest divergence of opinion which occurred in the discussion of the report "Design and Maintenance of Locomotive Boilers" presented at the Atlantic City convention of the American Railway Association, Division V, Mechanical, was on the use of radial taper crown stays or buttonhead stays. The committee recommended that buttonhead stays could be used satisfactorily on coal burning locomotives while taper radial stays were best practice on oil-fired engines where the intense action of the flame would have a deteriorating effect on the larger buttonhead bolt.

The same question was discussed at length at the annual convention of the Master Boiler Makers' Association and, although in this case the committee suggested the general use of taper stays on both coal and oil-burning equipment, the members of this association were as divided in their opinions as were the members of Division V. So many features enter the problem in different sections of the country—water conditions, the type of firebox, methods of stay installation and maintenance—that the results obtained are certain to vary widely.

This brings up the question of the value of investigations covering practices and equipment installations of a nature that cannot be applied generally. The discussions at both conventions indicated that many roads adopted a satisfactory stay installation on motive power only after years of experiment with different types of stays and then possibly some modified form of a standard bolt. In general it might be stated that coal burning roads have used the buttonhead stay most successfully while roads burning both coal and oil have endeavored to apply a taper bolt satisfactorily to both types and roads burning oil exclusively have unquestionably found the taper radial to be best, although there are notable exceptions.

And here is where the reports read at the conventions and the discussions which accompany them are of real value to every individual connected with the promotion of efficiency in locomotive design and maintenance. In this particular instance many roads had adopted a satisfactory practice of stay installation, but many others were still having difficulty in discovering exactly which type of bolt could best be utilized under the service conditions in their territory. By studying the results obtained on a road operating under similar conditions to their own, these mechanical officials have at hand a short cut to the solution of their difficulties.

As so often stated, those who attend the conventions of their trade or professional associations have available a wealth of experience and information particularly applicable to their own problems, if they will only enter into the discussions whole-heartedly and later, when the proceedings are published, study them with the idea of obtaining practical assistance from them.

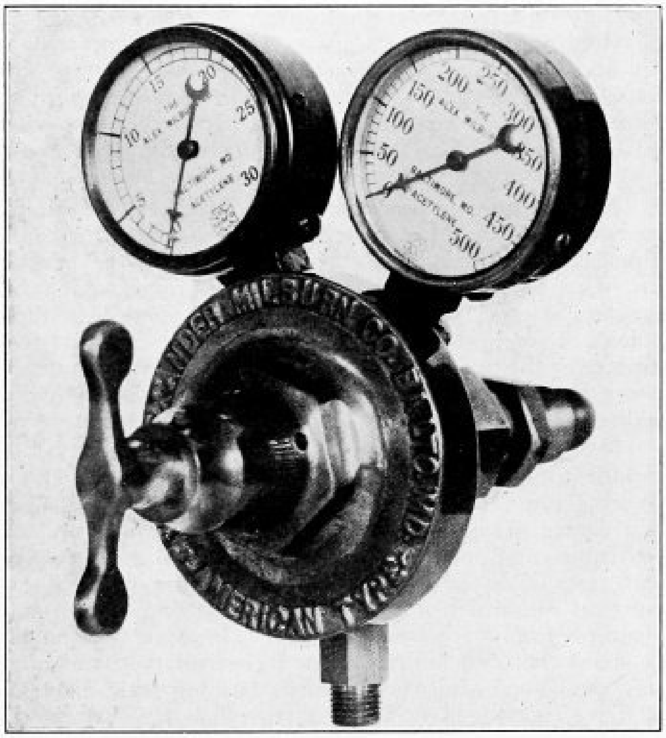
# Engineering Specialties for Boiler Making

**New Tools, Machinery, Appliances and Supplies for the Boiler Shop and Improved Fittings for Boilers**

## High Pressure Gas Regulator

For the control and delivery of acetylene, oxygen, hydrogen and other high pressure gases, the Alexander Milburn Company, Baltimore, Md., has developed the gas regulator shown. Features of this device are said to be simplicity, ease of assembly, direct action and accurate regulation.

The regulator comprises a front cap containing an adjusting key, top spring button and tension spring. The body contains a flexible metal diaphragm in front, soldered in place. Over the diaphragm is screwed a bronze diaphragm plate or spring button to hold the tension spring. Inside the body is a fixed nozzle, containing a loose operating pin. Over the nozzle is loosely assembled the valve sleeve which has a row of gas ports drilled around its circumference and carries the valve seat. The seat closes against the nozzle by initial gas pressure on the valve sleeve and the pressure of a compensating spring resting in the recessed back cap.



Milburn High Pressure Gas Regulator

The loose operating pin inside the nozzle is actuated at one end by a depression of the diaphragm and at the other end by pressure of the valve seat.

The seat of the regulator closes *with* instead of *against* the pressure, enabling the seating to be effected by a sealing pressure of several pounds instead of hundreds of pounds with attendant risk of damaging or splitting the seat, as in the case of regulators where the seat is yoked to the diaphragm. The closing of Milburn seat is independent of the diaphragm.

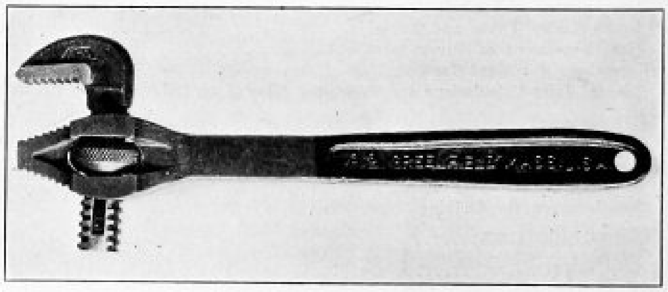
The valve is closed by the rear pressure of the compensating spring, assisted by initial gas pressure. When the adjusting key is turned to the right, the tension spring depresses the diaphragm, moving the loose pin, which forces the sleeve back, unseating the valve and permitting gas to enter through ports in the sleeve. The gas then passes through the nozzle to the diaphragm chamber and thence to the low pressure gage and through the outlet port. When multiplied gas pressure exceeds the tension of the adjusting key spring, the diaphragm is released, permitting the loose pin to advance and letting the valve sleeve close the valve by pressure of the rear compensating spring.

The main operating part of this regulator, comprising only the pin and nozzle and a seat carrying sleeve, is almost immediately accessible for examination, cleaning or renewal. The seat is subject to slight wear, as the spring closing the seat exerts only a pressure of several pounds in order to effect the regulation of the gas.

## Pipe Wrench Designed for Difficult Corners

The Little Giant pipe wrench, embodying several interesting new features, has just been put on the market by the Greenfield Tap & Die Corporation, Greenfield, Mass. This wrench has the "end opening" feature which is familiar to users of machinists' wrenches. Its application to pipe turning can readily be seen by a glance at the illustration.

One important advantage of the Little Giant wrench is the ease with which it can handle pipes in corners, close to walls, and similar confined places. The person using it can set it straight on the pipe as he would a pair of pliers, instead of having to fit the jaws on from the side. There are only three parts, a handle and jaw in one piece, which is drop forged and heat treated; a movable jaw, likewise drop forged and heat treated; and a hardened steel nut. In spite of the absence of springs the wrench is said to take hold and release instantly at the option of the user.



Little Giant Pipe Wrench Embodying New Principle of Design

The new wrench has been designed for maximum strength, the 14 inch size having successfully withstood stresses in excess of 4,700 inch pounds without slipping or bending. Yet owing to the elimination of extra parts the wrench is relatively light in weight.

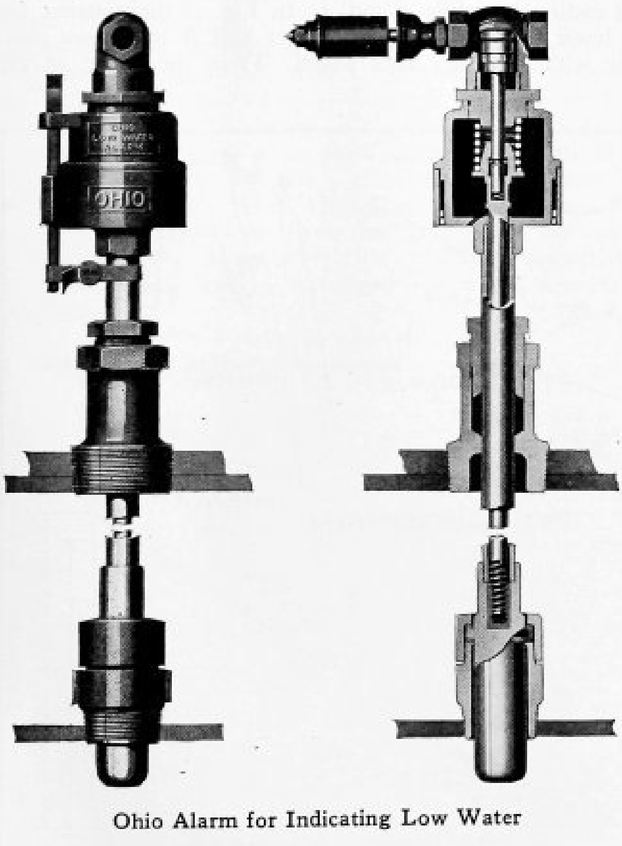
Another feature is the double set of teeth on the main jaw. The movable jaw can be engaged at the option of the operator with either of these sets of teeth with consequently lengthened life. On the large sizes, 14 inches and greater, two additional sets of teeth are provided, making four in all, and the movable jaw can be reversed to engage these additional sets of teeth, which are below the adjusting nut. This is very useful in connection with certain classes of work, besides tending to quadruple the life of the tool.

The Little Giant wrench is being manufactured in 8-, 10-, 14-, 18- and 24-inch sizes, of which the three smaller sizes are already on the market.

## Ohio Low Water Alarm

As an extra safeguard against the danger of explosions or burned crown sheets in locomotive boilers due to low water, the Ohio Injector Company, Chicago, has designed the automatic alarm shown in the illustration. This device includes a fusing chamber shell screwed into the crown sheet; and a fusing chamber plug which passes through this shell and extends 1¼ inches into the firebox and is held in position by a nut. The plug is insulated from shell and nut by an air space surrounding the plug and by two gaskets. The upper portion of the plug is provided with a chamber to receive the fusible material which consists of nothing but pure Banca tin.

A tube is screwed into the plug, passing up through a stuffing box in the wrapper sheet and supporting a valve cage. Into this cage is screwed the complete valve assembly that controls communication between a steam supply pipe from the boiler to the whistle in the cab. This valve as-




Ohio Alarm for Indicating Low Water

sembled consists of a body valve on the upper end of a stem with a retainer and an opening spring.

The operating rod is threaded at its lower extremity and these threads are in engagement with the fusible material in the plug. The upper end is provided with a hexagonal section to permit of its being rotated by a wrench, and is in contact with the valve stem through a small expansion spring. A wrench passes through slots provided in the cage and cage sleeve, thereby closing access to the hexagonal portion of the rod. It is sealed in this position, as shown in the view at the left.

With the rod screwed up, the valve to the whistle is closed. As long as a proper level is maintained in the boiler, water will surround the upper portion of the plug and absorb the heat conducted by the extension into the firebox, thereby keeping the fusible material below its melting point and providing support for the rod. With the water lowered to a dangerous point it no longer surrounds the upper portion of the plug and cannot absorb the heat. This results in a rapid rise of temperature in the upper portion of the plug, causing the fusible material to melt. The rod then no longer having any means of support drops in the molten tin to the bottom of the chamber; it is assisted in its downward movement by the large spring which opens the valve, causing the alarm whistle to give warning.

When the alarm whistle sounds, giving warning that the water is low, although the crown sheet is not uncovered, the engineman should proceed at once to start his injectors and bring the water to the proper level, which will again surround the upper portion of the plug with water and thereby cool the tin and solidify it. The lower extremity of the rod is threaded and having dropped to the bottom of the chamber in the plug will have the solidified tin cast around it somewhat in the form of a nut.

The engineman after making certain that he has 2 inches of water in the water glass, should break the seal and withdraw the wrench, which permits him to remove the cage sleeve and thereby gain access to the hexagonal portion of rod. He can now rotate the rod with a wrench, thereby shutting off the whistle, restoring the device to its initial position and placing it in readiness for another alarm. After replacing the cage sleeve and wrench the absence of the seal indicates that the device has operated.

## Water Treatment at Wayside Tanks

In treating locomotive feedwater with chemicals, which act inside the boiler, two problems have always been hard to overcome successfully. First, the difficulty of getting the chemicals applied with regularity, and, second, the attempt to treat all waters on a road division or district with the same formula or compound of chemicals. This latter is manifestly unscientific and impracticable since waters generally vary considerably at different sources, some coming from surface streams and others from driven wells. The formula that is chemically suitable for one source is not proper for all—in fact, may have a detrimental effect on the others.

The wayside tank method used by the Paige & Jones Chemical Company, New York, was designed to overcome these two objections to chemical treatment of road engine feedwater. At the pumping plant a feeder made from a piece of pipe is connected with the discharge line of the pump at the bottom, and with the suction line at the tóp, thus permitting a small stream of water to flow through the chemicals and back into the main line. When water is taken from the city pressure, the feeding device is attached to the feed pipe of the wayside tank.

The compounds are made in hard form, ball shape, weighing one pound each and of such a constituency that they will dissolve in the desired time, 8, 12 or 24 hours, depending upon the amount of water that is allowed to pass through the chemicals. This is regulated by a valve on the intake pipe to the feeder. The required number of balls, depending on the amount of water used, is placed in the feeder at the proper intervals, and with the valve correctly adjusted, all the water that goes into the wayside tank is uniformly treated, and with a formula suitable for that particular water.

# Questions and Answers for Boiler Makers

## Information for Those Who Design, Construct, Erect, Inspect and Repair Boilers—Practical Boiler Shop Problems

**Conducted by C. B. Lindstrom**

*This department is open to subscribers of* THE BOILER MAKER *for the purpose of helping those who desire assistance on practical boiler shop problems. All questions should be definitely stated and clearly written in ink, or typewritten, on one side of the paper, and sketches furnished if necessary.*

*Address your communication to the Editor of the Question and Answer Department of* THE BOILER MAKER, *Woolworth Building, New York City.*

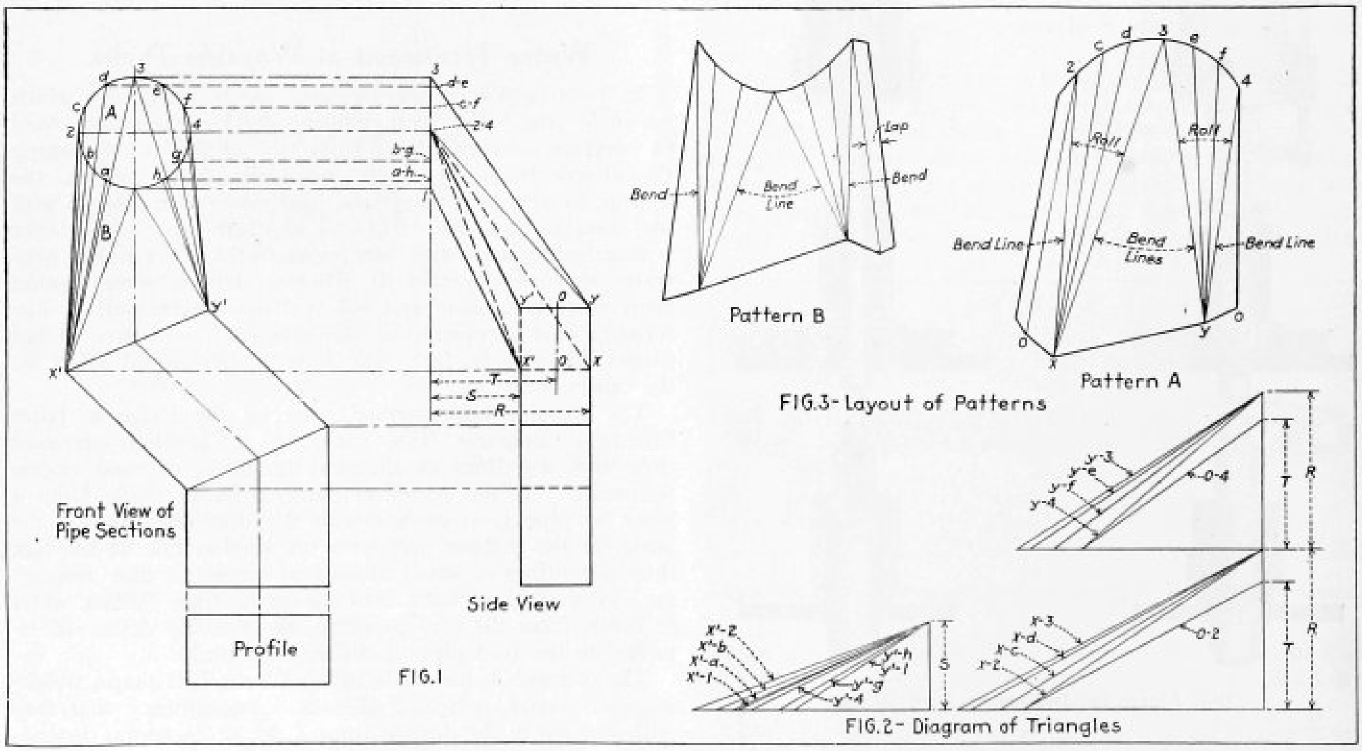
## Reason for Showing Complete Layout of Triangulation Lines in the Elevation

Q.—Would you please help me with the solution of the development of the transition piece on page 114 of the April issue of THE BOILER MAKER. I have been over the drawing with dividers and I cannot see why you project the divisions from the base to the elevation, after dividing the base. The true length of the lines can be marked (I think) without projecting the lines down; the only use for the elevation is to find the perpendicular heights.—I. H. T.

A.—Your understanding of the method for establishing the true lengths of the construction lines, and their required height, is correct. The only reason for showing the construction lines in the elevation in this case was to bring out the general relationship of the lines as shown in the two views. It also is of assistance in following the different steps of the pattern construction. Where the bases are not parallel, it is always well to produce these lines in the elevation and number them to correspond with those in the plan. This facilitates the work, making it easier to understand as well as easier to follow.

### Rectangular Elbow Mitering with a Transition Pipe

The construction of this problem is somewhat similar to the foregoing one, involving also the triangulation development. From the front and side views, Fig. 1, the various construction lines are obtained for making the diagram of triangles layout in Fig. 2. The side and front views show four flat triangular shaped sides and between these flat sections are the curved parts. These run from the circle and terminate in the points *x-y-y'-x'*. The heights of the triangles equal those at *R*, *S* and *T*. The seam is arranged to come on the narrowest side of the pipe starting from the points *o* and ending in points *2* and *4*. In Fig. 3, the patterns for the lower half section *A* and upper half *B* are shown complete with necessary laps added. From the shape of the transition pieces in both problems due to the method of locating the miters the cross-sectional areas of the pipes are less than the pipes they join.




Development of Rectangular Elbow

## Development of Tank Bottom

Q.—Kindly print in your next issue of THE BOILER MAKER a simple, accurate layout of a large steel tank, say 100 feet diameter, 30 feet high with conical roof. I wish to have a layout of a tank so as not to have to get the bottom plate by getting radius from the center but do not know how to get the radius for the different plates without laying, say, a quarter section of the bottom on the floor. G. A. S.

A.—From your request I understand that you desire a solution only for the layout of the circular arcs in the pattern for the bottom plates of the tank. In marking off circular arcs in structural work that cannot be drawn with the trammels there are a number of methods that can be used. The simplest method probably is shown in the accompanying sketch.

In order to lay off the arc without the use of its center, it is essential to know the chord length *a-a* and its rise as *a-e*, which is the distance measured between the chord center *a* and the center of the arc *e*. Lay off the chord length *a-a* and the rise *a-c* perpendicular to *a-a*. With the point *a* as center draw the semi-circle with *a-c* as a radius. Divide the arc *c-g* into a number of equal parts; in this example four divisions are used as shown at *c-d*, *d-e*, etc. Divide the chord *a-a* into twice as many parts and erect perpendiculars from these points to the line *a-a*. Connect the points *d-e* and *f* with point *o*. Where these lines cross the chord line at *1-2-3* establishes the lines for laying off the curve *a-f′-e′-d′-a*. Thus the lines *1-f′*, *2-e′*, *3-d′* equal respectively the corresponding lines *1-f*, *2-e* and *3-d* of the semi-circle construction.

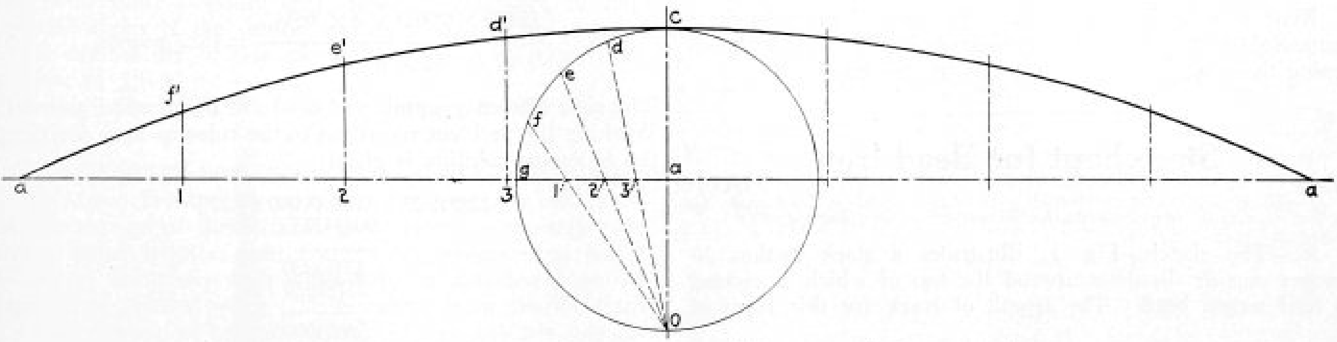



Fig. 1.—Illustrating Method of Describing Arcs of Long Radii

## Leaky Boiler Tubes and Stays

Q.—In regard to your question department of THE BOILER MAKER, we would like a little information on the following subject:

We have in our territory a number of Marion steam shovels, models "36, 270, 271 and 300." There is a model "271" at the Northwestern Indiana Coal Company at Ridgefarm, Illinois, with two firebox type boilers on it, which are giving us considerable trouble with the flues and staybolts. These fireboxes are about 6 by 8 feet grate surface and about 6 feet 6 inches high. Each boiler has two hundred and eleven $2\frac{1}{2}$-inch flues 9 feet $9\frac{1}{2}$ inches long. The staybolts are $1\frac{1}{4}$ inches diameter, $5\frac{3}{4}$ inches center to center; side sheets, $\frac{7}{16}$-inch and flue sheet and back sheet $\frac{1}{2}$-inch.

The trouble is in keeping these staybolts and flues tight. We have put a new set of flues in each boiler; also many new staybolts, some $1\frac{1}{16}$-inch and some $1\frac{3}{8}$-inch, but the new bolts give as much trouble as the old ones, and the flues were leaking within thirty days after being put in. They were put in with a copper ferrule rolled in the back sheet first, then rolled and expanded and beaded, all with air tools except rolling which was done by hand. The bolts which were renewed were all drilled out and retapped, and driven by hand, so you see the work was all done first class, but the bolts, new as well as old, leak all of the time. These boilers each have a fire door patch clear around the door, and one has a small side sheet patch taking in four staybolts.

I would like to have some information as to what can be done to stop these bolts from leaking. Are the bolts too large? It looks to me that way, as I think the bolts do not expand and contract with the sheet.—A. O. M.

A.—From your explanation of the condition of the boilers and repairs that have been made it would indicate that the boilers have been in service for some time. There are a number of conditions that will cause tubes to leak, namely, the ends of the tubes may not be properly expanded in the tube plate; frequent rolling or expanding causes the tube holes to become larger and to thin the metal of the tubes; the tube sheets may be badly corroded so that the seat for the tubes is too thin thus making it practically impossible to maintain a tight metal to metal contact between the tubes and tube plate, when a tube plate is under the stresses of expansion and contraction the tube holes will become slightly elliptical in shape and very often take this shape permanently, firebox tube sheets have become longer from $\frac{3}{8}$ to $\frac{1}{2}$ inch after continued use, thus elongating the tube holes. Copper ferrules should be used in resetting new tubes in oblong holes. The tubes may be split or cracked at an imperfect weld if lap welded tubes are used, or from working the tubes too much in expanding them in their seats. When a leak occurs around the tube end, if the tube is sound and the tube opening is in good shape, the leak can usually be stopped by expanding the tube slightly.

The leaky stays also arise from several conditions, but in your boiler the trouble is due principally to the size of stays. Being of large diameter and set in comparatively thin side sheets, which may be also badly corroded around the staybolt holes, it would be impossible to have good fitting stays. It is also difficult to upset large diameter stays uniformly and thus sufficient to obtain an absolute steam tight installation of the stays. The firebox side sheets may be badly corroded around the stayholes; as a result the stays have a reduced bearing area, especially when the stay ends are riveted over and not fitted with nuts. I would suggest that the thickness of the metal around the staybolts be determined and if metal has corroded considerably that new side sheets or sections be applied, using smaller diameter of staybolts in the new work, provided it is impossible to upset the old stays and produce tight staybolts. If the plate is in good condition and will safely carry the allowable working pressure, the ends of the stays can be welded around the outer edges to the plate, this will produce tight work if properly done. In doing this work carry the arc more into the solid plate than in the stays since the staybolt iron is much softer than the steel plate.

## Heat Treatment of Rivet Sets

Q.—I am interested to know whether it has been the custom of your readers to anneal the stakes of bull riveters with the idea of preventing crystallization and breakage. Any information which you have on this point will be much appreciated.—C. W. E.

A.—It is difficult to give specific information on work of this character, since the successful handling of the heat treating process depends upon the nature of the steel, methods of forming the sets, temperature and tempering process under the control of the tool worker. For forging the steel it should be heated slowly and uniformly to a temperature around 1,600 degrees F. which is a bright red. The forging operations are then carried on rapidly, striking the heaviest blows while the metal is hottest, reducing the weight of the blow and increasing the number as the temperature falls to a dull red heat. If re-heating is necessary, the same precautions should be taken to have it done uniformly. Otherwise the tempering may be done immediately after the forging process by bringing the heat temperature up to about 1,400 degrees F.

The hardening process is produced as follows: heat the tool from the shank end to within 1 or 2 inches of the cup end, depending on the size of the rivet set. Then cool it, but do not immerse it in a vat of water, as that will cause unequal stresses around the thinner cup edges possibly breaking off pieces and allowing the deeper end of the cup to remain soft. This would also produce a decided line between the hardened and unhardened parts of the tool. The proper way is to hold the tool over or under a stream of water so that the flow strikes directly on the bottom of the cup; remove it before the tempering heat is lost in the shank. Brighten a spot on the cup end and when the temper color appears, which should be peacock, the tool should be immediately plunged into water to prevent further softening.

Rivet sets having short life arise most frequently from annealed stock. Additional toughness is obtained by hardening the head in oil before hardening the cup.

## Stretchout for Bead Iron

Q.—Would you inform me through your magazine what is the formula for a bead iron to fit around the outside circumference of a smokestack?—J. L.

A.—The sketch, Fig. 1, illustrates a stack section 36 inches outside diameter around the top of which is riveted a half round bead. The length of stack for this form of

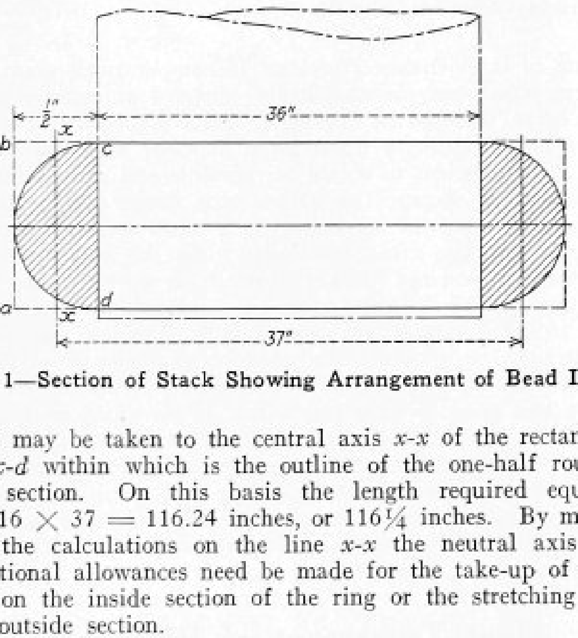



**Fig. 1—Section of Stack Showing Arrangement of Bead Iron**

bead may be taken to the central axis *x-x* of the rectangle *a-b-c-d* within which is the outline of the one-half round bar section. On this basis the length required equals 3.1416 × 37 = 116.24 inches, or 116¼ inches. By making the calculations on the line *x-x* the neutral axis in additional allowances need be made for the take-up of the bar on the inside section of the ring or the stretching on the outside section.

## Riveted Joint Calculations and Pressure Allowed on Cylinders

Q.—Would you kindly solve the following problem in pressure for a small boiler. I think this pressure is too high, though according to rules that is the pressure after being calculated. In this case consider a boiler of the following dimensions: Diameter of head, 3 inches; thickness, 1/16 inch; shell thickness the same. Diameter of rivet, ⅛ inch.

Pitch between rivets, 3 times diameter of rivet as 3 × 0.125 = 0.375 or ⅜ inch. Net section of plate, *a — a*, Fig. 1, equals 0.375 — diameter of rivet hole, equals 0.375 — 0.125 = 0.250 or ¼ inch.

¼ ÷ ⅜ = (0.25 ÷ 0.375) = 66¼ percent efficiency of net plate section as compared with solid plate. Strength of rivets as compared with solid plate is determined as follows: Area of driven size of rivet = ⅛ × ⅛ × 0.7854 = .0123 square inch. Shearing resistance of iron rivets equals 38,000 pounds per square inch. There are two rivets within the pitch so their combined strength equals 38,000 × 0.0123 × 2 = 934.8 pounds.

Consider the tensile strength of the plate to be used to equal 55,000 pounds per square inch. The strength of the solid plate section within the given pitch equals 55,000 × 0.375 × 0.0625 = 1289.0625 pounds. The rivet efficiency equals 934.8 ÷ 1289.0625 = (This is where I am in doubt for the percent.)

The allowable working pressure is figured from the weakest part, so in the case of the joint the plate efficiency of 66¼ percent would be used. Working pressure allowed with factor of safety of 10 equals:

$$\frac{55{,}000 \times .0625 \times 2 \times .6625}{3 \times 10} = 151 \text{ pounds.}$$

Is this calculated pressure too high for the size of the boiler?

I imagine, am I right, that the smaller diameter the higher the pressure allowed? Can you give me a practicable rule for the rivet efficiency compared with the plate efficiency. In case the rivet efficiency would be too high over the plate efficiency would the joint be too stiff for satisfactory work? Trusting I have marshalled the different calculations in the order they should be and hoping you can make out this lengthy letter. Thanking you in advance, always take interest in the Questions and Answers department of THE BOILER MAKER. Have been a reader since 1911.

R. W. E.

A.—In checking your calculation of the efficiency of the net plate section in which you give ¼ ÷ ⅜ = (0.25 ÷ 0.375) = 66¼ percent as compared with the solid plate, I find that the result should be 66⅔ percent. Therefore, the allowable working pressure will be greater as

$$\frac{55{,}000 \times 0.0625 \times 2 \times .66\tfrac{2}{3}}{3 \times 10} = 152.7 \text{ pounds.}$$

The rivet efficiency equals 934.8 ÷ 1,289.0625 = 72.5 percent. Working the problem according to the rules of long division, the following solution is given:

```
1289.0625 ) 934.8000000 ( 0.725
            90234375
            --------
             32456250
             25781350
             --------
              66749000
              64453125
              --------
```

The making of suitable riveted joints is one of the most important features of boiler construction. The strength of a riveted joint depends on a number of factors, namely, plate thickness, diameter and pitch of rivets, tensile strength of plate, strength of rivets, rivet arrangement according to whether the joint is single, double or triple riveted lap or butt joint.

To form a good joint the rivet must not be too large in diameter as this will require a wide lap and require too great a pitch between rivet centers. When the pitch is too large difficulty arises in producing tight seams. A good rule is to make the net section of the plate between two rivet centers or pitch equal in strength to the shearing strength of one rivet, in other words, the joint should be so proportioned that the rivets and plate are of equal strength. In practice, however, this is difficult to do on account of the rivet arrangement.

Riveted joints are not flexible, and a high rivet efficiency is not objectionable providing the net plate section efficiency is not reduced too much.

DIAMETER OF RIVETS

BASED ON PLATE THICKNESS

| Plate Thickness, Inches | Rivet Diameter Driven Size, Inches | Plate Thickness, Inches | Rivet Diameter Driven Size, Inches |
|---|---|---|---|
| ¼ | 11/16 | 7/16 | 15/16 |
| 9/32 | 11/16 | 15/32 | 15/16 |
| 5/16 | ¾ | ½ | 15/16 |
| 11/32 | ¾ | 9/16 | 1-1/16 |
| ⅜ | 13/16 | ⅝ | 1-1/16 |
| 1 3/32 | 13/16 | .... | .... |

The pressure tending to rupture a boiler shell or cylinder in a longitudinal plane is in direct ratio to the diameter of the shell. For illustration, consider in your example that the diameter of the shell is 6 inches instead of 3 inches. Substituting the value 6 in the solution for determining the allowable working pressure, the following result is obtained:

$$\frac{55{,}000 \times .0625 \times 2 \times .66\tfrac{2}{3}}{6 \times 10} = 76.35 \text{ pounds.}$$

# Letters from Practical Boiler Makers

**This Department Is Open to All Readers of the Magazine**
**—All Letters Published Are Paid for at Regular Rates**

## Construction Codes for Tanks

Some weeks ago, while I was living in Sherbrooke, Que., you were kind enough to accept from me a contribution. "Construction Codes for Boilers and Pressure Vessels." In this article, I suggested that eventually tanks of large size, subject to static pressure only, would be included in construction codes of the future, and mentioned as an instance of the desirability of this course, the Boston molasses tank incident of 1919.

In this connection, the following paragraph from the *Engineering News-Record* may be of interest:

MASSACHUSETTS LAW CONTROLS TANK CONSTRUCTION

"In Massachusetts the construction of 'tanks or containers for the storage of fluids other than water' is controlled by a law which requires that permits for constructing, maintaining or using any such tanks must be obtained from the chief of the district police (in the metropolitan district, from the fire prevention commissioner). These officials are required to make rules and regulations for such tanks, subject to the approval of the governor and council. The law, which was passed as a result of the Boston molasses tank incident in 1919, does not apply to tanks constructed principally of wood, or to tanks of 10,000 gallons or less capacity."

It may take some little time, but it would seem to the writer altogether likely that similar legislation will be adopted by nearly all of the States within the next few years.

Lachine, Que. D. M. McLEAN.

## Experiences of an Old-Timer

An interesting boiler job came to my mind recently which illustrates some of the problems that often came up in the old days in the field. The boiler in question, which was of 20 horsepower, was built in a hurry for a firm engaged in sinking a well near Bradford, Pa.

In those days the safety valve was a two-way valve; that is, there was an outlet for blowing off and one to connect the engine to the boiler. This valve had not been in use a week when word came to the office that the boiler would not work and the dome was leaking badly, so I was sent out to see what the trouble was. When I got there I found that the indicator hand on the gage was jammed against the pin it started from and there must have been 200 or more pounds of steam on her.

I also found that through some fault of the man who tested the boiler they had not taken the plug out of the outlet that led to the engine and the fellow who connected up did not bother to take it out but connected to the blowout outlet and the weight was set on the lever to the outer end, so of course no steam could reach the engine until it commenced to blow off and besides the ball there was a bit hung on to the lever and the bit was new and weighed over 50 pounds.

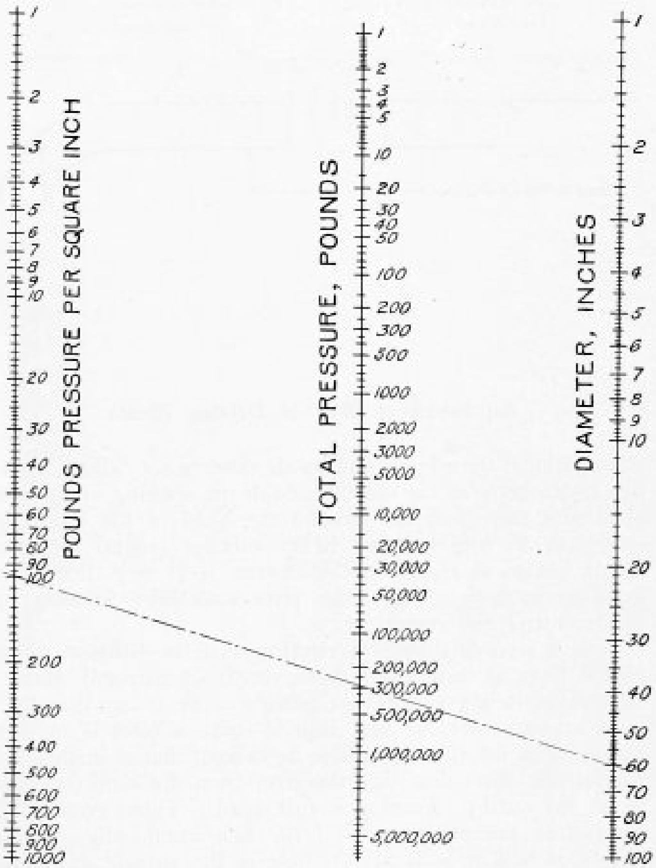
All around the flange of the dome was leaking. I had them stop drilling and drew the fire and waited about an hour to let her cool off and started to take the plug out. I had not taken a half dozen turns when it let go and buried itself three feet in a bank about 20 feet from the boiler.

I had them connect to the right outlet and filled the boiler up again (as when the plug gave way a lot of the water came with the steam) and fired up, but first I made them take off the drill and shifted the lever ball to the 100-pound mark. When it began to blow off, I tucked up the few leaks and the engine ran away—they had left the valve wide open.

Springfield, Ill. JOHN COOK.

## A Useful Chart for Finding Total Pressures

The dotted line drawn across this chart shows that if the barrel of any boiler is 60 inches in diameter, and the pressure within the boiler is 100 pounds per square inch, the total pressure on the boiler head or on the piston is close to 280,000 pounds. Just lay a straight edge across




**Method of Finding Pressure in Boiler Shells and Engine Cylinders**

from the pressure to the diameter and the total pressure is immediately found in the middle column.

Cylinders of engines are seldom 60 inches in diameter but boilers are often that large. The total pressure tending to tear such a boiler apart longitudinally, under 100 pounds pressure would therefore be approximately 280,000 pounds.

We often have to compute pressure on pistons in all kinds of engines, pumps, etc., and it is bothersome to deal with circular functions. Hence, the value of this chart. It does the figuring direct and its range is wide enough to care for almost any condition. The maximum, it will be noted, is over 7,000,000 pounds.

Newark, N. J. W. F. SCHAPHORST.

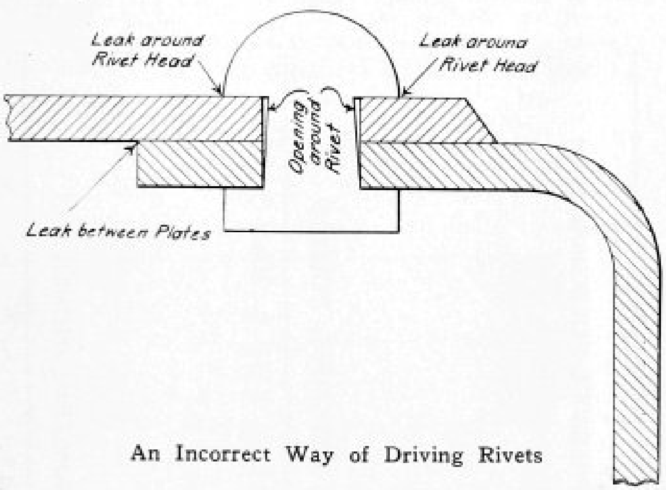
## Requirements for Driving Tight Rivets

I noticed in the July issue of THE BOILER MAKER a question* about riveting that interested me, also your answer to same.

While he does not say so, it appears as if the writer meant that the rivets were "back-driven," that is, inserted from the outside and driven on the head while the holder-on was placed against the point of the rivet and a flat head thus formed.

It is a difficult thing to make a rivet tight that way, especially if the vessel is not calked on the inside for reasons that I have tried to show in the accompanying sketch.

The rivet, when driven that way, does not swell uniformly, especially when of small diameter, so when it is upset from the point it has a tendency to swell and fill only the hole in the sheet that is nearest to the point, which in this case is the inside sheet. That leaves an opening in the outside sheet equal to the clearance for the rivet all around the rivet




An Incorrect Way of Driving Rivets

shank and, if the edge of the inside sheet is not calked, liquid can get in between the sheets through the opening around the rivet and then leak out around the head of the rivet, the only way to stop it being heavy calking around the rivet heads. Also as stated in the answer, it is very difficult to hold on squarely against the rivet sometimes forming the heads entirely off center.

I have seen this kind of riveting tried in different places that I have worked, but I have yet to see anybody make a success of it where water or oiltight work is concerned.

It appears that the best way to drive a rivet is to form the head on the sheet that is to be calked, that is in this case the outside sheet, inserting the rivet from the inside, driving it on the outside, forming a full head. Then, even if the rivet does not swell and fill the hole completely in both sheets, it will at least fill the hole in the outside sheet and, when the edge then is calked, the result is a tight job. This may be a little slower in the riveting but it saves time (and temper) when it comes to calking and testing and it will surely be cheaper in the long run, outside of the fact that it gives better work all the way through and does not necessitate the use of tarpaper and other foreign substances between the sheets which is not considered good practice and should not be necessary if the riveting is done right.

Sharpsville, Pa. ED. JOHNSON.

*The question referred to is one on "General Tank Construction," appearing on page 212 of the July issue.

## Design and Maintenance of Locomotive Boilers

(*Continued from page 266*)

money we have saved in our boiler-washing practice. Of course our boiler washing increased the cost of washing boilers. The biggest saving that we made was in the increased number of engine hours in the service.

With regard to the locomotive syphon, we have had very good success. I think that the reserve factor, at least on a railroad such as the Rock Island, where we have many short hills, has enabled us to take a heavier train over the divisions, and not only keep up our schedule, but make up time that was lost. Sometimes on a division run of 165 miles, we could make up 24 or 30 minutes with heavy trains. It seems that our savings have to be predicated on the efficient and economic handling of the train, rather than based on the locomotive alone. I believe that one reason for our fair success with the locomotive syphon has been that we spent a great deal of time and effort designing the method for welding or attaching syphons in the firebox.

Chairman Coleman: Mr. Oatley, will you please come forward?

H. B. Oatley (Superheater Company): The question has been raised as to the Hungarian Railway locomotive with a purifier. I happen to have a little information on that. I do not know that it will supplement a great deal the article that appeared recently in the *Railway Age*. It is merely a large chamber (barrel-shaped) on top of the boiler, into which the water is forced from a feed water heater. In the event there is no feed water heater the water is forced there and allowed to settle. In other words, the velocity is decreased and any precipitant is allowed to settle in this purifier and be blown off. In other words, it is an adjunct to a feed water heating system and a protection to the boiler. I think that purifier is little if any different from one developed in this country some years ago by two of the locomotive builders. You recall that a good many boilers of the large Mallet engines were built in what might be called two parts. Water was forced into the forward portion and from there into the main portion of the boiler. The heating of the water in that forward section where the circulation was relatively slow permitted settling of the precipitant. The water going from there to the boiler was relatively clean. In other words, it localized whatever harmful action there was from the solids and, to a large extent, saved the boiler.

The other form to which I refer was where a partition tube plate, a third tube plate if you please, was located about six feet back from the forward tube plate in the boiler, the water from the injector being delivered into this forward section. A similar action took place there and the relatively clean water was allowed to pass through or over the plates into the main portion of the boiler. I believe there will be further developments of the idea.

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Negotiations are under way and are expected to be completed soon for the sale of the Globe Seamless Steel Tubes Company, manufacturers of steel tubes for use in locomotive and stationary boilers and automobile parts. Works are at Milwaukee, Wisconsin, with sales offices in Chicago, Detroit, New York City, Atlanta, Houston, San Francisco and Portland.

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American Flexible Bolt Company announces a complete reorganization which they have been working out for the last six months, however, retaining the original charter. There is also a complete change in the board of directors. Stephen Robinson, Jr., is now president and in charge of sales; H. T. Frauenheim, vice-president; Chas. A. Seley, consulting engineer and district representative at Chicago.

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Assistant Chief Inspector—J. M. Hall, Washington, D. C.

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## TRADE PUBLICATIONS

Seamless Steel Tubes.—The third of the series of four bulletins describing the manufacturing processes carried on by the Standard Seamless Tube Company, Pittsburgh, Pa., has recently been sent out. The subject dealt with in this case is the cold draw department and, by means of illustrations and descriptive details, an excellent idea of the work at this stage of tube production can be obtained.

Cast Iron Storage Tank.—The Conveyors Corporation of America, Chicago, has issued a new booklet describing its American cast-iron sectional storage tank which is designed for holding loose, bulky, dry materials for storage or transfer. The booklet is illustrated with engravings showing the tanks in use at a number of well-known plants. Diagrams give details of construction and a comprehensive table of weights and measures is included.

Locomotive Injectors.—A neatly arranged catalogue has recently been issued by William Sellers & Co., Inc., Philadelphia, Pa., in which its line of injectors and boiler attachments is described and illustrated in detail. The results of high pressure steam tests of a No. 10½, Class N, improved self-acting injector, which were outlined in the October, 1906, Journal of the Franklin Institute, are contained in this catalogue, also a number of maintenance and repair hints.

Metals Coating.—A series of photographic reproductions with descriptive matter has been published by the Metals Coating Company of America, Philadelphia, Pa., which present the adaptability of commercial requirements of the Schoop metal coating process. As a protection against high temperatures, it is set forth that, by spraying with aluminum, oxidization and scaling in grate bars and similar pieces is retarded and clinkers are prevented from adhering. It is also claimed that the Schoop metal spraying process can be successfully applied to distributors and automatic stokers, condenser tubes, pyrometer couple tubes, boiler tube cleaning equipment, valves, pistons, explosion chambers of internal combustion engines, etc.

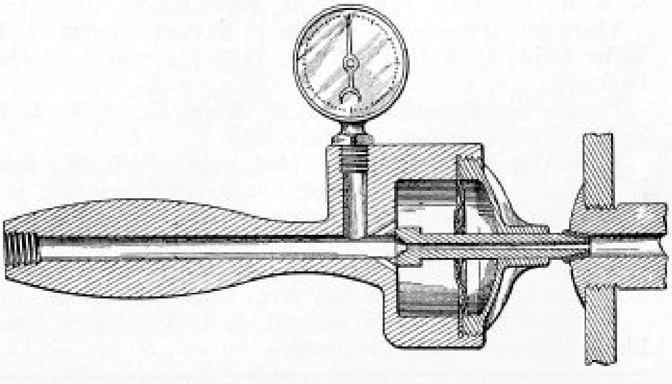
# SELECTED BOILER PATENTS

Compiled by
GEORGE A. HUTCHINSON, Patent Attorney,
Washington Loan and Trust Building,
Washington, D. C.

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

1,414,075. MEANS FOR TESTING STAYBOLTS FOR BOILERS. ETHAN I. DODDS, OF PITTSBURGH, PENNSYLVANIA, ASSIGNOR TO FLANNERY BOLT COMPANY, OF PITTSBURGH, PENNSYLVANIA.

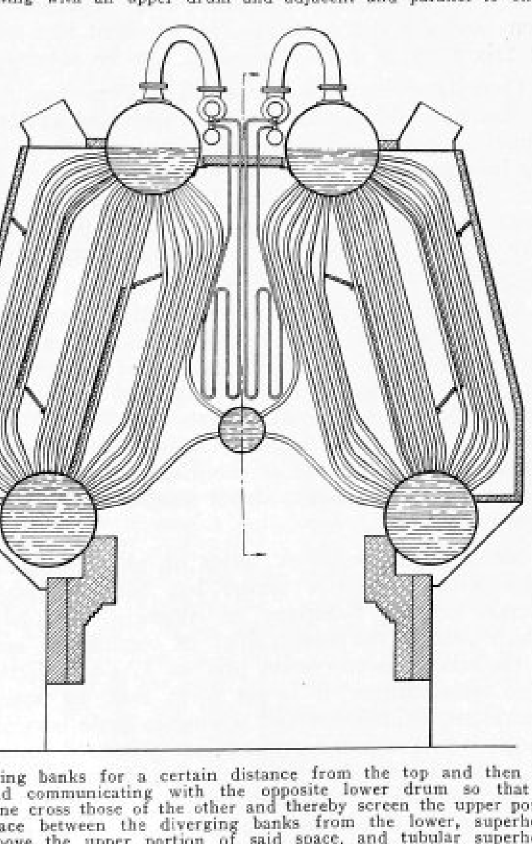
*Claim* 1.—A device for testing boiler staybolts having tell-tale bores, comprising a member having a duct, a nozzle slidingly mounted in said member



and adapted to communicate with said duct, means whereby fluid pressure may be applied to the slidable nozzle to press the same against a staybolt at the open end of the tell-tale bore thereof, and a pressure gage also communicating with said duct. Six claims.

1,417,024. WATER TUBE BOILER WITH SUPERHEATER. BENJAMIN BROIDO, OF NEW YORK, N. Y., ASSIGNOR TO THE SUPERHEATER COMPANY, OF NEW YORK, N. Y., A CORPORATION OF DELAWARE.

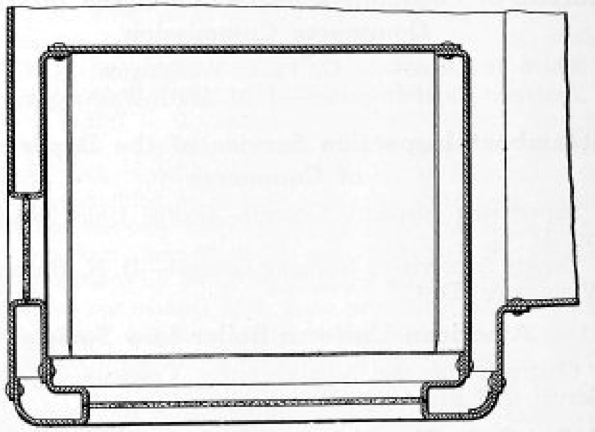
*Claim* 1.—In a boiler, the combination of two upper and two lower spaced parallel drums, two diverging banks of tubes connecting the two upper to the two lower drums, two additional rows of spaced tubes each communicating with an upper drum and adjacent and parallel to one of



the diverging banks for a certain distance from the top and then bent toward and communicating with the opposite lower drum so that the tubes of one cross those of the other and thereby screen the upper portion of the space between the diverging banks from the lower, superheater headers above the upper portion of said space, and tubular superheater elements secured to the headers and looping into said upper portion of the space. Two claims.

1,416,762. MUD RING FOR BOILERS AND METHOD OF APPLYING SAME. FREDERICK C. STIMMEL, OF CHATTANOOGA, TENNESSEE, ASSIGNOR TO THE CASEY-HEDGES CO., A CORPORATION OF TENNESSEE.

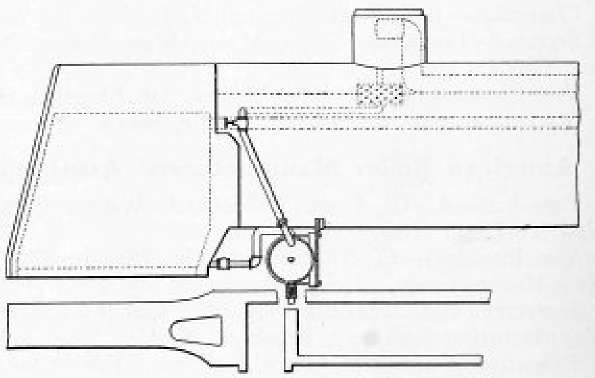
*Claim* 1.—A mud ring made in two sections for independent attachment, respectively, to the firebox and casing of a boiler, said sections having ver-



tical flanges to be subsequently connected together for completing said mud ring. Six claims.

1,419,701. APPARATUS FOR PREVENTING SCALE DEPOSIT AND FOAMING IN BOILERS. ABRAHAM A. STUTSMAN, OF HAMMOND, INDIANA.

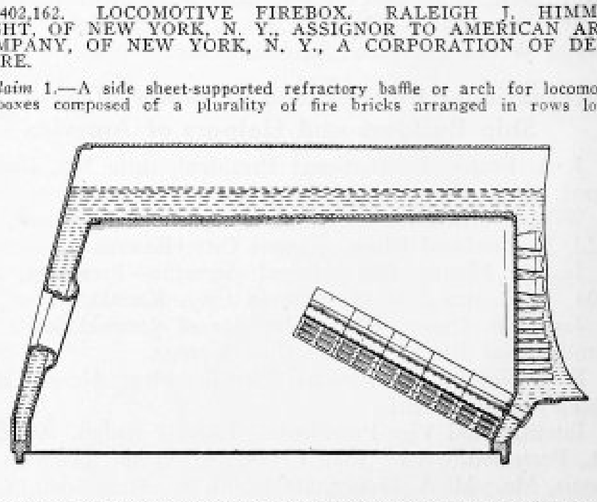
*Claim* 1.—In combination with a boiler having a steam dome and a steam pipe therein, of a scale preventer comprising a collecting pan having a closed base and a perforated wall with an open top, said pan disposed at approximately the water level in the boiler and spaced substantially below



the steam dome, a settling tank arranged beneath the boiler close to the firebox, a pipe communicating with the bottom of the collecting pan and extending down to and connected with the top portion of the settling tank, a second pipe leading from the upper portion of the settling tank to the portion of the boiler about the firebox, and blowoff means for the settling tank. Two claims.

1,402,162. LOCOMOTIVE FIREBOX. RALEIGH J. HIMMELRIGHT, OF NEW YORK, N. Y., ASSIGNOR TO AMERICAN ARCH COMPANY, OF NEW YORK, N. Y., A CORPORATION OF DELAWARE.

*Claim* 1.—A side sheet-supported refractory baffle or arch for locomotive fireboxes composed of a plurality of fire bricks arranged in rows longi-



tudinally of the firebox, tubular key members between the rows for preventing collapse of the arch, openings in the key members communicating with the firebox, and a connection between the key members and the atmosphere for admitting air therethrough to the firebox. Ten claims.

# The Boiler Maker

OCTOBER, 1922

# Applying Arc Welding to Locomotive Boiler Repairs

**By C. W. Roberts***

*The accompanying abstract of a paper presented at a recent meeting of the Pittsburgh Section of the American Welding Society contains suggestions for the preparation of locomotive boiler parts for welding and details of the methods to be followed in completing the work successfully and in a manner to uphold the reputation of the welding art.*

ELECTRIC arc welding is of comparatively recent origin, and as we believe in the American Welding Society is just in its infancy. As in everything else, we no sooner discover or perfect a new method, but what it is immediately subjected to abuse.

Electric arc welding is now indispensable in a large number of our industries and will continue to increase in importance and efficiency. It will increase more rapidly if we strive to eliminate the abuse that is brought about by carelessness, ignorance and lack of interest.

There is considerable discussion and differences of opinions as to just what should or should not be welded. It is undoubtedly true that in all processes of autogenous welding that an intense local heating is unavoidable and that in the cooling there is liable to be a certain amount of locked up stresses in some jobs. Are these locked up stresses great enough and so menacing as to warrant the discontinuance of a large amount of our welding?

In electric arc welding, as in everything else, there are limitations, and an efficient supervisor will know these limitations and will refuse to go beyond them, as he knows such work only leads to the condemning of the entire practice of electric arc welding. It therefore follows that your supervisor must have cooperation.

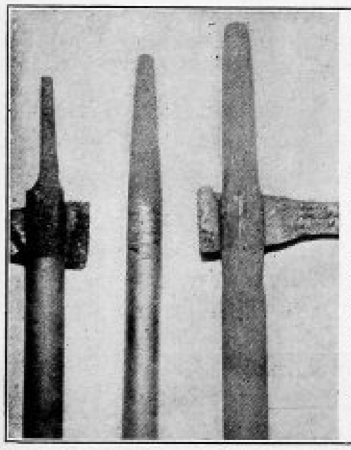


Fig. 1

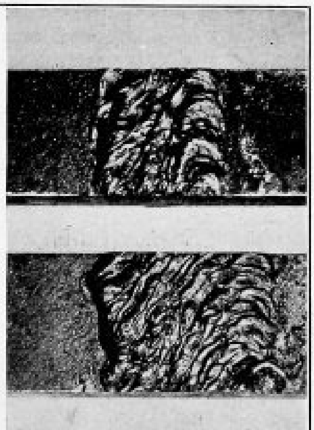


Fig. 2

**Fig. 1—How Various Electrodes Burn Away in Service**
**Fig. 2—View of Fire Side of Two Firebox Side Sheet Seam Welds**

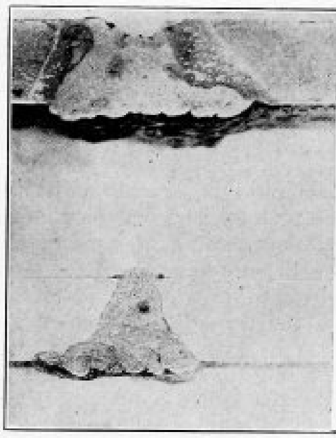


Fig. 3

Fig. 4

**Fig. 3—Improperly (Above) and Correctly Prepared Work**
**Fig. 4—Enlarged Section of Electrically Arc Welded Side Sheet Seam**

The commonest cause of failures is the inefficient and indifferent workmen and the little heed taken to have a perfectly clean and properly prepared job; although suitable equipment and proper electrodes for the work at hand should not be overlooked. Your finished result, I might say, is 90 percent operator, 10 percent equipment and materials, while preparation and operation are about a 50-50 break. You cannot get thoroughly satisfactory results no matter how good your welder's ability may be, if the work is not first properly prepared.

Our men on this work with which I am most familiar are welders; they are able and do do all kinds of autogenous welding. They are men who started at the bottom and were retained because of their ability and interest in welding. They have become proficient in all phases of electric arc welding and oxy-acetylene welding. They are welding operators; which is and should be recognized as a trade in itself; a trade in which a man should receive instructions and serve an apprenticeship, just as a boilermaker, blacksmith, machinist or any other craftsman. Just because a man is any one of these craftsmen, is far from being an intelligent or rational reason why that man should be called a welder, given the welder's rate of pay and set to work. This is one of the chief reasons why today we have so much inferior work for which electric arc welding is being condemned. It

*Welding foreman, Pennsylvania R. R., Columbus, Ohio.

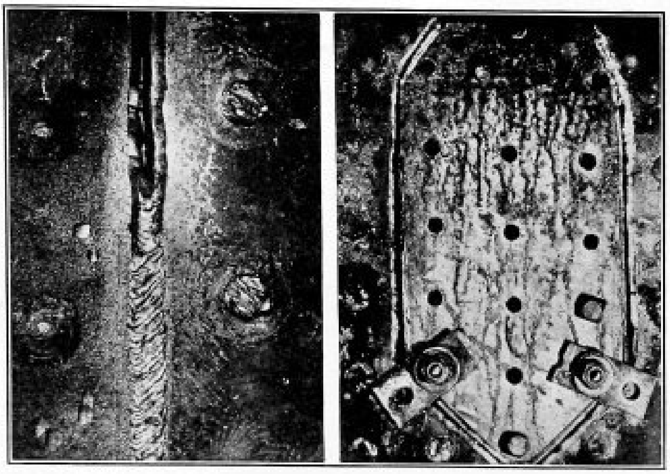


Fig. 5 Fig. 6

**Fig. 5—A ¾-Inch Side Sheet the Seam of Which Is Being Electrically Welded**

**Fig. 6—Method of Welding a Side Sheet Patch**

is the incapable operator and not the method that should be condemned.

Your craftsman may become a welding operator after he has received instructions and served his apprenticeship (if he has the ability), and he may be able to master all phases of electric arc welding and oxy-acetylene welding, such as firebox, boiler, machinery and equipment work, in the roundhouse, back shop, yard or road. However, he will not acquire that ability in its entirety in six days, six weeks, or six months. It takes perseverance, endeavor, and actual experience, and lots of it, to make a thoroughly reliable welding operator. They are not made over night.

We employ both the carbon and metallic arc processes and find a very large and ever-increasing field for both methods. The illustrations will give some idea of a few of our different operations.

### Good Materials a Factor in Satisfactory Welding

During the war when supplies were scarce, most any material that could be obtained was used in electric arc welding and I believe from the appearance of some of our work today, this condition is still permitted to exist at some places. This should not be tolerated, for proper and suitable electrodes and materials go a long way toward producing satisfactory results.

The truth of this statement in the matter of suitable electrodes for carbon arc welding is shown in Fig. 1. Electrodes one and two are ⅝ inch in diameter; both were placed in the holder jaw to extend through four inches; both were used constantly for 20 minutes under same voltage, amperage, and other conditions. No. 1 is a carbon and No. 2 a graphite electrode. The carbon decreased in length 1⅞ inches and in diameter to ¼ inch and burnt off the holder jaw as you will note, while No. 2, which is graphite, decreased in length 1⅛ inches with a gradual taper and the holder jaw was not affected in the least. No. 3 is a ¾ carbon, somewhat denser than No. 1 carbon. This lasted just 15 minutes (under same conditions as Nos. 1 and 2), when it dropped through the holder jaw having decreased ½ inch in length, also in diameter and burned out the jaws as you will note. A graphite electrode will carry your current in a straight, even flowing arc with practically no whipping or spluttering of the flame, while a carbon electrode is unstable, will whip and twist and give a constant spluttering and squealing arc. Graphite electrodes keep your welder operators amiable and contented and pay big dividends in the amount of work accomplished and the amount of electrodes and holder jaws saved, to say nothing of the superior quality and even flow of metal.

### Arc Welding of Fireboxes

We will now pass on to the metallic arc process as we use it in firebox work. Every welding operator considers himself your best welder, but an efficient supervisor knows his men and uses them according to their ability. When so much depends on a sound and thorough weld as in firebox work, employ only your highest trained men, men that have proven themselves by the actual result of their test stubs and whose ability is known beyond a doubt. Here perhaps more forcibly than in any other work, except flues, comes up the question of proper preparation before welding.

Fig. 2 gives a view of the fire side of two firebox side sheet seam welds, both beveled to a 45 degree angle, one with a ⅛-inch the other with a ⅜-inch opening between the two sheets. Both appear on the face or outward appearance to be very successful welds. But electric arc welds like men are not always what they appear outwardly. Note the uniformity of the welded metal in these two specimens.

The result obtained in the two specimens can be seen from Fig. 3, which is a cross section view of these same specimens. Notice how the metal from the electrode is forced through the ⅛-inch opening and how it forms both corners of the "V" into a seam resembling a rivet head; also note the small amount of metal that is required to fill the "V" and properly finish the seam. This is the ideal prepared seam as it requires a minimum amount of electrode or added metal, and a minimum amount of heat which is of great importance in all firebox work. While the ⅜-inch opening as you see requires an excessive amount of welded material, and therefore excessive heat. In the ⅜-inch opening or even ¼-inch opening you cannot unite the two sheets with one run of your electrode as in the ⅛-inch opening, but must first make two or more runs on your lower sheet in order to make the opening small enough to unite the two sheets. The side and door sheets being of from 5/16-inch to ½-inch steel gives you a very narrow surface on which to build up, with the result that your inside corner is melted off and your metal after the first run will be very hard to control and as you are not able to see the back side, you get results similar to those shown.

### Effect of Heat on Metal Structure

An enlarged view of electrically welded side sheet seams with 45-degree bevel and a ⅛-inch opening may be seen in

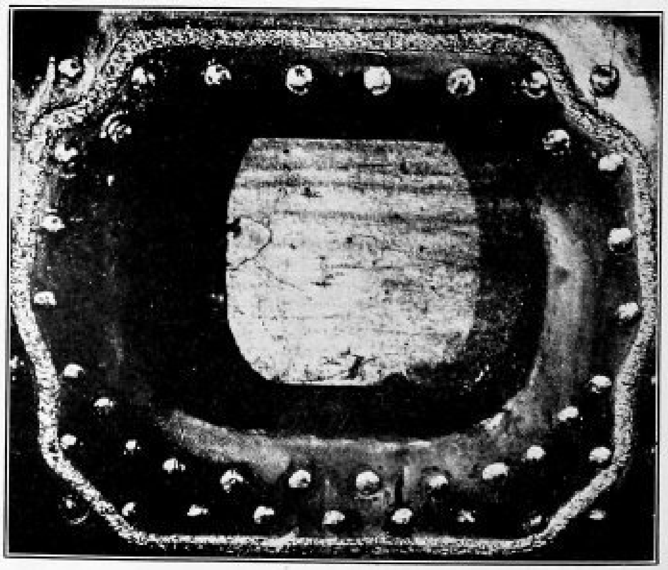


**Fig. 7—Showing Practice of Welding in a Door Hole Collar**

Fig. 4. Note the rivet head effect of the seam and the line of heat penetration or change in general structure of the parent metal.

Fig. 5 is a ¾-inch side sheet the seam of which is being electrically welded. You can readily see the process of the two runs of the electrode, which completely finishes the seam. With a 45-degree bevel in the two sheets with a ⅛-inch opening, the welder is able to completely unite the two sheets and fill in about one-half of the "V" with the first run of the electrode. Care must be taken not to proceed too rapidly so as to avoid an excessive amount of heat in the two sheets. Proceed slowly and weld thoroughly with your first run and you will never have one of these seams crack for you. The iron oxide (that has formed) should be completely brushed away with a wire hand brush, using a hand hammer and chisel to remove any slag that has been formed on the edge of the "V." The second run of the electrode should completely fill the remainder of the "V" reinforcing the weld about 1/16 inch and extending beyond the two edges of the "V" about ⅛ inch.

Prepare your seams in a straight line, but in door collars and all patches studiously avoid square corners. Fig. 6 illustrates a side sheet patch and Fig. 7 shows the practice in welding in a door hole collar.

No electric arc weld is as strong as the original sheet for the simple reason that the metal deposited through the arc is necessarily a cast metal, while your sheets are forged or rolled steel. Therefore, the more thorough your preparation of the sheets and the less welded material in your seams, the stronger your finished job. Use a ⅛ or 5/32 electrode, with the chemical properties about as follows:

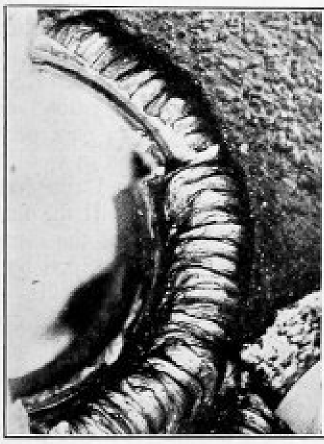


Fig. 8

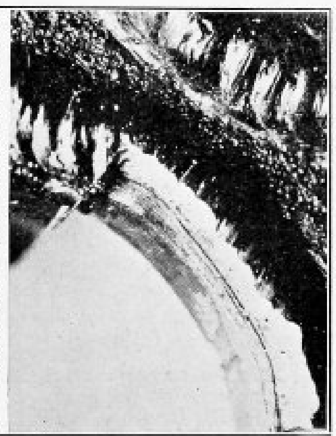


Fig. 9

**Fig. 8—A 2-Inch Flue Welded with ⅛-Inch Electrodes Using 140 Amperes and 21 Volts Across the Arc**

**Fig. 9—Flue Welded Under Same Conditions as Fig. 8, Excepting No Water Was Used in the Boiler**

| | |
|---|---|
| Carbon not over | 0.18 |
| Manganese | 0.64 |
| Sulphur and phosphorus | 0.05 |

Electric arc welding gives a stronger seam than riveting and there is never any future work necessary, such as calking. Your riveted seams give about 60 percent of the strength of the original steel, while I have gotten as much as 96 percent in an electric arc weld.

### Test Results

I have a test report here that I want to give you just to show what results are possible in metallic electrode welding. These test coupons were welded under the same conditions as I have described in the firebox, seam welded and are the results obtained by three of my welders.

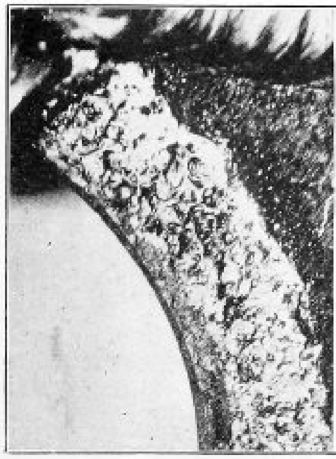


Fig. 10

Fig. 11

**Fig. 10—Flue Set the Same as Figs. 8 and 9, Welded with a Current of 140 Amperes with 26 Volts Across the Arc**

**Fig. 11—Showing the Necessity for Cleanliness and Proper Preparation**

| Specimen | Elongation in 2 in. | Load Pounds per sq. in. | Efficiency |
|---|---|---|---|
| 1 | 6.5% | 42,700 | |
| 2 | 8.5% | 52,800 | |
| 3 | 8.5% | 52,800 | |
| Avg. (above) | 6.7% | 47,700 | 86.7% |
| Avg. (3 others) | 7.0% | 51,400 | 93.5% |
| 4 | 8.0% | 51,900 | |
| 5 | 8.0% | 53,300 | |
| 6 | 7.0% | 51,400 | |
| Avg. (above) | 7.7% | 52,200 | 94.6% |

The original tensile strength was 55,000 pounds per square inch.

These coupons were ½-inch boiler steel which were planed smooth before testing, leaving no welding reinforcement.

These tests were made at the Ohio State University by Professor D. J. Demerest, Professor of Mines and Metallurgy.

Now the next question in your mind, no doubt, is what is the cost in comparison with a riveted seam. I will say in so far as I have investigated, that to rivet in these seams (labor and material) it will run from 90c to $1.25 per lineal foot, while with the metallic electrode these seams, electric energy at 3c per kilowatt hour (140 amperes at 92 volts or 22 volts across the arc), will cost per foot, .09c, 5/32 electrodes at 7.5c per pound; per foot, .05c 25 minute time for welder operator (a) 50c per hour; per foot, 21c, making the entire cost per lineal foot 35 cents.

### Method of Welding Flues

The question of proper procedure and method of flue welding is an open one and perhaps some of you may differ with me on the subject. I am not prepared to say that the method we pursue is best, but am simply going to give you a few facts as I have found them.

First, last and always, I am talking and insisting on proper preparation before welding any job, and in flue welding cleanliness and proper preparation are the first consideration. If your flue sheet is a new one, sand blasting thoroughly will give you a clean sheet; if an old sheet and one that has been welded before, the previous weld must be chipped clean from the sheet. Place your copper ferrules so that after rolling them in place they will set back from the fire side of the sheet about 1/16 of an inch. This will leave your copper back far enough so that when the flue is expanded and beaded down the copper ferrule will not inter-

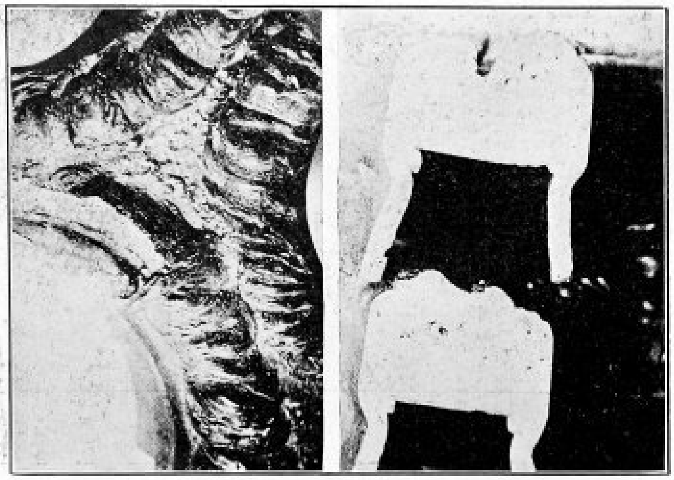


Fig. 12 Fig. 13

**Fig. 12—When Not Properly Prepared There Is an Uneven Application of the Metal**

**Fig. 13—Showing the Right (Below) and Wrong (Above) Methods of Placing the Copper Ferrule Prior to Welding**

fere with your weld. Set your flues in the usual manner, leaving the small flues extend through the back flue sheet about 3/16 of an inch and the superheater flues ¼ of an inch.

The boiler is then given the regular hydrostatic test and all leaking flues tightened, for if your flues are not tight in the sheet before welding, they will not be after. Keep oil and grease off the flue bead and sheet. Now sand blast your flues and sheet clean of all dirt and scale, bead down your flues tight against the sheet, or your beads will burn off in welding, fill your boiler with water and you are ready to weld.

### Steps in Flue Welding

Start at the top of the sheet and progress downward, starting each flue at the bottom, progressing first up one side, then the other, meeting at the top of the flue. Weld first to your flue sheet out from the flue bead the thickness of your welding wire or 5/32 of an inch, then by a weaving movement weld to the crown of your flue, bead back and forth until you have completed the flue. This will give you a strong weld on the sheet and enough metal on the flue beads to protect them.

Fig. 8 shows a 2-inch flue, welded with ⅛-inch electrodes, using 140 amperes and 21 volts across the arc. In this case the copper ferrule was properly set so as not to interfere with the welding. The flue beaded down tight against the sheet. No oil or grease was used on the flue sheet and the sheet was cleaned with the sand blast. The boiler was then filled with water and welded. This flue was then sawed horizontally and the strip of flue bent back and forth and finally broken off by a hand hammer and chisel. Notice how smooth and uniform the weld is applied in this case.

Fig. 9 was welded under the same conditions as the previous flue, excepting no water was used in the boiler. There was no oil or grease on the sheet or flue and the copper ferrule so placed as not to enter into the weld. Note the clean metal shown when this flue was broken down and the perfect penetration and fusion of the weld. These two flues were each welded by a different operator.

A flue that had been set just the same as the preceding two (no oil or grease used, sand blasted clean, copper ferrule placed as in the other two) is shown in Fig. 10. The amperage, however, was 170 with the voltage across the arc at about 26. When this flue was sawed horizontally and bent back the whole weld popped off the sheet.

You can readily see by the pocked and cinder appearance just what took place in this case. The welder operator who did this work also welded the first flue shown.

Fig. 11 shows a result quite different from the preceding illustrations, and shows very convincingly the necessity of cleanliness and proper preparation. In this flue the copper ferrule was placed in the sheet and allowed to come flush on the firebox side with the result that when the ferrule was rolled tight and the flue set and beaded down the copper protruded out under the bead.

Note the porous and slag-like appearance of the metal. This condition is caused by the burning of the copper and oil by the steel electrode, which forms a copper monoxide gas. This gas being densest at its source, which is the flue bead and sheet prevents the molten metal from the electrode from properly fusing with the parent metal, and the entrapped vapor in liberating itself forms the slag-like porous structure that you see.

Fig. 12 shows the result of the same preparations as the previous one. Note the appearance of the welded metal, also the uneven application of the metal, how it has splashed and run down. With a clean, properly prepared flue job your welder is able to apply the weld in a uniform manner, progressing rapidly and thoroughly as the metal penetrates or dives in and is readily controlled. While in an oil-soaked and dirty sheet or one with the copper ferrules interfering your metal has not that clean fusion or penetration.

A cross-section view may be seen in Fig. 13. Notice how the copper ferrule is placed in these two flues. One placed 1/16 back from the fire side of the sheet with the result that we have perfect penetration and a clean weld. While in the other the copper ferrule was allowed to extend out under the bead with the result as you see it here, poor penetration, porous metal, and an excessive amount as in welding under these conditions, your metal backs up and runs out.

Fig. 14 gives a view of a flue sheet in which all the flues have been electrically welded. The cross denotes the center of the sheet and divides it into four parts, each welded by a different operator. Note the smooth and uniform welds.

In welding in flues with the metallic arc process the cost per flue is as follows:

| | |
|---|---|
| Electric energy | $.017 |
| Labor at 78c. per hour | .025 |
| Metallic electrode material | .009 |
| Total cost per flue | $.051 |

In closing let me urge that welding engineers, supervisors, and welder operators, be ever alert to eliminate the abuses that are liable to occur in electric arc welding.

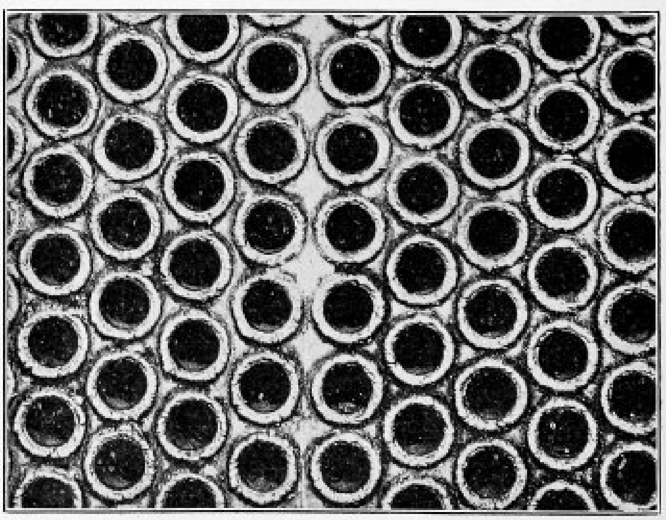


**Fig. 14—Showing a Flue Sheet in Which All of the Flues Have Been Electrically Welded**

# Second Revision of A. S. M. E. Boiler Code, 1922

## Rules Governing Boiler Fittings and Specifications for Welded and Seamless Steel and Wrought Iron Pipe

BELOW is a continuation of the proposed revisions of the American Society of Mechanical Engineers' Boiler Code which appeared on page 233 of the August issue of THE BOILER MAKER.

The Boiler Code Committee plans to hold a public hearing in connection with the next annual meeting of the Society in December, 1922, to which the membership of the Society and everyone interested in the steam-boiler industry will be invited and where they may present their views.

In the course of the Boiler Code Committee's work during the past four years, many suggestions have been received for revisions of the Power Boiler Section of the Code, as a result of the interpretations issued and also of the formulation of the Locomotive Boiler and the Miniature Boiler Codes. In order that due consideration might be accorded to these recommendations, the Committee began in the early part of 1921 to devote an extra day at each of its monthly meetings to the consideration of the proposed revision. As a result of this many of the recommendations have been accepted and revisions of the paragraphs formulated.

In connection with the revision work, the lack of rules and specifications relative to pipe, pipe material and fittings for use in connection with steam boilers up to the flanges for the connection of the first valves, has been apparent. The committee has endeavored, at the urgent request of many manufacturers, to supply this lack by rules and specifications which have been prepared in cooperation with the American Society for Testing Materials. These rules and specifications are here published and it is the request that they be fully and freely discussed so that it may be possible for any one to suggest changes before the rules are brought to final form and presented to the Council for approval. Discussions should be mailed to C. W. Obert, Secretary to the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Boiler Code Committee for consideration.

### RULES FOR PIPE, PIPE MATERIAL AND FITTINGS USED ON STEAM BOILERS

*X-1. Piping and Fittings.* The piping and fittings used on boilers up to the flanges for the connection of the first valves from the boiler on steam outlets, feed lines and blow-off lines shall conform to the rules given in *X-1* to *X-6*, and it is desirable that all piping, valves and fittings used on steam and exhaust lines, including the vacuum system and drain lines; all water lines, including boiler-feed suction and discharge lines; and all boiler blow-off lines shall conform to them.

*X-2. Steam Pipe.* Piping for steam mains carrying saturated or superheated steam may be of welded or seamless pipe made of wrought iron or steel. For sizes above 3 inches in diameter the steel pipe shall be of open-hearth steel. All pipes shall be straight and free from blisters, cracks, laminations and other injurious defects. Liquor marks and lap-seam lines incidental to the manufacture of pipe will not be considered defects. Each length of pipe is to be inspected separately for defects on the inside and outside, noting particularly the character of the cross-section when cutting off crop ends. Pipe up to 3 inches in diameter may be butt-welded or lap welded while that above 3 inches in diameter shall be lap-welded. Pipe material shall correspond with that required by the specifications of wrought-iron and steel pipe included in paragraph *X-9*, et seq.

*X-3. Thickness of Steam Pipe.* In determining the thickness to be used for pipes at different pressures and for temperatures not exceeding 700 degrees F. the following formula is to be used:

$$P = \frac{2\ S(t - 1/16)}{D}$$

where
$P$ = the working pressure in pounds per square inch above atmosphere
$t$ = thickness of wall in inches
$D$ = inside diameter of pipe in inches
$S$ = 3500 pounds per square inch for seamless steel pipe
= 3200 pounds per square inch for lap-welded steel pipe
= 2500 pounds per square inch for butt-welded steel pipe
= 2500 pounds per square inch for lap-welded iron pipe
= 2000 pounds per square inch for butt-welded iron pipe
= 2000 pounds per square inch for brass pipe
= 2000 pounds per square inch for copper pipe

*X-4. Feed Lines.* High-pressure hot-water and cold-water lines may be made of welded or seamless pipe of wrought-iron or steel as called for under *X-2*. Where the water contains corrosive material or air, brass or copper tubing may be used. In determining the thickness of water pipe the following formula will be used:

$$P = \frac{2\ S(t - 3/32)}{D}$$

where:
$P$ = water pressure in pounds per square inch.
$t$ = thickness of pipe in inches
$D$ = inside diameter of pipe in inches
$S$ = 2625 pounds per square inch for seamless steel pipe
= 2400 pounds per square inch for lap-welded steel pipe
= 1875 pounds per square inch for butt-welded steel pipe
= 1875 pounds per square inch for lap-welded iron pipe
= 1500 pounds per square inch for butt-welded iron pipe
= 1500 pounds per square inch for brass pipe
= 1500 pounds per square inch for copper pipe

Where brass pipe is desired for finish or for any other reason it may be used. The brass and copper pipes used shall correspond to the specifications given under paragraphs ——— and the brass pipe shall be half-annealed in order to leave it in proper condition for use in feed-water piping.

*X-5. Blow-off Piping.* Blow-off pipe is to be of extra strong size and to be made of genuine wrought iron or steel as preferred.

*X-6. Pipe Bends.* Pipes when bent may be made of steel or wrought iron and after bending are to be free from buckles and blisters and practically circular in cross-section. They are to be bent before being threaded or flanged, and where flanged they are to be refaced to dimensions so that they may be bolted or faced without forcing. Where possible, the tangent length of pipe at the end of each bend should be of a length equal to at least twice the nominal diameter of the pipe, although tangents may be used with lengths which are equal to the nominal diameter of the pipe. The advisable radius to which pipe should be bent should be five or six times the nominal diameter of the pipe, although pipe may be bent to a radius equal to four times the diameter of standard pipe and three and one half times the diameter for extra strong pipe up to 12 inches. The thickness of the pipe is to be determined by the formula given in *X-3*. The boiler-feed line bends are to conform with the above, while for blow-off lines the rules are to be applied to extra strong pipe.

## Specifications for Welded and Seamless Steel Pipe

*X-7.* These specifications cover "standard" and "extra strong" welded and seamless steel pipe, but not "double extra strong" pipe. Pipe ordered under these specifications are intended for bending, flanging and other special purposes.

### I—Manufacture

*X-8.* (*a*) The steel for welded pipe shall be of soft weldable quality made by the bessemer or open-hearth process. The steel for seamless pipe shall be made by the open-hearth process.

(*b*) Welded pipe 3 inches or under in nominal diameter may be butt-welded, unless otherwise specified. Welded pipe over 3 inches in nominal diameter shall be lap-welded.

### II—Chemical Properties and Tests

*X-9.* Open-hearth steel shall conform to the following requirement as to chemical composition:

Phosphorus................not over 0.05 percent

### III—Physical Properties and Tests

*X-10.* (*a*) The material shall conform to the following minimum requirements as to tensile properties:

| | Welded | | Seamless |
|---|---|---|---|
| | Bessemer | Open hearth | Open hearth |
| Tensile strength, lb. per sq. in..... | 50,000 | 45,000 | 48,000 |
| Yield, point, " " " "..... | 30,000 | 25,000 | 26,500 |
| Elongation in 8 in., per cent...... | 18 | 20 | 18 |

(*b*) The yield point shall be determined by the drop of the beam of the testing machine.

*X-11.* (*a*) Welded pipe shall be tested at the mill to the hydrostatic pressures specified in Table I.

Table I—Hydrostatic Pressures for Welded Steel Pipe

(Black and galvanized. Pressures expressed in pounds per square inch.)

| | "Standard" Pipe | | | "Extra Strong" Pipe | | |
|---|---|---|---|---|---|---|
| Size, (nominal inside diameter), in. | Weight of pipe per linear foot, threaded and with couplings, lb. | Butt-weld | Lap-weld | Weight of pipe per linear foot, plain ends, lb. | Butt-weld | Lap-weld |
| 1/8......... | .... | 700 | .... | .... | 700 | .... |
| 1/4......... | .... | 700 | .... | .... | 700 | .... |
| 3/8......... | .... | 700 | .... | .... | 700 | .... |
| 1/4......... | .... | 700 | .... | .... | 700 | .... |
| 3/8......... | .... | 700 | .... | .... | 700 | .... |
| 1........... | .... | 700 | .... | .... | 700 | .... |
| 1 1/4......... | .... | 700 | 1,000 | .... | 1,500 | 2,500 |
| 1 1/2......... | .... | 700 | 1,000 | .... | 1,500 | 2,500 |
| 2........... | .... | 700 | 1,000 | .... | 1,500 | 2,500 |
| 2 1/2......... | .... | 800 | 1,000 | .... | 1,500 | 2,000 |
| 3........... | .... | 800 | 1,000 | .... | 1,500 | 2,000 |
| 3 1/2......... | .... | ... | 1,000 | .... | .... | 2,000 |
| 4........... | .... | ... | 1,000 | .... | .... | 2,000 |
| 4 1/2......... | .... | ... | 1,000 | .... | .... | 1,800 |
| 5........... | .... | ... | 1,000 | .... | .... | 1,800 |
| 6........... | .... | ... | 1,000 | .... | .... | 1,800 |
| 7........... | .... | ... | 1,000 | .... | .... | 1,500 |
| 8........... | 25.00 | ... | 800 | .... | .... | .... |
| 8........... | 28.81 | ... | 1,000 | 43.39 | .... | 1,500 |
| 9........... | 34.19 | ... | 900 | 48.73 | .... | 1,200 |
| 10.......... | 32.00 | ... | 600 | .... | .... | .... |
| 10.......... | 35.00 | ... | 700 | .... | .... | .... |
| 10.......... | 41.13 | ... | 900 | 54.74 | .... | 1,000 |
| 11.......... | 46.25 | ... | 800 | 60.08 | .... | 1,000 |
| 12.......... | 45.00 | ... | 600 | .... | .... | .... |
| 12.......... | 50.71 | ... | 800 | 65.42 | .... | 1,000 |

For pipes over 12 inches in inside diameter, the test pressure should be calculated by the formula $P = 2St/D$, in which $P$ = pressure in pounds per square inch; $S$ = fiber stress = 12,000 lb. per square inch; $t$ = thickness of wall in inches; $D$ = inside diameter in inches.

(*b*) Seamless pipe shall be tested at the mill to hydrostatic pressures not exceeding that required by the formula:

$$P = \frac{2\ S\ t}{D}$$

in which $P$ = pressure in pounds per square inch; $S$ = allowable fiber stress = 16,000 pounds per square inch; $t$ = thickness of wall in inches; and $D$ = inside diameter in inches.

*X-12.* (*a*) For lap-welded pipe over 2 inches in diameter, a section of pipe 6 inches long shall be flattened between parallel plates until the distance between the plates is one-third the outside diameter of the pipe with the weld located 45 degrees from the line of direction of the applied force, without developing cracks.

(*b*) For butt-welded pipe over 2 inches in diameter, a section of pipe 6 inches long shall be flattened between parallel plates until the distance between the plates is 60 percent of the outside diameter of the pipe with the weld located 45 degrees from the line of direction of the applied force, without developing cracks.

*X-13.* For pipe 2 inches or under in diameter, a sufficient length of pipe shall withstand being bent cold through 90 degrees around a cylindrical mandrel the diameter of which is 12 times the nominal diameter of the pipe, without developing cracks at any portion and without opening the weld.

*X-14.* (*a*) Test specimens shall consist of sections cut from a pipe. They shall be smooth on the ends and free from burrs.

(*b*) Tension test specimens shall be longitudinal.

(*c*) All specimens shall be tested cold.

*X-15.* One of each of the tests specified in paragraphs *X-10*, *X-12* and *X-13* may be made on a length in each lot of 500 or less, of each size. Each length shall be subjected to the hydrostatic test.

*X-16.* If the results of the physical tests of any lot do not conform to the requirements specified in paragraphs *X-10*, *X-12* and *X-13*, retests of two additional pipes shall be made, each of which shall conform to the requirements specified.

### IV—Workmanship and Finish

*X-17.* For pipe 1½ inches or under in inside diameter, the outside diameter at any point shall not vary more than $^1/_{64}$ inch over nor more than $^1/_{32}$ inch under the standard size. For pipe 2 inches or over in inside diameter, the outside diameter shall not vary more than 1 percent over or under the standard size.

*X-18.* Unless otherwise specified, pipe shall conform to the following regular practice:

(*a*) Each end of standard welded pipe shall be threaded.

(*b*) Extra strong welded pipe and standard and extra strong seamless pipe shall be furnished with plain ends.

(*c*) All threads shall be in accordance with the American Standard and cut so as to make a tight joint when the pipe is tested at the mill to the specified internal hydrostatic pressure. The variation from the standard, when tested with the standard working gage, shall not exceed a maximum of one and one-half turns either way.

(*d*) Each length of threaded pipe shall be provided with one coupling, having clean-cut threads of such a pitch diameter as to make a tight joint. Couplings may be made of wrought iron or steel.

*X-19.* The finished pipe shall be reasonably straight and free from injurious defects. All burrs at the ends of the pipe shall be removed.

### V—Inspection and Rejection

*X-20.* The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the pipe ordered. The manufacturer shall afford the inspector, free of charge, all reasonable facilities to satisfy him that the pipe is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Each length of pipe which develops injurious defects in shop working or application will be rejected, and the manufacturer shall be notified.

### Specifications for Welded and Seamless Wrought-Iron Pipe

*X-21.* These specifications cover "standard" and "extra strong" welded wrought-iron pipe, but not "double extra strong" pipe.

*X-22.* All pipes to be used on locomotives and cars shall be of coiling or bending quality.

#### I—Manufacture

*X-23.* (*a*) The iron shall be made from muck bars, made from puddled pig iron, free from any admixture of iron scrap or steel.

(*b*) All pipe 3 inches or under in nominal diameter may be butt-welded, unless otherwise specified. All pipe over 3 inches in nominal diameter shall be lap-welded.

*X-24. Iron Scrap.* This term applies only to foreign or bought scrap and does not include local mill products, free from foreign or bought scrap.

#### II—Physical Properties and Tests

*X-25.* (*a*) The material shall conform to the following minimum requirements as to tensile properties:

| | |
|---|---|
| Tensile strength, pounds per square inch | 40,000 |
| Yield point, pounds per square inch | 24,000 |
| Elongation in 8 inches, per cent | 12 |

(*b*) The yield point shall be determined by the drop of the beam of the testing machine. The speed of the cross-head of the machine shall not exceed ¾ inch per minute.

*X-26.* All pipe shall be tested at the mill to the hydrostatic pressures specified in Table I.

*X-27.* A section of pipe 6 inches in length shall be flattened until broken by repeated light blows of a hammer or by pressure; the fracture developed shall have a fibrous appearance.

*X-28.* For pipe 2 inches or under in diameter, a sufficient length of coiling or bending pipe shall withstand being bent cold through 90 deg., around a cylindrical mandrel the diameter of which is 15 times the nominal diameter of the pipe, without developing cracks at any portion and without opening the weld.

*X-29.* (*a*) Test specimens shall consist of sections cut from a pipe. They shall be smooth on the ends and free from burrs.

(*b*) Tension-test specimens shall be longitudinal.

(*c*) All specimens shall be tested cold.

*X-30.* One of each of the tests specified in paragraphs *X-25*, *X-27* and *X-28* may be made on a length in each lot of 500 or less, of each size. Each length shall be subjected to the hydrostatic test.

*X-31.* If the results of the physical tests of any lot do not conform to the requirements specified in sections *X-25*, *X-27* and *X-28*, retests of two additional pipes shall be made, each of which shall conform to the requirements specified.

#### III—Workmanship and Finish

*X-32.* (*a*) For pipe 1½ inches or under in inside diameter, the outside diameter at any point shall vary not more than $^1/_{64}$ inch over nor more than $^1/_{32}$ inch under the standard size. For pipe 2 inches or over in inside diameter, the outside diameter shall vary not more than 1 percent over or under the standard size.

*X-33.* Unless otherwise specified, pipe shall conform to the following regular practices:

(*a*) Each end of standard pipe shall be threaded.

(*b*) Extra strong pipe shall be furnished with plain ends.

(*c*) All threads shall be in accordance with the American Standard and cut so as to make a tight joint when the pipe is tested at the mill to the specified internal hydrostatic pressure. The variation from the standard, when tested with the standard working gage, shall not exceed a maximum of one and one-half turns either way.

(*d*) Each length of threaded pipe shall be provided with one coupling, having a clean-cut thread of such a pitch diameter as to make a tight joint. Couplings shall be of wrought iron.

*X-34.* The finished pipe shall be reasonably straight and free from injurious defects. All burrs at the ends of the pipe shall be removed.

#### IV—Inspection and Rejection

*X-35.* The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the pipe ordered. The manufacturer shall afford the inspector, free of charge, all reasonable facilities to satisfy him that the pipes are being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

*X-36.* Each length of pipe which develops injurious defects in shop working or application will be rejected, and the manufacturer shall be notified.

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## Proceedings of American Boiler Manufacturers' Association Annual Convention Issued

THE proceedings of the thirty-fourth annual convention of the American Boiler Manufacturers' Association have recently been distributed to the members of the association, with the president's suggestion that they be carefully studied and that the executives of the entire boiler manufacturing industry will find a great deal of value to them in meeting production problems in the coming months of increased prosperity.

Special attention is called to the paper on the "Thickness of Shell Plates in Return Tubular Boilers." This paper appeared as part of the convention report in the June issue of The Boiler Maker. Other sections and reports of the proceedings are specially emphasized as important and among these is the action taken by the association in assisting in the financing of the National Board of Boiler and Pressure Vessel Inspectors in order that the board might more speedily fulfill the object for which it was organized.

The report of the sub-committee of the American Society of Mechanical Engineers' Boiler Code Committee on "Inspection and Boiler Tolerances" requires a careful study and a further discussion of the recommendations than was possible at the annual meeting should be sent to the committee in order that the report as finally submitted to the Boiler Code Committee will represent the concensus of opinion of the members of the association.

Another report which is of great importance to members who build horizontal return tubular boilers—that on the setting heights for hand-fired boilers—will be supplemented by a later report after the matter has been discussed with representatives of the Smoke Prevention Association.

# Practical Methods of Patching Locomotives Boilers*

## British Railroad Boiler Makers Develop Effective Flange, Side Sheet, Barrel and Various Other Types of Patches

By A. Wrench†

PATCHING is extensively employed in the repair of locomotive boilers. This is brought about by the defects which occur in the firebox plates and seams. Firebox patches present many difficulties to the boilermaker owing to the narrow water spaces which in many cases make the water side of the plates inaccessible. This necessitates the use of studs instead of rivets as a method of securing the laps.

The most common form of patch is the side-plate patch, which varies in size to cover the defective portion. Such patches are called after the number of stays which they contain, thus 2, 4, 12 and 36 stay patches. Three types of these patches are shown in Figs. 1, 2 and 3.

### Types of Outside Patches

The four-stay patch must be a laid on or outside patch, as must all square patches. The disadvantage of these patches lies in the fact that a large seam is exposed to the flame and pressure tends to force the patch off. This is not the case where the patch is inserted through the hole into the water space. The pressure on these tends to make a good joint.

The six-stay and two-stay patches shown in Figs. 1 and 3 are of this latter kind. It will be noticed that the studs with which the patches are secured to the firebox are between the rows of stays. This method has been found to make a better joint than when the seam is made between the stays, as stays in the seam of a patch tend to restrict breathing and cause leakages. The two-stay patch has two stays in the lap and is of irregular shape. This enables the patch to be passed through the hole and into the water space.

### Method of Inserting Patches

It is necessary when inserting patches to remove three stays from near the bottom of the patch to allow it to be turned after it has been passed into the water space. These stays are marked *a* in Fig. 1. When using the outside patch this is, of course, not necessary. The marking-off of the holes in these patches is mostly done from standard templates. The stud holes should be marked so as not to be in line with the stays; this reduces the tendency to crack from stud to stay hole.

### Mud Burns and Corrosion

An accumulation of dirt in the water spaces as shown in Fig. 11 is often found in locomotive boilers, and if neglected will allow the plates to burn and necessitate a patch. Cracks from stay holes and corrosion around stay heads Fig. 12 are also repaired by patching. Seam and flange patches are often used in the repair of locomotive fireboxes, and are more difficult to fit than the side-plate patches. The method of fitting usually involves the use of thinned joints.

### Applying the Flange Patch

The flange patch, Fig. 4, is used to repair flanges which have cracked in the root or bend. The cracked portion is cut away and also a portion of the flange is removed. The joints are then thinned and made ready to receive the patch. The patch is placed in position, and the holes marked off by the trammel method. This method of marking off is explained by Figs 18 and 19. Centered pegs are inserted in the hole, prior to the patch being placed in position, and points marked in two places on the firebox side. The patch is then fixed with a screw and pipe, and the position of the holes marked from the two corresponding places on the firebox side. This method of marking-off is adopted on all laid-on seam patches where the water space does not permit the use of a scriber.

Fig. 5 shows a patch used to renew a portion of the lap of a seam which is found to be wasted and badly cracked. This patch has one seam inserted in the water space while the other is on the fire side of the plate. This is necessary as the position of the patch shown in the illustration is near the fire-hole flange and in a position where it is in contact with the flame. Thinning of joints is employed to enable the patch to fit properly. The thinning of the joint marked *b*, Fig. 5, is very difficult, as this work has to be done under the flange of the fire-door plate. To enable this to be done this flange is lifted by a wedge after several rivets have been removed. This patch forms a good repair and gives very little trouble from leakage in service.

A similar patch to this one is shown in Fig. 8, but this is an outside patch, the two thinned joints of the patch being passed under the flange. This type of patch is usually employed on the seam near the tube plate, and being well away from the fire gives satisfaction during working.

### Combination Half Side Sheet and Flange Patches

Frequently when a firebox has been working for some years it is found advisable to renew the bottom half of the side plates. In addition to this, the flanges may need patching. It is the practice of some firms to fit new half-sides and then patch the flanges. Fig. 10 shows a combined half-side and flange patch. It will be noticed that the flange is transferred from the side plate to the back plate, a row of rivets being dispensed with. The top of the new flange must extend above the half side seam to enable a good-shaped thinned joint to be made. This method of repair is considerably cheaper than the fitting of a flange patch separately and is quite satisfactory in service.

Cracks, such as shown in Fig. 14, which occur about the side plate seam which are due to the upward expansion of the firebox, are repaired by a patch inserted under the lap, the cracked portions having previously been cut away. Such a patch is shown in Fig. 9. Grooving near the foundation ring and cracked outer firehole plates are repairable by patching.

### Smoke Box Tube Sheet Repairs

Figs. 16 and 17 show a defect of the smoke-box tube-plate caused by leakage from the hand hole. This is repairable by a patch which should be made of copper to enable it to be properly fitted on to the wasted portion. The writer once fitted a steel patch on a tube-plate similar to the one shown, and had considerable difficulty in making a proper fit. The patch had to be bolted up several times while hot, and some of the holes were drawn out of true. This drawing was allowed for by drilling the holes small, but this necessitated the use of bolts of small diameter and little drawing power.

Inserting and screwing up bolts in a hot patch is difficult

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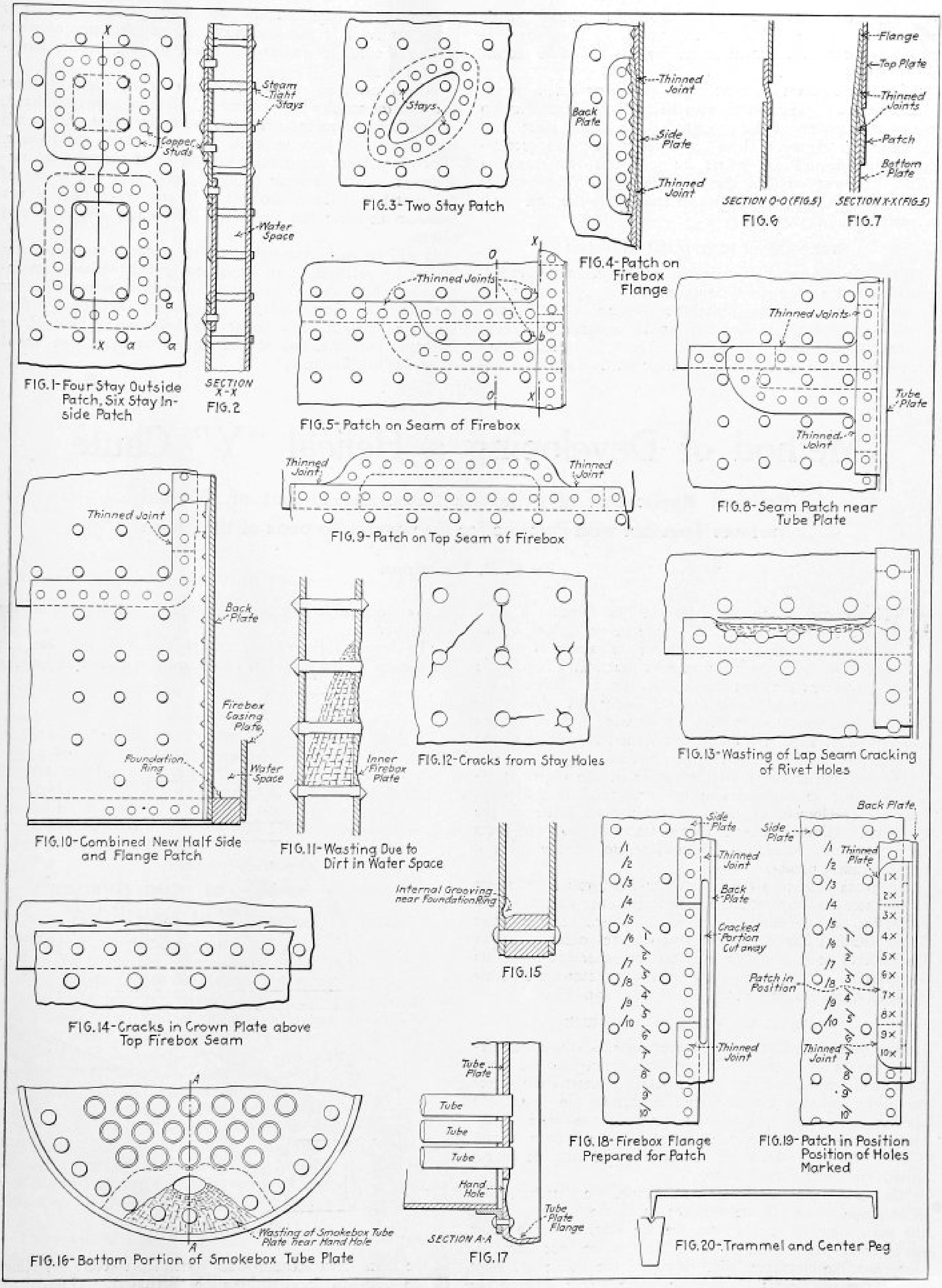
†Member Institute of Locomotive Engineers.




**Typical Patches Used in Locomotive Boiler Work**

and the patch cools considerably before the hammer can be applied to do the necessary bedding-on. Filling the corroded portions with cement or red lead is not to be recommended.

The throat plates of some types of boilers crack on the shoulders, and boilers fitted with Belpaire fireboxes develop corrosive grooving at the junction of the throat plate with the barrel at the top. These two defects have been successfully patched, and new boilers are now built with extension plates to cover each of these two places. This practice stiffens the boiler at the two points and delays the time when a patch will be necessary.

### Strength of Barrel Patch Seams

When the bottom of a locomotive boiler becomes corroded, patching, when properly designed, makes a good repair. It is not always recognized that the riveting of a "barrel" patch in a longitudinal direction should be equal in strength to that of the longitudinal joint. Many of these patches are merely single riveted with a narrow pitch of rivets. Considering that these patches are cover patches, a narrow pitch of rivets is not necessary and an efficiency of plate section should be maintained equal to that of the longitudinal joint.

When designing the rivet section to be used in these patches the tenacity of the corroded plate may be considered, as, unlike the longitudinal joint, the boiler plate underneath the patch would have to break before the rivets could shear. "Barrel" patches are usually joggled to fit over the circumferential seam, the seam being chipped near the seams of the patch to make a good fit. If any space then occurs between the plate and the patch a wedge is driven in and calked.

It will be seen from the foregoing remarks that repairing boilers by patching is an important branch of boiler maintenance which should be studied by those responsible for the safety of steam boilers. Inspectors occasionally find that the strength of a boiler has been much reduced by improper patching, and several explosions have been found to be due to this cause.

# Method of Developing a Helical "Y" Chute

## Practical Application of Principles Governing Layout of Warped Surfaces Together with Patterns for the Several Sections of the Chute

**By C. B. Lindstrom**

On account of the respective sections forming a helix in the layout of the "Y" chute given in the accompanying illustration the surfaces are known as warped surfaces. Owing to their shape, it is practically impossible to make patterns that are absolutely correct. However, for practical purposes a layout can be made that gives close results. The solution involves the drawing first of a plan and elevation, Fig. 1, showing the respective widths at the ends of the chute and the rise or pitch at *a*.

The outline or curve on the inside of the object is elliptical and the outer section is circular, so that in each case a development of the curves must be made in the elevation. Divide the inner curve into any number of parts as from 1 to 5 inclusive. Likewise step off the pitch *a* into the same number.

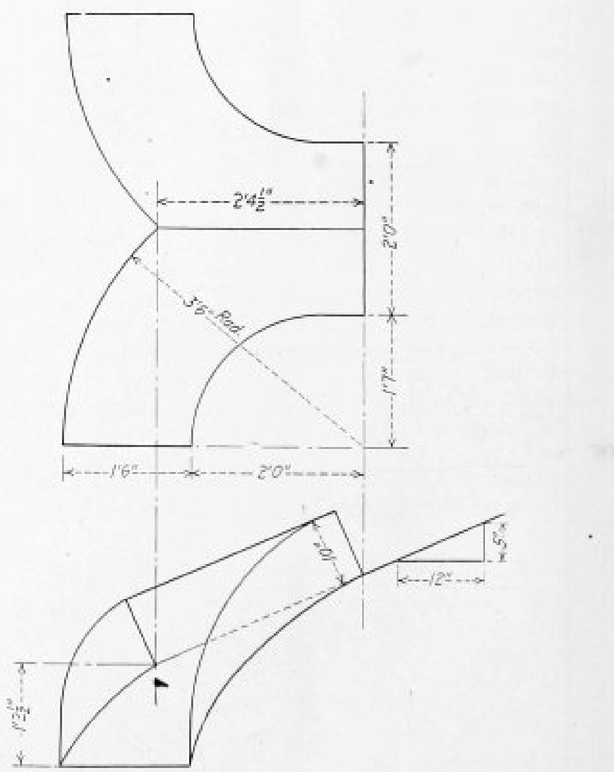
From the points on the plan draw the vertical projectors to intersect the corresponding horizontal ones drawn in the elevation, thus locating points 1, 2, 3, etc., for the inner helix. Radial lines are drawn through the points 1, 2, 3 of the plan to point *b* which intersect the outer arc in points 7, 8 and 9. Vertical projectors are drawn from these points as before, intersecting at $6_1$, $7_1$, $8_1$, $9_1$, and $10_1$.

### Intersection of Legs of Chute

Since the chute legs miter on the plane *x-x* their intersection appears as a straight line in both views and the lower helix does not extend beyond the point of intersection where the miter begins. For convenience in making the layout, the one leg is extended as though it comprised the chute for the purpose of securing the data for making the pattern layout. The sides of the chute are 10 inches wide and the curves follow the lower plate outline.

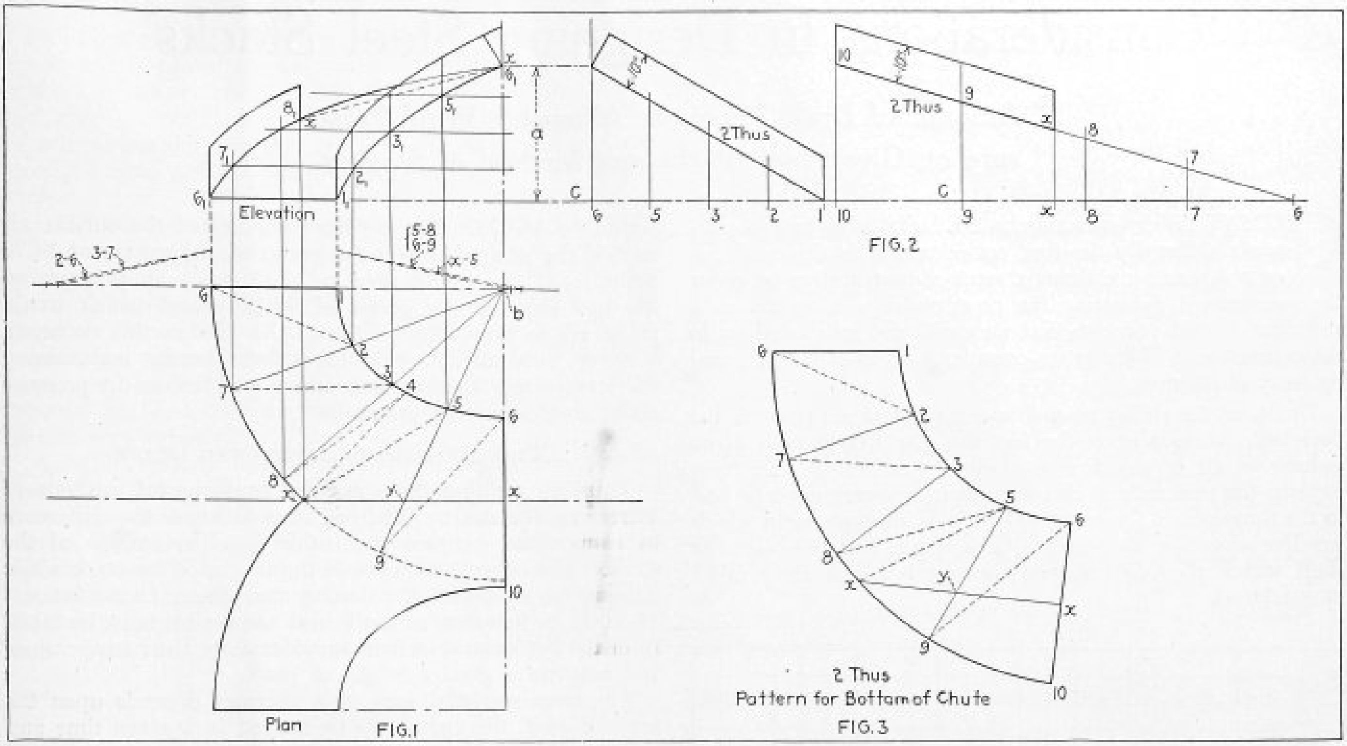
To show their true length and shape, the diagram, Fig. 2, is made. Lay off the arc lengths of the inner curve of the plan view as at (a) and the arc lengths of the outer curve as at (b). Erect perpendiculars to the base line *C-C* and from the elevation, Fig. 1, extend the horizontal lines drawn through points 1, 2, 3, etc. The spaces between the points $1_1$, $2_1$, $3_1$, etc., of (a) are the true lengths of the spaces on the inner curve and those between $6_1$, $7_1$, $8_1$, etc., on the outer curve.

The lengths between the points 1-6, 2-7, 3-8, etc., as represented by the solid lines are shown in their true lengths




**Sketch of Chute**

in the plan view, because their vertical projectors are shown in the elevation parallel with the horizontal. Thus in any case where an oblique line is so arranged that one of its




Figs. 1, 2 and 3—Layout of Helical "Y" Chute

projections is parallel to a plane of projection, its true length appears in one of the principal views in its true length. The dotted diagonals are not shown in their true length in either view. Hence it is necessary to determine their correct lengths by the triangle method. The base lines are transferred to the respective triangles and equal respectively the lines 1-7, 2-8, 3-9, etc.

### Pattern Layout

The pattern for the bottom of the chute is made in one piece but generally where the object is large it is made in several sections so that the required twist can be secured to form the helix. It will be noted in Fig. 3 that the pattern is made in the full shape as would be required for one complete leg of the "*Y*" and then the straight miter between the "*Y*" is laid off.

## Pennsylvania to Make Extensive Additions to Altoona Works

THE Pennsylvania system has announced the program for extensive improvements to be made at Altoona, Pa., including the construction of two extremely large repair shops and the electrification of the heavy grades west of Altoona. The first of the improvements will be made at Juniata shops and includes the building of a new erecting and machine shop, 340 feet by 670 feet, including a midway crane runway with a 105-foot span and 715 feet long. This large shop will be devoted to repairing and building locomotives, and will accommodate 49 locomotives at one time. The framework will be of steel and the walls of brick. The locomotive erecting bays will have two 250-ton capacity electric traveling cranes for lifting locomotives, and six 15-ton capacity cranes for lighter work. The machine bays will have two 25-ton capacity cranes, together with jib cranes of from 1 to 8 tons capacity.

There will also be erected a reinforced concrete storehouse, three stories high, with basement, which building is to be 60 feet by 400 feet. A crane runway for handling material will also be erected with a 95-foot span and about 600 feet long.

The building of the shop and storehouse will necessitate changes in the existing buildings as follows: the scale shop will be moved to a new location and will be changed to a flue shop, the machinery now in the scale shop being transferred to the present paint shop. The present storehouse building will be moved to a new location and will be used as a cab shop. The present erecting shop will be changed to a paint shop, while machinery will be installed in the present paint shop and the name changed to Machine Shop No. 2.

At the Altoona car shops will be located facilities for preparing repaired locomotives for service. The present circular building, known as the freight car shop, will be remodelled and 15 stalls will be used as a finishing shop. East of this shop will be located the necessary ash pits and coal handling facilities.

Further additions to the shops at Altoona will be made following the electrification of the heavy grade west of the city. After the electrification is completed, the roundhouse at Sixteenth street, Altoona, will be abandoned. On the site of the roundhouse a duplicate of the erecting and machine shop at Juniata will be built and the present erecting shop at the Altoona machine shop will be fitted up for the use of other departments.

## Formation of Sulphurous Acid in Boiler Drums

In a letter recently received from J. P. Morrison, author of the article on "Mud Drums" appearing on page 151 of the June issue of The Boiler Maker, attention is called to the misuse of the term "sulphuric acid."

In the eighth line from the bottom of the page the term "sulphuric acid" was used instead of "sulphurous acid." Sulphuric acid, which is known by the chemical term $H_2SO_4$, effects steel but slightly and, as a matter of fact, it is often shipped in steel containers.

However, sulphurous acid, known by the chemical term $H_2SO_3$ when formed at high temperature, as would be the case where tube leakage combines with the soot in the furnace of a boiler in operation, attacks steel quite rapidly. This action takes place less rapidly at lower temperatures.

# Considerations In Designing Steel Stacks*

## Amount of Draft Required, Allowable Wind Pressure on Given Size Stacks and Method of Staying

CHIMNEYS or smokestacks are built to serve two purposes. Usually the first consideration is the draft required, but some thought must almost always be given the question of delivering the products of combustion at a sufficiently high point so that they will not be obnoxious to the community. This latter consideration is often governed by local ordinances.

Draft, or the ability of a chimney to draw air through the fuel bed, depends upon the fact that the weight of a given volume of air or gas decreases when it is heated. To fully explain the principle of chimney draft, resource must be had to the atmospheric pressure. The air or atmosphere in which we live envelops the earth like a great hollow sphere or shell which physicists have estimated is about sixty miles in thickness.

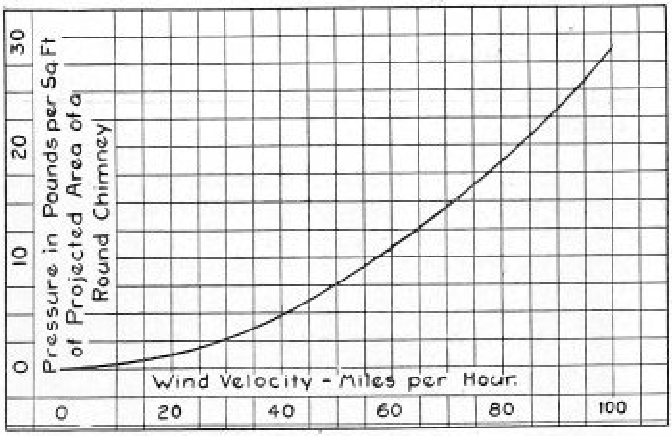



Fig. 1—Pressures on Stacks Due to Wind Velocities

### Principles on Which Draft is Determined

Because of the pull of gravity on this envelope of air a pressure is exerted upon the surface of the earth which amounts to 14.7 pounds per square inch of area at sea level. The further we go from the surface the less the pressure becomes. For instance, suppose we have a boiler room at the sea level with a chimney 100 feet high. The pressure in the boiler room would be 14.70 pounds and the pressure at the top of the stack would be about 14.65 pounds. The difference of .05 pound would be caused by the 100 feet of air between the two levels. If we consider the furnace of the boiler when there is no fire in it, the pressure on the under side of the grates would be 14.70 pounds and on the upper side of the grates it would also be 14.70 pounds. Of this 14.70 pounds pressure, 0.05 pound is caused, both on the upper and lower side, by the 100 feet of air that we have under consideration. Suppose, however, that we put a fire under the boiler and that the gas in the chimney becomes so heated and expanded that the weight of one cubic foot is but one-half that when cold.

The pressure exerted by 100 feet of this gas in the chimney would only be one-half its former value or it would be 0.025 pound. To this we would have to add the weight of the cold air above the top of the chimney (14.65 pounds) so that the total pressure in the furnace *above* the grates would be 14.675. But we have not heated the outside air so that the pressure *under* the grates would remain at 14.70 pounds. There would then be a difference in pressure on the two sides of the grates of 0.025 pound which would cause air to flow through them. As fast as this occurred, however, combustion would take place thereby maintaining the temperature in the stack and the difference in pressure above and below the grates.

### Two Methods of Increasing Draft

Thus we see that there are two fundamental methods of increasing the draft. The one is to increase the difference in temperature between the inside and the outside of the stack. The other is to increase the height of the stack while holding the temperature difference the same. In the interest of economy, however, as much heat as possible must be taken from the hot gases which in turn decreases their temperature and requires a greater height of stack.

The cross sectional area of a chimney depends upon the kind of coal, the amount to be burned in a given time and

Table I—Size of Chimneys for Steam Boilers

| Diam. Inches | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 125 | 150 |
|---|---|---|---|---|---|---|---|---|---|
| | Commercial Horse Power of Boiler | | | | | | | | |
| 18 | 23 | 25 | 27 | 29 | | | | | |
| 21 | 35 | 38 | 41 | 44 | | | | | |
| 24 | 49 | 54 | 58 | 62 | 66 | | | | |
| 27 | 65 | 72 | 78 | 83 | 88 | | | | |
| 30 | 84 | 92 | 100 | 107 | 113 | 119 | | | |
| 33 | | 115 | 125 | 133 | 141 | 149 | 156 | | |
| 36 | | 141 | 152 | 163 | 173 | 182 | 191 | 204 | |
| 39 | | | 183 | 196 | 208 | 219 | 229 | 245 | 268 |
| 42 | | | 216 | 231 | 245 | 258 | 271 | 289 | 316 |
| 48 | | | | 311 | 330 | 348 | 365 | 389 | 426 |
| 54 | | | | | 427 | 449 | 472 | 503 | 551 |
| 60 | | | | | 536 | 565 | 593 | 632 | 662 |

(Height of Chimney in feet)

the velocity of the gases in the stack. The height depends upon the draft pressure required to burn the coal at the desired rate and also upon the temperature of the gases in the stack. The large number of unknown variables make the field of chimney design a difficult one and proportions that have been found, in years of practical experiment, to give good results are relied upon rather than theoretical formulae. The proportions as given by Kent's Handbook for Mechanical Engineers have been used for many years and are as given in Table I.

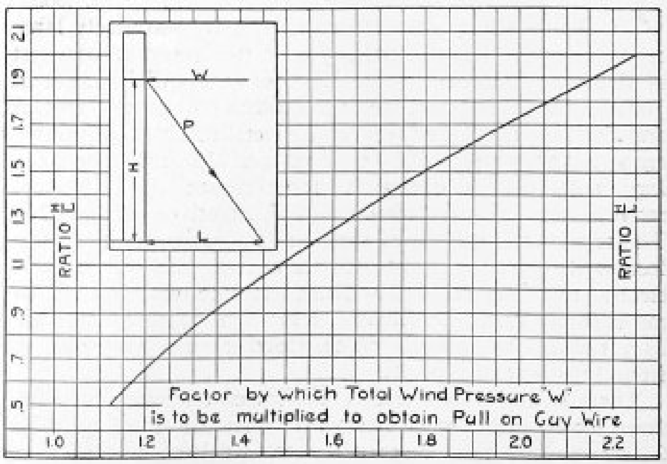



Fig. 2—Total Pull on Guy Wires

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

### TYPES OF STACK CONSTRUCTION

Chimneys are built of brick, concrete or steel. The first two materials named are only used for self-supported stacks or those whose weight and design of base are such that no guy wires are necessary. Steel chimneys are also built to be self-supporting but the smaller size steel chimneys are usually braced against the wind pressure by the use of guy wires.

The wind pressure varies greatly with the wind velocity. With a round stack the relation between the two is expressed by the formula $P = 0.0029\ V^2$ in which $P$ is the pressure in pounds per square foot of projected area of the stack and $V$ is the velocity of the wind in miles per hour. This relation has been plotted as a curve in Fig. 1. From this curve we see that low wind velocities produce but little pressure but that with the higher velocities the pressure increases very rapidly.

A wind velocity approximately 100 miles per hour is classed as "an immense hurricane" and while such a wind storm is unheard of in many sections of the country, nevertheless, engineers base their designs of guy wires on this velocity. It will be noted that a wind velocity of 100 miles per hour corresponds to a pressure of 30 pounds per square foot of projected area. We might add that by "projected area" is meant the diameter of the stack multiplied by the height. Thus the total pressure on a 100-foot stack 24 inches in diameter, would be 2 feet by 100 feet by 30 pounds, or 6,000 pounds total.

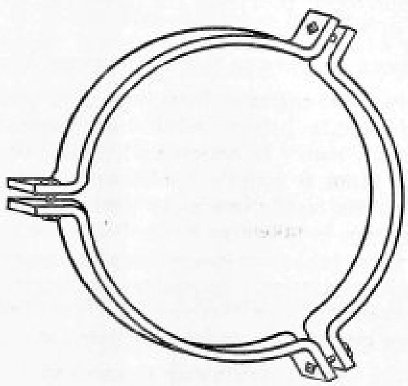


**Fig. 2—Type of Ring for Staying Steel Stacks**

### SIZE OF GUYED STACKS

Guyed stacks are not commonly built in sizes greater than 6 feet in diameter or 100 feet in height. They are guyed with one, two or three sets of guys having three or four strands in each set. The greater the number of sets of guys the greater, of course, will be the stability of the stack. For general practice it might be well to use one set for stacks 50 feet or less in height, two sets for stacks between 50 and 100 feet and three sets for stacks above 100 feet. The guys are attached to the stack by means of an iron ring made as shown in Fig. 2 and at the lower end are secured to a building or to an anchor, such as a heavy block of concrete, buried in the ground. If but one set of guys is used, the ring in the stack is usually placed at about two-thirds of the height above the base. If two sets are used it is common practice to place one at 2/5 and one at 4/5 of the height.

In determining the size of the guy wires it is assumed first of all that the wind is blowing directly in line with one of the guys. If one guy is used it is assumed to carry the load caused by the wind pressure on all the stack above the guy ring and that on two-thirds of the distance between the ring and the foundation. If two guys are used the upper one is figured for all the stack above its ring plus two-thirds of the space between the upper and lower ring; the lower one is figured for two-thirds of the sections both above and below it.

The guy wires must, of course, make an angle with the stack and the pull on them will be more than the total horizontal force of the wind. The curve in Fig. 3 has been worked out to show the relation between the two. For ready reference the ratio of height to horizontal distance has been plotted instead of the value of the upper or lower angle of the guy wire (see the sketch in Fig. 3). Thus for a ratio of $H$ of 1.4, which represents average practice, the total wind pressure $W$ that any one guy is to carry should be multiplied by 1.5 to obtain the actual pull on that guy. To allow for the initial tension, that must exist even when there is no wind, this assumed load should be increased 50 percent.

### EXAMPLE OF STAYING

As an example, suppose that we have an 80-foot stack, 4 feet in diameter, to be supported by two sets of guys. The upper set would be placed at $4/5 \times 80$ or 64 feet from the base and the lower set at $2/5 \times 80$ or 32 feet from the base. The wind pressure carried by a guy in the upper set would be:

$$[16 \text{ feet} + (2/3 \times 32 \text{ feet})] \times 4 \text{ feet} \times 30 \text{ pounds} = 3{,}199 \text{ pounds.}$$

Assuming a ratio of $\frac{H}{L}$ of 1.4 we must increase this by 50 percent.

$$3{,}199 \text{ pounds} \times 1.5 = 4{,}798 \text{ pounds.}$$

This must be increased again by 50 percent to allow for initial tension.

$$4{,}798 \text{ pounds} \times 1.5 = 7{,}197 \text{ pounds.}$$

which is the assumed maximum pull that the guy will ever be called upon to withstand. From Table II we find that a 9/16-inch galvanized iron wire rope would carry the load.

The lower guy would figure as follows:

$$[(2/3 \times 32) + (2/3 \times 32)] \times 4 \times 30 = 2{,}558 \text{ pounds wind pressure}$$

$$2{,}558 \times 1.5 \times 1.5 = 5{,}775 \text{ pounds total.}$$

which would call for a ½-inch galvanized iron wire rope.

TABLE II—ULTIMATE STRENGTH OF GALVANIZED IRON WIRE ROPE COMPOSED OF 6 STRANDS AND A HEMP CENTER, 7 OR 12 WIRES TO THE STRAND

| Approximate diam., inches | Circumference inches | Approximate breaking strain in pounds |
|---|---|---|
| 5/16 | 1 | 2,800 |
| 3/8 | 1⅛ | 3,600 |
| 7/16 | 1¼ | 4,600 |
| ½ | 1½ | 6,400 |
| 9/16 | 1¾ | 8,800 |
| ⅝ | 2 | 11,600 |
| ¾ | 2¼ | 14,600 |
| 13/16 | 2½ | 18,000 |
| ⅞ | 2¾ | 22,000 |

Note that in the selection of a guy rope practically no factor of safety is assumed other than the remote possibility of the wind pressure reaching a high value and the allowance that is made for initial tension. However, if the wind velocity is 50 miles per hour, which is classed as a "very high storm," the wind pressure is but 7½ pounds per square foot instead of 30, so that ordinarily, the guy is not heavily stressed. Of course in localities where extreme high wind velocities are common, a larger strand should be used.

The sections of the stack should "shingle" on the inside. This is to avoid, as far as possible, the entrance of water into the joint which might occur when the stack is not in use. To protect the joint on the outside it may be calked tight. The rivets, for a stack made of ¼-inch plate, would ordinarily be ½-inch in diameter and spaced 2 inches on centers.

Little can be done to prevent corrosion on the inside of a stack but the outside should be protected by a good stack paint and a new coat should be applied from time to time.

# Condensed Formulas for the Estimator's Note Book

## Practical Rules for Use in the Boiler Shop with Examples Illustrating Their Application

By Donald M. McLean

IN preliminary work and in general designing and estimating on boiler and steel plate work it is always useful to have the following formulas before one in small compass. They are printed here in condensed form so that they may be clipped out and pasted in the user's note book.

As presented here, these notes and formulas take into account certain practical considerations not always provided for in the strictly theoretical formulas, and they apply only to work intended to sustain internal pressure.

(1.) To find the allowable working pressure on the shell of a cylindrical pressure vessel of any kind:

$$W = \frac{T \times t \times E}{R \times F}$$

(2.) To find the thickness of shell, the other factors above being known:

$$t = \frac{W \times R \times F}{T \times E}$$

(3.) To find the factor of safety used, the other factors above being known:

$$F = \frac{T \times t \times E}{W \times R}$$

(4.) To find the joint efficiency required to carry a given working pressure, the other factors above being known:

$$E = \frac{W \times R \times F}{T \times t}$$

$W$ = Maximum allowable pressure. (Working pressure.)
$T$ = Tensile strength of material.
$t$ = Thickness of shell.
$E$ = Efficiency of riveted joint. (Longitudinal seam.)
$R$ = Radius of shell.
$F$ = Factor of safety.

The usual values placed on some of these factors are as follows:

*Maximum allowable working pressure* means the allowable gage pressure or pressure above the atmosphere.

$T$ is usually taken as 55,000 pounds for flange steel and 52,000 pounds for firebox steel. Standard steel specifications require that the lowest tensile strength of the steel manufacturers' stipulated range—55,000 to 65,000 pounds for flange and 52,000 to 62,000 pounds for firebox steel—be stamped on the plates. If the plates have been ordered specially and are mill stamped 60,000 pounds, then, of course, 60,000 pounds should be taken.

### Longitudinal Seam Efficiency

$E$ or efficiency of longitudinal seam is usually taken at the percentage shown in the following table for the particular type of joint adopted:

| | |
|---|---|
| Single riveted lap joint | 56 per cent |
| Double riveted lap joint | 70 per cent |
| Triple riveted lap joint | 75 per cent |
| Triple riveted, double buttstrap joint | 85 per cent |
| Quadruple riveted, double buttstrap joint | 90 per cent |

All based on plate at 55,000 pounds tensile strength and 44,000 pounds shearing strength for steel rivets in single shear.

The above-mentioned efficiencies are averages, as the percentages will vary with the thickness of plate and the diameter of rivet used. Higher efficiencies than shown above can be reached, but since in practice it is customary to make the number of pitches or spaces in the longitudinal seams divisible by two and the number of pitches in the circular seams divisible by four in order to simplify the laying out, it is usually necessary to add in one or more pitches, which will reduce the joint efficiency two to three percent and bring the percentage figures to about those given above.

$F$ or factor of safety is subject to much variation in practice and depends considerably on State or Provincial rules, designer's judgment, provision for corrosion, etc., according to the class of work.

### Factors of Safety for Different Vessels

Air receivers, for example, have been used with a factor of safety of 3 in certain districts, while 4 is common practice and 4.5 is frequently met. In boilers and similar vessels exposed to flame, the factor is usually 5, although 4.5 is occasionally used, with certain restrictions as to workmanship, etc. Average practice may be taken as 5 for boilers, 4.5 for pressure tanks and 4 for tanks containing liquids under static pressure only. In preliminary estimates, the figures will have to be made "subject to inspection rules," if any, for the particular district or proposition under consideration.

### Applications of Formulas

Example: What is the safe working pressure on an air receiver 42 inches diameter by 10 feet in length, with shell 9/32 inch thick, longitudinal seam, double riveted lap construction?

Formula (1).

$$\frac{55{,}000 \times 0.28125 \times 0.70}{21 \times 4.5} = 114 \text{ pounds.}$$

This receiver would probably be rated at a working pressure of 110 pounds.

Example: In a stand pipe 20 feet diameter by 80 feet high, with the longitudinal seam in the lower course of triple riveted lap construction, what should the plate thickness be in the lower course?

Formula (2).

$$\frac{(80 \times 0.434) \times 120 \times 4}{55{,}000 \times 0.75} = 0.398$$

Plate 7/16 inch thick would be used, or in a bad water district the thickness might be increased to ½ inch as providing a margin for corrosion. (0.434 is pressure in pounds per foot of depth.)

Example: A boiler 66 inches in diameter with triple riveted, double buttstrap joint, ⅜ inch shell, is allowed 106 pounds working pressure. What is the factor of safety?

Formula (3).

$$\frac{55{,}000 \times 0.375 \times 0.85}{106 \times 33} = 5.$$

Example: A boiler 66 inches in diameter, with 3/8 inch shell, 55,000 pounds tensile strength plate, is to be used at 106 pounds working pressure; factor of safety, 5. What should be the efficiency of the longitudinal seam?

Formula (4).

$$\frac{106 \times 33 \times 5}{55{,}000 \times 0.375} = 85 \text{ percent.}$$

Thicknesses of heads will vary with the various codes. In preliminary work, the following will represent the average American and Canadian practice:

| | |
|---|---|
| 40 inches and under | 5/16 inch thick |
| 41 inches diameter to 52 inches | 3/8 inch thick |
| 53 inches diameter to 60 inches | 7/16 inch thick |
| 61 inches diameter to 66 inches | 1/2 inch thick |
| 67 inches diameter to 72 inches | 9/16 inch thick |

In the case of reversed dished heads, or dished heads having the pressure on the convex side, it is usual to allow only 60 percent of the pressure allowed on dished heads with the pressure on the concave side. Reversed heads must therefore have their thickness increased by two-thirds the thickness of the unreversed head, in order to be allowed an equal pressure. This requirement sometimes results in a thickness which is impracticable on account of the expense of flanging and dishing the heavy metal, particularly in the smaller diameters. It is therefore desirable to avoid reversing the heads in pressure tanks. For pressures of 110 pounds and under, the practice is fairly common, however, and we find some designers using reversed heads in tanks up to 60 inches diameter. Others set the maximum diameter at 42 inches, others at 36 inches, while the largest builder of air receivers in Canada fixes it at 24 inches, and in view of the fairly frequent failures of reversed heads of larger diameters the latter practice perhaps is to be commended.

## Precautions to Be Observed in Welding

We have repeatedly emphasized the fact that welding is a profession in itself and should be undertaken only by persons who are thoroughly familiar with the operation. There are many factors to be considered in the making of a good weld. The nature of the material to be welded, the type of welding apparatus, the composition of the welding materials and fluxes, the thickness and shape of the weld, the preparation of the break or cavity, the manipulation and qualities of the welding flame,—all of these are vital points which must be thoroughly understood if a successful job is to be turned out. Altogether too frequently we meet persons who apparently believe that a torch, a bit of wire, and a pair of dark goggles will make any one a welder, and the number of poor jobs turned out is due in large degree to this erroneous notion.

### Welding a Closed Vessel

No closed vessel, pipe, or container should ever be welded, or even strongly heated, unless a vent of some kind is provided to relieve any pressure that may be developed inside. Even if the vessel contains nothing but air, it should not be forgotten that the expansion of the air, under the influence of high temperature, may give rise to considerable pressure and lead to unfortunate results. We have known of a number of cases of this kind. In one of them a blacksmith put a piece of pipe in his forge fire to heat it up, preparatory to straightening it. The pipe was closed at both ends and as the temperature of the metal rose, the pressure of the air inside increased and the iron softened at the same time. Presently the pipe burst open and the fine coal on the forge fire was thrown upward in the form of a cloud of combustible dust-like material, which took fire and exploded with considerable violence,—the blacksmith being severely burned. Several windows were broken, and the explosion alarmed the teacher of a nearby school, so that she put her pupils through a fire drill and caused them to march out into the street.

### Goggles Necessary for Eye Protection

Another important precaution that must be observed by welders is the wearing of suitable eye-protectors or goggles. The subject of proper protection for the eyes of welders has received considerable attention from many investigators and all are agreed that serious injury will be caused by failure to wear eye-protectors, or by wearing those which are improperly designed and have lenses of an unsuitable color. The lenses of eye-protectors should be large enough in diameter to fully shield the eyes from the direct heat and light rays, and also from spattered particles of material. The color of the lenses should preferably be a deep green. Blue glass is not satisfactory for use in connection with high-temperature work, because it is not sufficiently opaque to the ultra-violet rays which are specially active in producing injury to the eyesight. Suitable side shields should be attached to the eye-protectors, to prevent injury to the eyes from spattered bits of metal coming toward them from either side. The framework of the eye-protectors should be made of non-inflammable material, and should preferably be covered with a non-conductor of heat. Frames of bare metal often becomes uncomfortably hot and may even burn the skin of the wearer.

The importance of wearing eye-protectors at all times while welding is forcibly illustrated by examining the lenses of a pair of protectors that have been used for some time by a welder. The surface of the glass will usually be found to be pitted in many places where bits of spattered molten metal have struck it, and sharp bits of metal or of oxide are often found to be imbedded in the glass.

### Wall Reflection Injurious to Welding Operators

The paint used on the walls and ceiling of a room in which considerable welding is performed should also receive attention. Even though the eyes are protected from the light that proceeds directly from the work, they may receive a considerable amount of light indirectly by reflection from the walls and it is possible for injurious non-luminous rays to be reflected from surfaces that are so dim and smoky that they do not appear to be reflecting any sensible amount of the light that they receive. It has been found that a paint consisting chiefly of zinc oxide and oil will absorb ultra-violet rays and will reflect only the ordinary light rays. A small quantity of lampblack can be mixed with the zinc oxide to tone down the whiteness and give a gray color, and a paint of this kind, when applied to the walls and ceiling of the welding room, will absorb the injurious rays and at the same time will not present too glaring a surface for ordinary illumination.

In conclusion, we must again emphasize the fact that welding is an art, and that it should be performed only by persons who understand the importance of using approved apparatus and materials, and who are skilled in the proper methods of doing their work, and who recognize the need for adequate protection for themselves and for others.—*The Travelers Standard.*

Suspension of Hydrostatic Tests of Tanks.—The Mechanical Division of the American Railway Association has announced that upon recommendation from the Committee on Tank Cars, that part of Sections 23 and 24 of the Standard Specifications for Tank Cars, Classes I, II, III and IV, covering the requirements of testing of tanks hydraulically and testing of safety valves, has been suspended as to tanks for which such tests shall become due prior to January 1, 1923, except when such cars are shopped for repairs.

# Development of the Vertical Type Boiler

## Reasons Why Certain Types of Multitubular Boilers Have Found Wide Application in Portable Service

**By A. L. Haas**

THE types of boilers actual or projected, commercial or on the patent office files, are legion. The variety in existence proves that certain advantages accrue to each type and among these, the vertical boiler has found a wide application in industry.

Among other factors which influence selection are location, fuel and feed water, to say nothing at all as to the mean efficiency. Each type is more or less special to peculiar ends while a large range of choice affords selection. There is probably no special boiler; only a more suitable adaptation to a particular service.

Capital cost, space occupied and economy achieved are all determinant variables in the selection of boilers; but the restrictions of location, fuel and feed water form problems of their own, while in some instances ease of transport and capacity for abuse must be considered.

The rise of pressure is always to a higher figure and this alone with its corresponding economy in generating power alters construction, revises workmanship and develops new types.

### Gradual Increase of Boiler Pressures

It has been stated that starting from atmospheric pressure in the time of Watt 25 to 35 pounds was reached in 1860, 65 to 70 pounds in 1870, 120 pounds in 1880, 200 pounds was being considered in 1890. One small experimental boiler for test purposes, known to the writer, designed for 550 pounds per square inch, has just been installed in London and there seems no valid reason why such pressures should not become common where thermal efficiency is the one guide to choice. It is the central electric power station which has given the greatest impetus to boiler development in recent years, both as to amount of steam generated from a single unit and the value of higher pressures and superheat. It may be taken for granted that where economy alone guides choice the watertube boiler today reigns supreme, although it involves feed water treatment. A leading central station authority states: "It is now generally recognized that a modern boiler should be used for evaporating water and not for purifying it, with the result that boilers can be forced to higher rates of evaporation without detriment to the tubes." On the continent, a system of distilling the makeup water is developing, and with the absence of concentration in the boiler water, the necessity for frequent blowing down largely disappears, with a consequent reduction in the percentage of makeup.

### Types of Portable Boilers

Turning aside from these considerations of pure economy to others where different conditions rule, there are virtually only two types of boilers available where ease of transport is in question and small power required—the locomotive type and the vertical. In Great Britain the vertical boiler receives much favor for small powers and difficult locations. It is the lowest in first cost, has the greatest adaptability of any, it economizes space, requires no special setting, it is easily transported and in spite of the most cruel abuse continues to give reasonable results.

Its drawbacks are, that in its more primitive forms it is expensive in terms of fuel, and because of its manifold advantages and its low cost tends to be the worst made and the least economical. In these particulars the locomotive type boilers used on portable and semi-portable engines are used almost as much as the vertical. Both are now getting more rigorous attention and in the matter of workmanship are steadily improving.

Where convenience and initial cost are of greater moment than economy and for situations where permanency is not in question, the vertical type for small powers seems natural and is largely employed. It is necessary only to set it on an approximately level surface, connect up the feed water and the steam pipe to the stop valve and the plant is ready for operation. A transport test on a 4-foot by 9-foot vertical was recently made. It was unloaded from railway truck, assembled, mounted, filled, and chimney rigged in 90 minutes, and in another 90 minutes was under 100 pounds of steam.

### American and British Vertical Boilers

The two most primitive vertical boilers are the cross tube type in which large size Galloway watertubes cross the combustion chamber; and the vertical firetube, where a sheaf of vertical firetubes split up the products of combustion, delivering them to the base of the stack. The former is British and the latter American practice. Diligent inquiry has discovered only one instance of the vertical firetube made in the United Kingdom and this for an American customer abroad.

The earliest reference to a vertical boiler which the present writer has come across was a boiler fitted into a steamer called the *Waterman,* built by Napier in London in 1842. The following description is not without interest. Its diameter was seven feet. "The fire grate of the boiler is cylindrical and is of the diameter of the shell diminished by the breadth of a water space all round. Above the fire a water space of 14 inches in depth extends all over the grate, with the exception of a space left at that part most remote from the fire door for the escape of smoke. All above this horizontal water space is one large chamber, in the middle of which the chimney is situated; but around the chimney are a number of concentric circles of locomotive tubes, communicating at their under ends with the water in the horizontal water space, and at their upper ends with the water reposing on the top of the chamber. The hot air proceeding from the fire must, before it can reach the chimney, wend its way through this forest of brass tubes; in which operation it is robbed of its heat to the uttermost farthing."

This description is evidently of a vertical watertube boiler, or more properly a vertical boiler fitted with vertical watertubes, and would seem to be identical in general design with Marston's patent of more recent date.

As the description above is taken from a current periodical of the time, and the boiler is described as extraordinary on account of its being vertical, it may be assumed confidently that the first vertical boiler had vertical watertubes.

### Variations in Vertical Boiler Design

The writer has some personal experience with the Cochrane boiler for he was instrumental in replacing a cross tube vertical with a Cochrane of slightly smaller size. The substitution turned the hardest job a fireman ever had into a simple pastime. Another interesting vertical is the Essex, made by Messrs. Daner Paxman of Colchester, England. The difference from the Cochrane is evident. Two nests of curved tubes carry the product of combustion from the rear chamber to the front smokebox. These tubes are of greater radius than the shell of boiler, and this difference in curvature allows them to be placed and expanded.

Steam fire engine boilers form a class by themselves. The need for quick steaming and rapid steam raising are problems of peculiar difficulty. The boiler is vital and of supreme importance; its water capacity is trivial, while for weight relations to steaming power, or heating surface per unit of water it is unique. Steam at 100 pounds pressure has been raised from cold water in five minutes. Fifty pounds of coal can be burned per hour per square foot of fire grate; 20 pounds of water can be evaporated per square foot of heating surface, with an economy of 8 pounds of water evaporated per pound of coal burned. Feed temperature is 60 degrees. The smallest size made is 16½ inches diameter by 3 feet 3 inches total height; the largest, 4 feet 3 inches diameter by 9 feet 5 inches total height. The entire exhaust from the pumps, as in a locomotive, serves to create forced draft for the boiler and it is manifest that only under such conditions can the consumption of fuel and evaporation be obtained.

The chief feature distinguishing fire engine boilers from other vertical boilers is the divided shell which allows the exterior of firebox and tubes to be exposed by the breaking of two joints. Curiously enough, while every insurance authority prohibits welded shells or any welded joint under tensile stress, these boilers have always been welded all over and are exempt from usual regulations. One maker (Merryweather) uses mild steel plates and copper tubes; another uses Lowmoor plates and brass tubes, and although for fire purposes the boilers are only in very intermittent operation, since water is always standing ready for emergency, it is a fact that some boilers of this type, seen by the writer, twenty and thirty years of age, do not show undue corrosion.

In pumping service boilers of this type have been operated under the most adverse conditions over long periods of time. Their power relative to weight is a great factor in their favor in the matter of transport. It is thought that this divided shell construction is insufficiently known and worth much wider adoption, since it allows thorough cleaning and small size watertubes with their consequent economy. Larger vertical boilers on this plan have occasionally been built.

### Classes of Service in Which Vertical Boilers Are Used

Unlike the modern watertube boiler, verticals of all the types mentioned have been used with inferior feed water, and even the fire engine boiler has to use pond and river water or water from any source which happens to be available. Laundries, dairies, and quarries are three outstanding instances where vertical boilers are favored, while low pressure boilers of vertical type are largely used for institution cooking in jails, workhouses and elsewhere. For running winches and on steam cranes the vertical boiler is very noticeable and its very advantages lend themselves to abuse. One hundred pounds per square inch is about the usual pressure but 150 pounds is by no means unusual.

Considerable attention has been devoted to improving the more primitive forms of vertical boiler and the additional cost of the Cochrane, for example, over the cross tube for equivalent evaporation, is only about 7 percent with an 18 percent diminution in coal consumption, a saving which would equal the cost of a new boiler in less than four years. Over 11 pounds of water evaporated per pound of oil burned with a thermal efficiency of 71 percent is also claimed for this boiler. Similar results are obtainable from Hopwood (Marshall's) and Spencer-Hopwood boilers, the latter made at Hitchin by Spencer.

All the types mentioned are superior to the common cross tubes and all repay their extra initial cost. Small vertical boilers are often fitted with exterior angle rings of much larger diameter than the boiler proper, a pair of such rolling hoops enabling the boiler to be trundled along like a barrel. Some years ago in a tropical island the present writer witnessed the transport of a vertical boiler up a steep hillside through almost virgin bush. Two bights of rope were round the barrel of the boiler, one end of each rope fastened to a convenient tree, the other to a loaded hand winch. It took six weeks to land the boiler (which had to be floated ashore) at a point five miles from the start of its journey. When fixed together with a small duplex pump it provided the settlement with water from a good spring.

As stated at the beginning, the types of boilers are numerous. All have special advantages in some connection or other, but in many respects the vertical is the most neglected, and prime cost is too apt to cause the installation of the most primitive type.

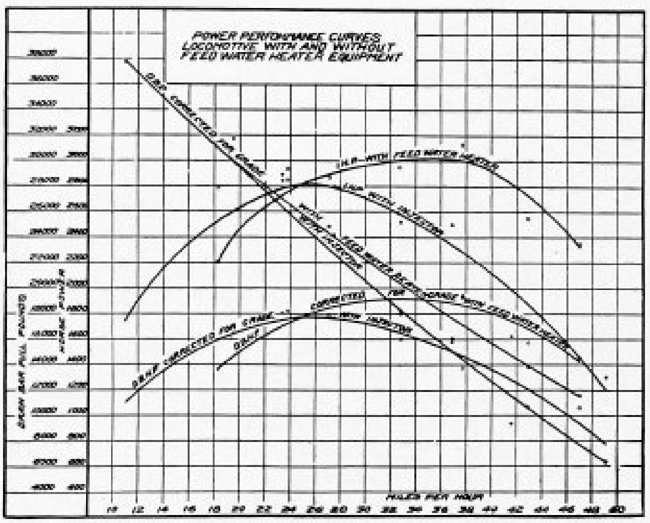
## Locomotive Feed Water Heaters*

In order that definite information might be obtained as to the operation and maintenance of the locomotive feed water heaters, a questionnaire was compiled and sent to the presidents of 137 railroads in the United States and Canada. Answers were received from 78 of these roads, 20 roads having feed water heaters.

In 1920 there were seven roads using feed water heaters. There are now 28 American roads with five types of heaters on order or in service. The number of the different types of heaters in use or on order are as follows:

| | |
|---|---|
| The Superheater Company's feed water heater | 93 |
| Worthington feed water heater | 136 |
| Weir feed water heater | 1 |
| Simplex-Blake-Knowles feed water heater | 3 |
| Local type | 1 |
| Total heaters applied or on order | 234 |

The advisability of extending the use of locomotive feed water heaters is strongly recommended by five railroads; the




**Results of Dynamometer Tests With and Without Feed Water Heaters**

other roads consider that the process of development is yet in the experimental stage and are waiting until further tests show that the economy derived will justify their use.

The application of feed water heaters has not been limited to any single class of power or service. The largest locomotive equipped with a feed water heater is a Mallet type of 107,961 lb. tractive effort, while the smallest is an American type of 24,000 lb. tractive effort. Other types of locomotives to which feed water heaters have been applied are Mikado, Pacific, Consolidation, Mountain and locomotives

*Abstract of a paper presented before the International Railway Fuel Association, Chicago, May, 1922.

in suburban service. These locomotives operate in both passenger and freight service on mountainous and rolling territory. Both coal and oil are used for fuel.

One of the most important considerations in the selection of the type of feed water heater to be used, is the character of the water in the territory through which the locomotive is to operate. In bad water districts, the open type heater seems to be preferred, as the scale deposits on the tubes of the closed type heater retard the heat transmitted and reduce the efficiency of the heater, and there would be less danger of boiler trouble from oil due to the frequent washouts. No road has reported trouble from oil from the feed water in the boiler. Roads where the boiler washout period averages 30 days generally prefer the closed type of feed water heater.

Three roads have reduced the size of the exhaust nozzles on application of feed water heaters and one road has enlarged the nozzle. The reduction in the size of the nozzle is done in order to offset the loss in superheat temperature which occurs when a feed water heater is applied to a locomotive. This is not considered advisable, as the reduction of the size of the nozzle increases the back pressure, which will probably offset any saving that would be effected by the increased superheat.

There has been no difference reported in the amount of boiler scale in boilers equipped with feed water heaters over the other engines.

The open type heater has in all cases gone from shopping to shopping without cleaning, regardless of the water conditions. While going through the shop the scale deposit is scraped from the inside of the heater, no acid or cleaning solution being used.

In good water territory, the closed type of heater is cleaned each time the locomotive is shopped. The usual method of doing this is to dip the tube nest into a lye vat to remove any oily deposit which may have formed on the outside of the tubes. In districts where the water conditions necessitate more frequent cleaning, the deposit is either washed out by flushing the heater with water or, if the scale is not soluble, a dilute solution of muriatic acid is pumped through the heater for a short time and then water is pumped through to clean out the acid. The strength of the acid varies from 20 to 33⅓ percent.

The highest cost of cleaning the feed water heater is $170 per year, both labor and material, and the lowest cost is $2.31. In one case the heater is cleaned by the use of dilute muriatic acid; the other, by a basic solution. An average of the cost data submitted by all the roads for cleaning by the acid progress is $62.19 per heater per year, which includes both labor and material.

The cost of other maintenance of the heater proper per year is practically nothing on both the open and closed types. Where weak acid solutions are used, none of the heaters cleaned show any signs of deterioration due to the use of the acid. The territory in which locomotives equipped with feed water heaters operate, includes the greatest range of climatic conditions possible. No serious difficulty has been encountered with any of the feed water heater systems freezing up. Drain valves and telltale pipes have frozen up, but these have given no further trouble after lagging.

Failures of the heater proper while in service have occurred, due to tubes bursting or becoming loose in the tube sheet, heater heads cracking with the closed type of heater, and a crack developed in the cylinder near the discharge valve on the open type of heater. The brass tubes in the closed heater have been replaced by copper tubes, which are more ductile than the brass and a better joint can be made when the tubes fasten into the header. Some trouble has been experienced with the boiler checks pounding out or breaking off with the use of feed water heater equipment. This has been largely overcome by using larger boiler checks with reduced lift.

The boiler feed pump has given good service with all types of heaters. The most common defects which have been encountered are the pump piston rod packing leaking, rods wearing, water valve springs breaking, water cylinder scoring, top head pump gasket leaking, abnormal lift of intake and outlet valves, and valves stuck or leaking. The average cost of maintenance per pump, taken from the data submitted, is $55.16 per year, including both labor and material.

The cost of maintenance of the feed water heater apparatus complete averages $97.15 per locomotive for labor and material per year. This figure was determined by averaging the maintenance costs submitted by all the roads, regardless of the type of heater used.

As all the locomotives, which are equipped with feed water heaters, have an injector, no engine failures could be attributed to the operation of the feed water heater apparatus, as the injector was used to supply the boiler in case of the failure of the feed water heater.

Where feed water heaters are applied, the enginemen should be personally instructed relative to the operation of the equipment in order that the highest efficiency may be obtained. The feed water heater pump should only be used to supply the boiler when the engine is working steam, as the exhaust steam from the auxiliaries is not sufficient to heat the water hot enough to show a saving, and the introduction of the cold water into the boiler would tend to cause serious strains in the flues and flue sheets. The rule to pump locomotives with feed water heaters only when working steam, is in force on very nearly all the roads.

It has been possible to eliminate some water tank stops when the condensate from the feed water heater is returned to the boiler.

On tests made on feed water heater locomotives, the feed water heater shows a saving of between 10 and 16 percent in fuel, based on the evaporation performance of the locomotive. On two roads where dynamometer car tests had been conducted on feed water heater locomotives, there was a saving of approximately 10 percent based on fuel consumption per drawbar horsepower. On a thousand ton mile basis, the saving varies from 4 to 11 percent.

The accompanying power performance chart is based on data taken on dynamometer car tests. It shows that with the feed water heater locomotives, there is an increase of both indicated and drawbar horsepower. This increase in horsepower is due to the back pressure being decreased by diverting about 12 percent of the exhaust steam from the cylinders to the feed water heater, thus increasing the steaming capacity of the locomotive at high speeds. This increased horsepower will permit an increase in the tonnage rating and average speed of the locomotive.

In its present form the locomotive feed water heater has passed through the experimental stage in this country and the results indicated in this report are typical of what may be anticipated from the application of feed water heaters on other railroads, barring unusual local conditions.

At the present time, the exhaust steam injector as extensively used abroad is being considered as an alternative to the open type of locomotive feed water heater. One American firm is already engaged in the manufacture of this device, and arrangements are being perfected for supplying the railroads in this country with a type of exhaust steam injector that has been successfully used on an extensive scale in England and her colonies.

The report was signed by E. E. Chapman, chairman (A. T. & S. F.); J. R. Alexander (Penn.), E. A. Averill (Superheater Company), J. A. Carney (C. B. & Q.), J. N. Lammedee (Worthington Pump & Mchy. Corp.), L. P. Michael (C. & N. W.), Geo. E. Murray (Grand Trunk), C. B. Peck (Railway Age), L. G. Plant (Railway Review), G. B. Von Boden (Sou. Pac.), W. H. Winterrowd (Can. Pac.).

# The Boiler Maker

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The position of the foreman in the boiler making industry is one of leadership. He must have an intimate knowledge of the practical work of boiler and other construction coming under his supervision and see that it is carried out efficiently. He must work with the men under him and for their interest and, at the same time, uphold the dignity of his position as the representative of the management. He is the point of contact between one and the other. His virtues must be many—the ability to accomplish a maximum production with the available equipment, the knowledge necessary to promote efficiency in his staff by example and instruction, the vision to see his own mistakes and to correct them before they react against the work of the shop.

To a very great extent foremen are self-trained and for this reason it is possible for every ambitious man in the shop to acquire the knowledge necessary to become a successful foreman. It takes time for a man to train himself in all the branches of the boiler making trade, but, if the opportunity is given him to work in the various departments of the shop until he has mastered each process in construction, he will have laid an excellent foundation for success. Above all, however, he must have qualities that will make him a good leader for the production of the shop largely depends on the support he obtains from the men under him.

For young men who are entering the trade as apprentices, the opportunity for studying the industry from the ground up is excellent. At the present time, the need for a class of beginners is greater than ever before and those who take up the work will find a broad field for the realization of their ambitions.

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In his address at the annual meeting of the American Boiler Manufacturers' Association in June the chairman of the Administrative Council of the Uniform Boiler Law Society outlined the progress made by the society during the past year in promulgating the adoption of the American Society of Mechanical Engineers' Boiler Code in the United States. Since that time several states and cities have adopted legislation making the requirements of the Code compulsory and these were included in the report of the chairman presented at the annual meeting of the Boiler Law Society held in New York, September 22, in addition to the information formerly made public.

The Building Code of the city of Omaha, Nebraska, which became effective July 28, contains rules based on the A. S. M. E. Code governing boilers, tanks, retorts and other pressure vessels having a capacity of 50 gallons or over. Since the passage of this ordinance, permits have not been issued for the installation of any boiler unless constructed in accordance with the Boiler Code. The rules also apply to second-hand boilers.

The city boiler inspection ordinance recently passed by the city of Parkersburg, W. Va., is based on the A. S. M. E. Code and includes all the provisions of the Code with the exception of the section dealing with heating boilers, rules for which are to be incorporated in the Building Code.

The adoption of the provisions of the Code by the State of Washington is a real achievement for the society as the matter has been before the governor and safety commission of the state for nearly three years. On August 1, the A. S. M. E. Code was adopted by the commission with the exception of the provision dealing with the location of the water glass. The slight difference between the Code and the instructions of the commission in this respect will be further discussed in order to clear away the difficulties.

# Engineering Specialties for Boiler Making

**New Tools, Machinery, Appliances and Supplies for the Boiler Shop and Improved Fittings for Boilers**

## Recent Improvements in Plate Planer

In the new plate planers made by the Niles-Bement-Pond Company, New York, it will be noted that the design of the bed and carriage is such as to prevent chips from getting on the bearing surface of the carriage and screw. This adds materially to the life of these parts. The tool carriage is attached to the front vertical side of the bed, and is guided by square shears. It is secured at the top and bottom by removable bearing supports which will permit the carriage to be taken from the bed at any part of its length. The bearing surfaces are provided with taper gibs for taking up wear.

Two relieving tool holder slides are mounted on a standard, and have simultaneous vertical adjustment by means of a screw and hand wheel, and horizontal adjustment to the standard through a screw and hand wheel. Both tool slides are arranged to swivel for planing bevels.

The drive screw is supported in a trough with an oil channel of sufficient depth to cover the full depth of the thread with oil. Roller bearings are provided to take the end thrust of the screw. The pneumatic jacks are of the two-way type, i.e., air is admitted in the top for clamping the plate. For unclamping, the air is admitted at the bottom. The carriage is reversed automatically at any desired position by contact with stops adjustable on the shifter rod. The operator can start, stop, or reverse the carriage by manipulating this shifter rod by hand. This can be done with very little effort on the part of the operator.

The main driving gears are enclosed in a box, and run partly submerged in oil. The motor is controlled by a master switch attached to the shifter rod, and an enclosed panel with forward, reverse, accelerating, and dynamic brake contactor. A push button is mounted on the right hand housing, so that the machine may be started and stopped without manipulating the shifter rod. The cutting speeds range from 20 to 40 feet per min.

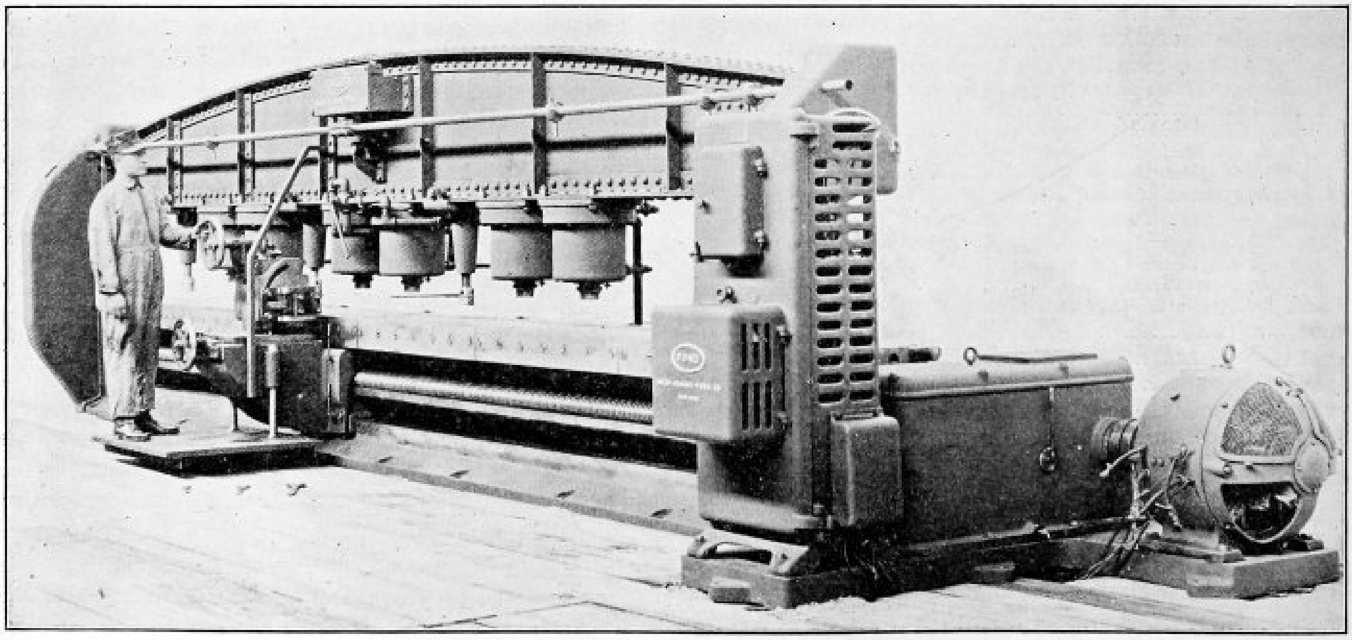
The housings for the clamp beam overhang the bed so that plates of any length can be planed by shifting them along the bed and taking a series of cuts. These planers are equipped entirely with pneumatic jacks, or with hand-operated screw jacks, or with both types.

## Large Size Boiler Plates

Probably comparatively few realize the large size of the plates which are being used today in some of the latest designs of locomotive boilers. The fact that the largest plates in the world have been and are now being rolled in American mills has made it possible to use a single sheet for the crown and sides of fireboxes, a practice which has recently become quite common.

Among the large size boiler sheets which have been rolled by the Lukens Steel Company, Coatesville, Pa., for locomotive fireboxes are those for the Union Pacific which were 250 inches by 183 inches by 3/8 inch, some for the Atchison, Topeka & Santa Fe, 250 inches by 195½ inches by 3/8 inch, others for the Union Pacific, 241 inches by 195 inches by 3/8 inch, and also the large sheets for the new Southern Pacific locomotives, 223 inches by 150 inches by 3/8 inch.

Sheets of very large size and of greater thickness are used for marine boilers. For such boilers, shell sheets have been rolled which were 144¼ inches by 246 inches by 2 inches and weighed 21,000 pounds each; also flanged



**Niles-Bement-Pond Plate Planer of Improved Design; Arrangement for Keeping Chips Out of Carriage Ways and Screw a Valuable Feature**

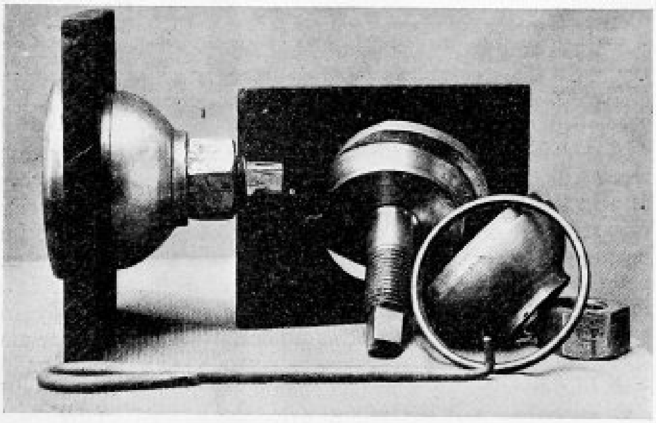
heads, 183 inches diameter, 1⅛ inch thick and flanged 11 inches deep, the sheets before flanging being 199 inches diameter. For stationary boilers, sheets have been used which were 280 inches by 196 inches by 2 3/32 inches and weighed 33,400 pounds each.

The mechanical difficulties of rolling such large sheets of only ⅜-inch thickness have been considerable and the fact that they have been made is a real achievement. The use of such sheets is distinctively advantageous to the railroads, as the number of seams is reduced with a saving in rivets and labor; also the possibility of leakage is decreased.

## Boiler Handhole Plate Having Safety Features

Below is shown the assembly and parts of a handhole plate for use on high or low pressure stationary or locomotive boilers and other places where a reliable handhole plate or plug is needed. A special feature of the design is that a new gasket can be applied by simply releasing the pressure on the boiler. Each plate can be readily installed and removed through the handhole that it is intended to close, the hook shown in the illustration being used to replace the plate when it is inconvenient to do this operation by hand.

Another feature of the device specially emphasized by the inventor is the oval flange that fits on the inside of the hole which, it is claimed, is of such thickness that it is impossible to blow it out with steam or water pressure. The metallic or copper gasket used between the plate and the boiler shell



**Hand Hole Plate for Use on High and Low Pressure Boilers**

will not blow out under pressure, this fact contributing to the safety of the device.

Tightening the nut on the stem of the plate does not have a tendency to pull the plate through the hole as the gland on the cap simply pushes the gasket over the bevel of the plate without putting any strain on the boiler sheet. The joint is made by forcing a copper or metallic gasket over the bevel of the plate with the cap, tightening the bell which has an extended gland on it of suitable depth. This cap fits over a central stud attached to the plate and, by turning the nut, the stud gasket is forced to find a seat against the wall of the hole.

Because the plate cannot be pulled through the hole, the nut can be tightened while the boiler is under pressure. It is claimed that even if the stud should be broken off danger of scalding is practically eliminated because the pressure on the boiler will hold the plate in place until the boiler can be emptied or the pressure blown off.

The handhole plate, which was invented by William C. Jacobs, 2011 South 70th street, Philadelphia, Pa., has received the approval of various locomotive and insurance company boiler inspectors.

## Ball Bearing Sensitive Radial Drill

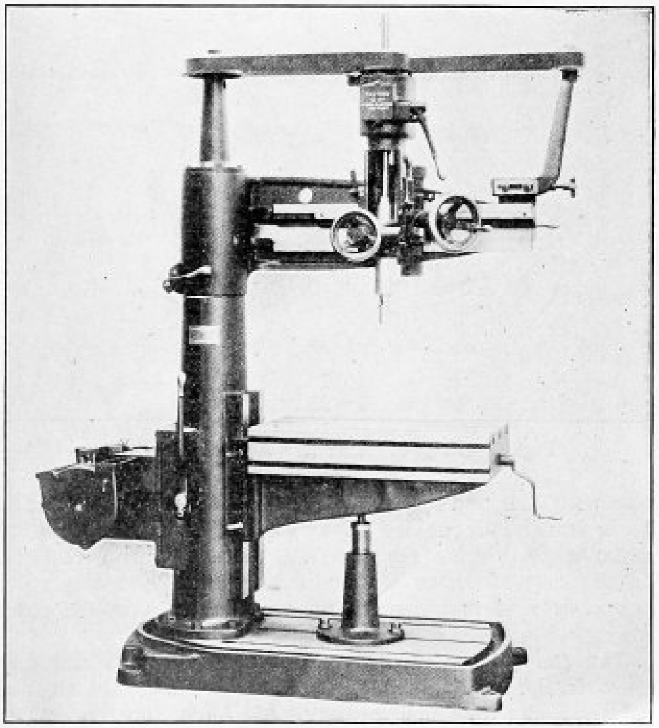
The object of a new high speed radial drill, developed by the Fosdick Machine Tool Company, Cincinnati, Ohio, is to drill and tap work of too large an area for the high speed sensitive upright drill. The rapidity of positioning the drill, together with ease and convenience of operation minimizes the time "between holes," while high speeds and excess power reduces the actual drilling time.

The table is readily removed, allowing 49½ inches between the spindle and base, which has a working surface of 28 inches by 36 inches and is planed and provided with T-slots. The vertical movement of the table is 16 inches through a ball-bearing telescopic screw. The working surface is 20 inches by 33 inches with 21 inches maximum to the spindle.

The arm, sensitive in its movement, may be swung completely around the column, and is supported on both annular and thrust ball bearings on the column, which extends through to the top. The spindle, as all other revolving members, is equipped with ball bearing journals. It has a No. 2 Morse taper, and a vertical traverse of 8 inches. The horizontal movement of 28½ inches along the arm is through rack and spiral gear with the handwheel to the right. This position of the hand wheel enables the operator to swing the arm and move the head simultaneously with the right hand.

The sensitive feed and quick return are operated by the lever at the right, or the handwheel at the left. Friction back gears, a new feature for a machine of this type, permit instantaneous shifting from high drilling speeds to slow speeds for tapping or drilling large holes, the ratio being 4½ to 1. The tapping attachment frictions, like those of the back gears, are easily adjustable with an ordinary screw driver. The drive is regularly through tight and loose pulleys on the machine which gives both a high and low speed forward and reverse. The pulley guard and belt-shifter are adjustable to meet the belt from any angle.

Another important improvement is the full tractive contact of the belt, which maintains a uniform tension at every position of the head. A reservoir for coolant is cast in the base, and a pump with nozzle to the drill point can be supplied if desired.



**Fosdick Radial for High Speed Drilling of Large Work**

# Questions and Answers for Boiler Makers

## Information for Those Who Design, Construct, Erect, Inspect and Repair Boilers—Practical Boiler Shop Problems

**Conducted by C. B. Lindstrom**

*This department is open to subscribers of* The Boiler Maker *for the purpose of helping those who desire assistance on practical boiler shop problems. All questions should be definitely stated and clearly written in ink, or typewritten, on one side of the paper, and sketches furnished if necessary. 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 permission to do so.*

## Installation of Tubes in the V-Type Watertube Boiler

Q.—I would like to get this information: On the gunboat watertube boilers, which are made in a V-shape, consisting of one large top drum and two small bottom drums, some of the drums being 10 inches in diameter and 12 feet long, how are the tubes in the bottom drums rolled?—W. G. B.

A.—Since the expanding of the tubes is a part of the tube installation a few suggestions are given on the method of

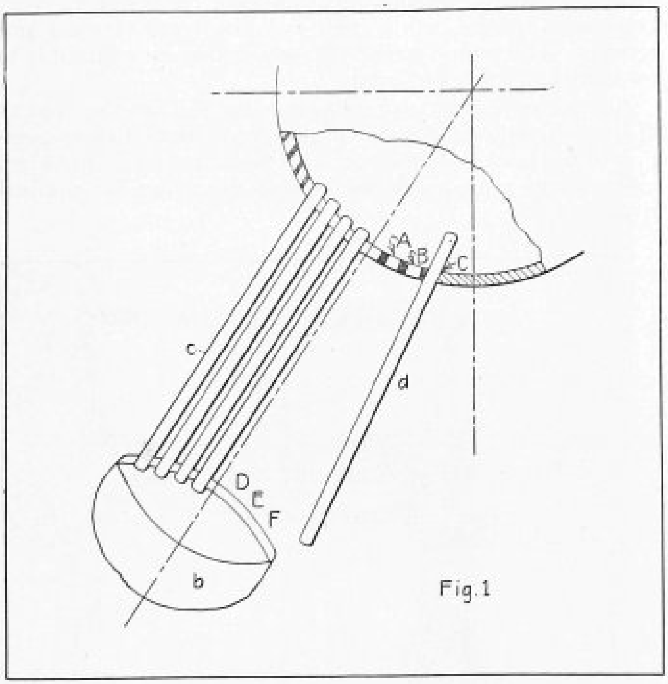



Fig. 1—Leg of Yarrow Watertube Boiler

removing and replacing the tubes. In the diagram, Fig. 1, is illustrated one leg of a Yarrow boiler. The steam drum *a* and water drum *b* are connected with tubes *c*. In the case of removing the tubes especially in the center row it is first necessary to remove the tubes in the outer rows.

The ends of the tubes are split and set in so that they move freely in the tube holes, then the tubes are stepped out from one tube hole to another. Thus, the top end of tube *d* is passed successively into the upper holes *A B C* and the lower end to the holes *D*, *E* and *F*. By reversing the operation the new tubes are replaced. The tubes are expanded in the drums in the usual way, but if the lower drum is too small for handling the work the expander is worked from the steam drum by means of a long mandrel. The tubes being straight, the mandrel is readily passed through the tubes.

The manufacturers of the Thornycroft watertube boiler having small bent tubes expanded in small water drums employ an angle expander of special form driving it by a flexible shaft or rope.

## Boiler Repairs

Q.—I have just been called on a job on a Manning upright boiler. The boiler is 25 years old, running at 110 pounds pressure, in a paper mill. Two of the tubes collapsed and split 4 inches. The boiler has never been retubed. What would you suggest doing? I suggested retubing it but the company does not want to put the money in it so I am going to put in only a few tubes.

(2) Is it good policy to drive a bag back in a firebox or is it safe to let it stay the way it is, one about 8 inches in length? What would you consider the best patch in a firebox? Is it possible to do this, for instance, to take out the lap in the firebox and weld a new piece or patch or put a patch in and how?

(3) Can you give me some information on rigging or tell me where I could get it, such as smokestacks, etc.?—F. B. P.

A.—A boiler that has been in service 25 years without any repairs is a remarkable boiler and it has received the best of attention. The first consideration in the repair of a boiler is safety, not only from the standpoint of protecting life but property as well, so it would seem in this case that the expense of repair after so many years of boiler service is a minor consideration. The boiler should be thoroughly inspected and then overhauled as no doubt the boiler plate and stays as well as the tubes have corroded considerably.

A bag or bulge in the plate should be cut out and a patch applied unless it is possible to drive the bagged section back and stay. Usually the bag forms at the bottom of the shell, due to mud and scale that collects and prevents the water from reaching the plate, as a result, the plate overheats, weakening it, thus causing the plate to bulge out or bag. It is unwise to operate a boiler with such a deformation in the plate, since it will form a pocket for the sediment and within a very short time the bag will become larger and a serious explosion may result.

Boiler patches should be so shaped that the riveted seams are not in a horizontal plane, as in such arrangements a very low riveted strength is obtained. The better plan is to make the patch circular if possible, in which case the seam is much stronger thus producing a patch that will withstand a higher boiler pressure. Bear in mind, that in patching a boiler, the strength of the patch seams must be determined, which is done in the same manner as for the regular boiler joints. If the patch seam is the weaker, the working pressure allowed in the boiler will be determined from the weakest part.

Boiler plate that is supported by stays so that the load or boiler pressure is carried by the staybolts can be repaired by removing the damaged plate and welding in a new section. In such cases the patch plate as well as the metal in the boiler that is to form a part of the welded seam must be beveled and then thoroughly cleaned. The angle of bevel recommended for plates is 90 degrees. To take care of expansion and contraction the patch plate should be slightly dished. Where the plate has cracked in the knuckle of a flange in a firebox sheet it should not be welded. Where the lap or flange section of the seams in a firebox becomes defective, providing the defects do not run back to the knuckle of the flange, the damaged plate can be removed and a new section added and the damaged part rebuilt by the electric process. Your attention is called to the instructions on repairing of locomotive boilers by electric welding which appeared in the November, 1921, issue of THE BOILER MAKER.

Rigging is an extensive subject, requiring special equipment to handle the different conditions met with so it would be impossible to answer this question in the space given for the Questions and Answers column. We do not know of any book dealing directly on this subject. Probably some of our readers can supply the information.

## Determining Stretchout for Shell Courses of Heavy Plate

Q.—Suppose a cylindrical boiler is being made of ½-inch plate, would six times the thickness of the sheet be sufficient for the large course? Would that make it hard to assemble?—H. O. S.

A.—There are several methods of ascertaining the required stretchout of cylinders made from thick plate; all of which give very nearly the same result. The purpose of taking into account the plate thickness is to take care of the gain and loss of plate length undergoing the rolling operation, as the outside of the shell plate stretches and the inside gathers.

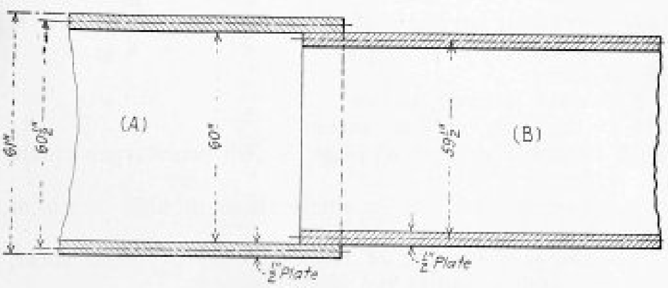



**Fig. 1—Methods of Determining Working Diameter of Shells**

The inside of the plate does not gather or upset as much as the outside stretches. This difference in plate length is often referred to as "takeup."

The following three rules may be applied in determining the circumference to be used for the plate length called the "stretchout."

*Rule 1.* Multiply the outside diameter of the boiler shell by 3.1416 and substract 3 times the plate thickness which is necessary to take care of the increase of plate length.

*Rule 2.* Multiply the inside diameter of the boiler shell by 3.1416 and add 3 times the plate thickness, which is necessary to take care of the gather and consequent shortening in the plate length.

*Rule 3.* Multiply the mean diameter of the boiler (measured to the center of the plate thickness) by 3.1416.

Rule 3 is the one generally used as it saves considerable time in making the calculations and is also accurate since at the middle of the plate thickness, called the *neutral axis*, the plate does not change in length during the rolling operation.

To illustrate the application of the foregoing rules, consider the boiler shells given in Fig. 1 according to rule 1: Stretchout of *A* equals $61 \times 3.1416 - (\frac{1}{2} \times 3) = 191.64 - 1.5 = 190.14$ inches. According to rule 2, stretchout of *A* equals $60 \times 3.1416 + (\frac{1}{2} \times 3) = 184.496 + 1.5 = 189.996$ inches. According to rule 3, stretchout of *A* equals $60\frac{1}{2} \times 3.1416 = 190.06$ inches.

By subtracting the lesser of these values from the greater it will be seen that there is a very small difference in the respective plate lengths.

The smaller course is figured in a like manner but it is customary to simply make it 6 times the plate thickness shorter than the large course. Allow ⅛ inch for squaring up the plate. This gives a good bit and if the work is done right no trouble should be had in fitting the sections together.

## Repairing the Shell of a Vertical Type Boiler

Q.—There is some doubt in my mind as to the reliability of the repair job cited below, and I will appreciate your opinion in the matter. In the case in question, a new section had been welded into a vertical boiler from which the bottom portion had been cut away. This part, Fig. 1, was welded in by the oxyacetylene process just above the line of the lower tube sheet. The staybolts are about 6 inches below, and so there is no means of staying the upper portion, save the holding power of the tubes. The new section was made in two pieces and welded together with the seams vertical. After welding, butt straps were riveted on with two rows of rivets on each side of the weld, but only on the outer side of the shell up to the line of the weld in the girth joint. In your opinion, is this a good method of doing the work, and what would be the advantage of putting a butt strap on the other side? Would the welded joint be weaker than the riveted type, especially when it comes between two rows of staybolts which hold the sheet securely to the inner box?—C. A. N.

A.—The A. S. M. E. Boiler Code specifies the following conditions on welding joints by either the electric or oxyacetylene methods:

> "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 structure is not dependent upon the strength of the weld."

The welded seam, as you describe, is subjected to two stresses acting as follows: A stress due to the pressure

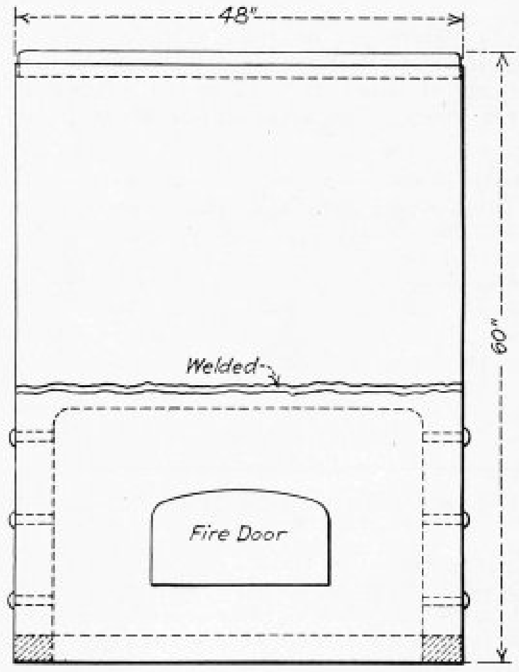



**Diagram Showing Location of Weld**

tending to burst the shell and a stress arising from the pressure on the top tube sheet. If the outer strap is equal at least to the shell plate thickness and the rivets properly pitched and of sufficient size the welded construction and reinforcing ring will meet the requirements of the code. The strength of the repair is figured from the outer strap construction. An inner strap would increase the strength of the joint.

With the welded joint it is impossible to determine what the condition of the weld is, as its strength depends on not only the material used but on the preparation of the joint for welding and the skill of the welder in performing it. The personal element is so uncertain in this work that to obtain a uniform weld requires, especially in the case of oxy-acetylene welding, an expert who understands materials and what the effect is in applying the heat from the gas, and then how the work should be done without burning the material in the joint. If the weld is burned the weld will be brittle and porous.

A good weld will have a high tensile strength but the general characteristics of the metal in the weld are not the same as the original or parent metal. Therefore, it does not have the same degree of ductility and when under pressure would not stand the continued bending action arising from the expansion and contraction of the plate. Thus the welded joint may be weakened within a short time due to the crystallizing of the metal. For that reason in high pressure boilers the weld must be reinforced or not be subjected to direct loads.

# Lap Riveted Joint Design—Ellipse Construction

Q.—Will you please answer for me the following question when space is available in The Boiler Maker: (1) Show by calculations and rules how to find the number and diameter of rivets required in the circular seam as shown at *x* in the accompanying sketch, Fig. 1: supposing that every other part of the vessel is strong enough to resist pressure given, (2) How do you find the true percentage of strength of countersunk riveted joint in the accompanying sketch, Fig. 2, for strength of the net plate section; shearing strength of the rivets (single shear); crushing strength of the plate. (3) Please show me how to lay out an ellipse that conforms to rules which state:

$$\text{Area of ellipse} = 0.7854 \ (D \times d)$$
$$\text{Circumference} = 3.1416 \ \frac{(D + d)}{2}$$

L. T.

A.—(1) There are no rules that definitely give the required size of rivets for a given thickness of plate, since the efficiency of joints vary and may be attained with different size rivets. The required size of rivets and pitch

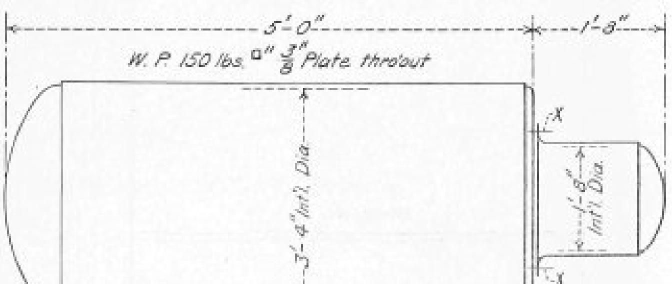



Fig. 1—Joint Used in Fastening Head of Drum to Barrel

depend on a number of factors, viz.: shearing strength of rivets, tensile strength of the plate, and type of joint. The greatest permissible pitch of rivets depends on the thickness of plate, and the pitch must be small enough to produce a steam tight joint.

The following proportions have been used for establishing the rivet diameter:

For single and double riveted lap and butt joints,—diameter of rivet equals the plate thickness plus 3/8 inch for plate 1/4 inch thick up to 1/2 inch, and for 1/2-inch plate the diameter equals the plate thickness plus 7/16 inch.

To fasten the drum *a*, Fig. 1, to the shell head *b*, a double riveted joint should be used. Such joints have an efficiency ranging from 70 to 74 percent. To illustrate the method applied in calculating the joint efficiency the following example is given basing the calculation on the requirements of the A. S. M. E. Code.

*Example:* Consider a lap joint having a plate thickness of 3/8 inch, rivets 3/4 inch in diameter, driven size of rivets

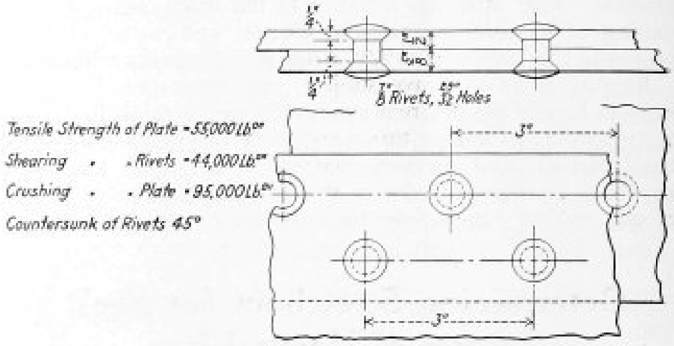



Fig. 2—Efficiency of Countersunk Riveted Joint

equals 13/16 inch and pitch of rivets equals 3 inches. Required to find the efficiency of the joint.

*Solution*:

$A$ = strength of solid plate $= P \times t \times T.\,S.$

$B$ = strength of plate between rivet holes $= (P - d) \times t \times T.\,S.$

$C$ = shearing strength of two rivets in single shear $= n \times S \times a.$

$D$ = crushing strength of plate in front of two rivets $= n \times d \times t \times c.$

In the above:

$P$ = pitch of rivets, inches.

$t$ = thickness of plate, inches.

$T.\,S.$ = tensile strength of plate, 55,000 pounds per square inch.

$n$ = number of rivets in single shear in unit length or pitch.

$S$ = shearing strength of rivet material in single shear, 44,000 pounds per square inch.

$a$ = cross sectional area of rivet after driving square inch $= 13/16^2 \times .7854 = .5185$ square inch.

$c$ = crushing strength of boiler plate steel, 95,000 pounds per square inch.

$d$ = diameter of rivet after driving, inches, $13/16 = 0.8125$.

Using the values of the example and solving for $A$, $B$, $C$ and $D$, we have

$A = 55{,}000 \times .375 \times 3 = 61{,}875$ pounds.

$B = (3 - 0.8125) \times 0.375 \times 55{,}000 = 45{,}117$ pounds.

$C = 2 \times 44{,}000 \times .5185 = 45{,}628$ pounds.

$D = 2 \times .8125 \times .375 \times 95{,}000 = 57{,}890$ pounds.

Dividing the smallest value of the joint strength by the strength of the solid plate section $A$ gives the joint efficiency. Thus

$B \div A = 45{,}117 \div 61{,}875 = 0.729$,—an efficiency of 72.9 percent.

The total pressure acting on the head of the drum $c$ equals the area of the drum head times the working pressure. First find the area of the head which equals $20^2 \times 0.7854 = 314.16$ square inches.

Total pressure on the head equals $314.16 \times 150 = 47{,}124$ pounds.

If there were no riveted joint the pressure would be resisted by the strength of the solid plate section of the drum $a$, which is figured by multiplying the neutral diameter of the drum times 3.1416 times the plate thickness, times the tensile strength of the plate,—thus

$20\frac{3}{8} \times 3.1416 \times 0.375 \times 55{,}000 = 420{,}234$ pounds.

Since the riveted joint holding the drum to the shell head has an efficiency of 72.9 percent, the strength must be figured from the joint; hence $420{,}234 \times 0.729 = 310{,}555$ pounds.

The factor of safety in this case is the ratio of the strength of the joint to resist the pressure acting on the drum head, which is $310{,}553 \div 47{,}124 = 6.4$ nearly.

A high factor of safety is required as the plate in the flange section is liable to be thinned down from the flanging process, thus reducing the plate thickness at the joint.

(2). The joint efficiency for the countersunk riveted form of joint is determined in the same manner as explained for lap joint, Fig. 1.

(3). This question cannot be definitely answered since there are an infinite number of diameter ratios that would give the same area. Thus a given ellipse approaching nearly the outline of a circle can have the same area as another ellipse that has a greater difference in the diameters $D$ and $d$, Fig. 3.

The construction of an ellipse when the diameters $D$ and $d$ are known is done as shown in Fig. 3 which is an ac-

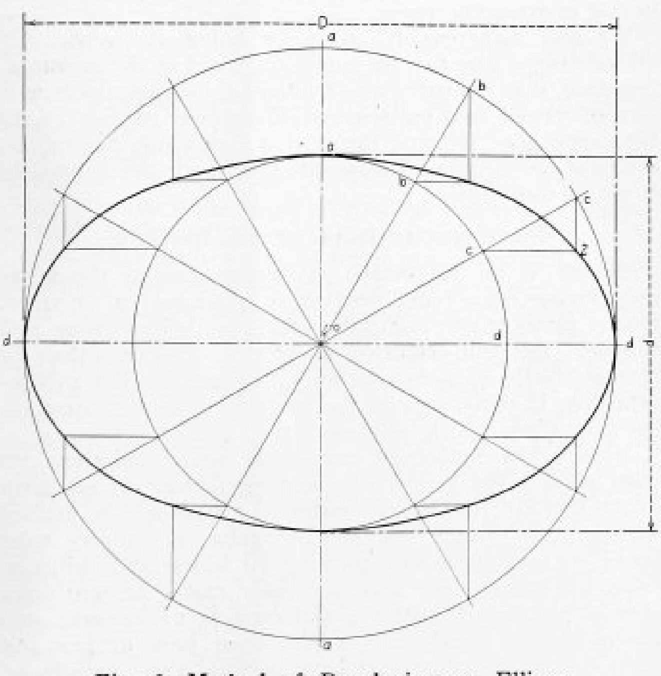


**Fig. 3—Method of Developing an Ellipse**

curate method. There are other methods that are shorter but they produce only an approximate ellipse.

### Development of an Ellipse

Draw the lines *a-a* and *d-d*, Fig. 3, at right angles to each other. From point *o* set off the distance *o-a* and *o-d* equal to one-half the minor and major diameters. With *o* as a center and with the trammels or dividers draw the circles using *o-a* and *o-d* as radii. At any desired position on either circle locate the points *b* and *c* and from these points draw radial lines through the point *o*. From *b* and *c* on the outer circle draw perpendiculars to *d-d* and from the points *b-c* of the smaller circle draw perpendiculars to *a-a*. The intersections of these perpendiculars locate points 1 and 2 on the ellipse. The points *a* and *d* are located in the intersection of the respective circles with the axes of the ellipse. The other sections of the ellipse are laid off in a like manner.

# Commercial Rating of Boiler Horsepower

Q.—Would you please inform me of the simplest and best method of finding the horsepower of a portable type boiler or what is commonly called an *oil well* boiler?—F. G. S.

A.—The *commercial rating* of *boiler horsepower* is approximately determined by estimating the number of square feet of heating surface per boiler horsepower; or it may be calculated according to ratio of grate surface per horsepower. The heating surface of a boiler means that part of the boiler where heat is applied to one side and the water is on the opposite side. In a locomotive portable boiler, the heating surfaces comprise the internal surfaces of tubes, inside firebox sheets, as the crown sheet, wrapper plate, door sheet, firebox tube sheet, except the area taken up by the tubes, etc. The following table gives the estimated grate to heating surface per boiler horsepower:

| Type of Boiler | Heating Surface per Horsepower in Sq. Ft. | Heating Surface to 1 Sq. Ft. of Grate Area |
|---|---|---|
| Locomotive | 12 to 15 | 50 to 100 |
| Watertube | 11 to 12 | 35 to 40 |
| Horizontal return tubular | 12 to 14 | 25 to 35 |
| Vertical | 10 to 12 | 25 to 30 |
| Flue | 8 to 12 | 20 to 25 |

Having determined the heating surface of the boiler, divide the total effective heating surface area by the unit of heating surface estimated to produce a boiler horsepower.

*Example:* A portable locomotive boiler has an effective heating surface of 850 square feet. What boiler horsepower rating has this boiler considering 12 square feet of heating per boiler horsepower?

*Answer:* By dividing 850 by 12 the commercial horsepower equals 70.8.

The actual boiler horsepower depends on the amount of water evaporated per hour. The unit of boiler horsepower is the evaporation of 30 pounds of water per hour from a feedwater temperature of 100 degrees Fahrenheit into steam at 70 pounds gage pressure. This is equivalent to the evaporation of 34.5 pounds of water at 212 degrees Fahrenheit into steam of the same temperature at atmospheric pressure. Boilers generate steam at different pressures and feedwater is fed into the boilers at different temperatures so these conditions must be taken into account in making boiler comparisons and in estimating the horsepower.

For this purpose a *factor of evaporation* is employed. This factor of evaporation is the ratio of the amount of heat required to make a pound of steam under actual working conditions to that required to produce a pound of steam from a feedwater temperature at 212 degrees into steam at atmospheric pressure. This is found by subtracting the heat units in one pound of feedwater at the given temperature from the heat units in one pound of steam at the working pressure. This difference is divided by 965.7, the number of British thermal units in one pound of water evaporated from and at 212 degrees F. Engineers' hand-books give the table covering the factors of evaporation, which are used in making boiler horsepower calculations.

*Example:* If a boiler evaporates 10,000 pounds of water per hour from a feedwater temperature of 70 degrees F. at a steam pressure of 100 pounds per square inch, gage, the factor of evaporation given in the table of factors of evaporation equals 1.188. This factor indicates that if the feedwater had been 212 degrees F. and evaporated into steam at the same temperature, or at atmospheric pressure the boiler could have evaporated $10{,}000 \times 1.188 = 11{,}880$ pounds of water, which is called the *equivalent evaporation*. Since one boiler horsepower is the evaporation of 34.5 pounds of water per hour at 212 degrees F. with steam at the same temperature, the horsepower of any boiler is determined by dividing the equivalent evaporation by 34.5, and in this example $11{,}880 \div 34.5 = 344.3$ boiler horsepower.

# Letters from Practical Boiler Makers

**This Department Is Open to All Readers of the Magazine —All Letters Published Are Paid for at Regular Rates**

## Boiler Explosions and Their Causes

Boiler explosions are usually caused by over pressure of steam. Boiler inspectors are usually called on to investigate the circumstances causing boiler explosions and give an opinion concerning the same. They must be familiar with the cause of such explosions.

Over pressure may be caused by the safety valve sticking or failing to properly carry off the steam; insufficient capacity to discharge the steam; improper design of boilers in that the parts are not sufficiently strong to carry the pressure, in which case the pressure rises beyond the ultimate strength of the boiler.

The following defects render a boiler unfit for pressure: Corrosion and pitting, mismanagement in operating, wear and tear of boiler, defective design, workmanship and material, low water and numerous other causes.

### Testing Boilers

In applying the hydrostatic test, if the boiler fractures the water escapes through a rent or opening in the boiler plate and, consequently, no explosion takes place, owing to the fact that cold water has little or no stored energy. When the boiler is filled with steam and water heated to a high temperature and the boiler fractures, a violent explosion usually follows; for steam and water have considerable stored energy.

The cause explained is that steam escaping through the opening or rent in the plate diminishes the pressure and, consequently, a new body of steam forms from the water, which by escaping through the opening lowers the pressure still more, allowing still further formation of a body of steam at a still lower pressure and this action is continued until the pressure reaches or attains that of the atmosphere. Forming of several large successive bodies of steam in this way occurring almost instantaneously produces disastrous explosions.

As a general rule, the larger the body of water contained in the vessel the more disastrous will be the explosion. For this reason, watertube boilers are considered safer for they contain a comparatively small amount of water compared with firetube boilers.

### Defects in Design

The faults leading to improper design are insufficient staying; stays not of sufficient size and too few in number; cutting large openings in the boiler plate for manhole, dome or other mountings without sufficiently reinforcing the edge of the plate around the opening; making the boiler setting too rigid, causing it to be fractured on account of unequal expansion and contraction; poor and defective water circulation, causing an excessive incrustation to form and, indirectly, explosions; also defective safety valves, poorly designed feed water appurtenances; blow-off cocks improperly designed; discharging feed water directly on to the hot plates near the fire line.

Defective workmanship and material consist of faulty plates, stays or rivets, material containing blisters and lamination; burning or breaking rivets; improperly or carelessly punching and shearing plates; injuring the plates or burning them during flanging, welding or bending operations; using the drift pin excessively and scoring the plates by using too sharp calking tools.

In repairing old boilers, the plates may be fractured or injured by removing the old rivets and applying new ones; also, new plates contract and expand more readily than old ones which have gradually lost their life or flexibility. Shells or plates are weakened by pitting, grooving and corrosion, these defects being caused by impurities in the water and the chemical action set up inside of the boiler due to the changing temperatures of the water while in the process of forming steam.

In several boilers that have exploded plates have been found to have wasted to a thickness of 1/16-inch or even to that of wrapping paper.

We find many reports given on boiler explosions, but are we always sure that the cause attributed to the explosion, is correct, that the party who rendered the decision was well enough versed and experienced to advance the decision? We cannot give the first theory that comes into our minds, but must conscientiously enter into every little detail possible if we are to be sure.

### Procedure in Determining Defects

To get at all the details, we must examine the water glass fittings, gage cocks, feed water apparatus, safety valve, braces, plates, rivets and pipe work, also boiler setting and supports, age and condition of boiler. The conditions in general should be gone over very thoroughly. Get in conversation, if possible, with the party in charge to ascertain his fitness and ability to operate the boiler.

If we are to reduce the number of boiler explosions, we must enforce the boiler rules and regulations as set forth in the Codes of the various states. Laws should be drafted whereby the fireman, engineer or party in charge must submit to an examination showing his fitness and ability to fulfil his duties. See that the boiler maker or repairman applies properly all patches and corrects weaknesses; stop the user from purchasing boilers from junk dealers and from operating boilers that have outlived their usefulness; cut down the pressure on improperly designed and aged boilers; require the services of an inspector who thoroughly understands the boilers in general and not one who has but a book education on the subject.

### Boiler Inspections

When an inspector inspects the boiler he should explain to the owner or user every defect he finds, the proper way to apply patches when necessary or other recommendations that are to be carried out. The repair reports sent back to the owner or user after inspection merely state that the boiler requires a patch or such other work as it does need. The owner or user calls up a boiler maker or, in many cases out in the country, a shoemaker (as we call them) to do the job. He goes at it with very little idea as to the proper kind of patch to apply, whether the bracing is sufficient to carry the load, etc., and the result is that he has weakened the structure of the boiler so that his repair has become insufficient to carry the desired pressure.

Olean, N. Y. C. W. Carter, Jr.

## Questions and Answers for Apprentices

Q.—What is meant by atmospheric pressure?

A.—The weight of the atmosphere is 14.7 pounds at the sea level.

Q.—What is the weight of a cubic foot of fresh water?

A.—Sixty-two and one-half pounds.

Q.—What is steam?

A.—Steam is a vapor or gas generated from water by heat.

Q.—What is a vacuum?

A.—A vacuum is a space void of all pressure.

Q.—What is the heating surface on a boiler?

A.—The heating surface is that part of the boiler in contact with the flames and hot gases.

Q.—What are the advantages of steel as a material for boiler plates?

A.—Homogeneity, tensile strength, malleability, ductility and general freedom from laminations and blisters.

Q.—What are laminations?

A.—Laminations are the partings of the sheet into layers.

Q.—Give the purpose of the fusible plug.

A.—The fusible plug is for the purpose of giving warning of low water, but its use with the larger type of locomotive boilers is becoming less year by year. Some railroads have discarded it entirely.

Q.—Give the purpose of the water glass.

A.—The water glass is a second or auxiliary device for ascertaining the water level. Some engineers use the gage cocks principally to ascertain the true water level.

Q.—How much pressure is applied to a boiler at a hydrostatic test?

A.—The hydrostatic test pressure when applied to a boiler should be 25 percent above the working pressure of the boiler. Some manufacturers apply 50 percent above the calculated working pressure.

Q.—What items are to be taken into consideration in arranging braces and staybolts?

A.—In the distribution of braces and staybolts every effort should be put forth to distribute them so each brace and staybolt will have the same stress per square inch; that is, as near as practicable. In arranging the staybolts attention must be paid to the size of the staybolt, the pitch, and the thickness of the plate that it supports. The same of the braces. It is possible that the staybolts or the brace will be large enough to support the area allotted, but the plate may be so light that the pitch will be excessive and cause deformation. In deciding upon the pitch it is required that the formula in regards to same be known. There are many such rules and regulations, all varying in a general way.

Q.—How would you determine the following? A riveted joint has the following values: Plate ½ inch thick, 60,000 pounds tensile strength; rivets in single shear have a shearing strength of 42,000 pounds per square inch, and rivets in double shear have a shearing strength of 80,000 pounds per square inch; diameter of hole 1 inch, minimum pitch of rivets 3¾, maximum pitch of rivets 7½ inches.

A.—(a) Efficiency of the net section of plate at the maximum pitch of rivets.

(b) Efficiency of the net section of plate at the minimum pitch of rivets.

(c) Efficiency of the rivet in single shear.

(d) The combined efficiency of the net section of plate at the minimum pitch of rivets and the rivets in single shear.

(e) Efficiency of rivets in double shear.

(a) $$\frac{7.5 - 1}{7.5} = 86.6\% \text{ efficiency.}$$

(b) $$\frac{3.75 - 1}{3.75} = 73.33\% \text{ efficiency.}$$

(c) $$\frac{1 \times .7845 \times 42{,}000}{60{,}000 \times .5 \times 7.5} = 14.66\% \text{ efficiency.}$$

(d) $73.33 + 14.66 = 87.99\%$ efficiency.

(e) $$\frac{4 \times 0.7854 \times 80{,}000}{60{,}000 \times 0.5 \times 7.5} = 120\% \text{ efficiency.}$$

Canton, Ohio. Geo. L. Price.

## A Boiler Scale Paradox

Many engineers of much experience have never thought of this easily explained truth—that the boiler tubes that are cleanest scale the most. Sounds like a contradictory statement, doesn't it? Yet it is a fact. The catch that "gets 'em" is that the word "outside" is omitted. In other words, the tubes that are dirty with soot will not be so dirty inside, because soot is about as good an insulator as there is against the flow of heat. Authorities who should know declare that soot is a more effective insulator than asbestos and that is "going some." To cause all boiler tubes to scale an equal amount in a given time, therefore, it behooves the operator of the soot cleaning machine to keep all tubes equally clean, from top to bottom. And even then, perhaps, there will be considerably more scale to be found in the bottom tubes where heat is most intense. The tube that absorbs the most heat will evaporate the most water and therefore will leave the most scale to cling to and impair the heat transmitting qualities of the tube. Thus the boiler tube is "twixt the devil and the deep sea" in that it is beset on both sides by a substance that is injurious to the plant owner's pocketbook, directly through the coal pile—soot on the outside and scale on the inside. If it is a fire tube boiler the reverse is the case.

### Difference in Scale Thickness

This explains why it is that in many boilers scale in the tubes is thicker on one side of the tube bank than on the other. In such boilers it is invariably found that the soot is blown off the tubes through the dusting doors at the sides of the setting. The cleaning, however, is not thorough enough because the boiler is not equipped with the proper kind of apparatus for regular cleaning. A hand lance thrust through the dusting doors does not clean the far side of the boiler.

Instead of cleaning the tubes on the far side it blows the soot from the near side over onto the tubes farther away and makes matters worse. In some cases it has been found that tubes have been packed completely full of soot, and they might just as well not have been in the boiler at all. By looking into the problem with care, and studying the cross section of a typical horizontal watertube boiler, it will be readily understood why and how it is possible for the tubes to become packed full of soot where hand lance blowers are constantly used.

### Best Method of Cleaning Tubes

The better way to clean off the soot is to install a permanent cleaner on top of the tube bank and blow down between the tubes. The soot is thus cleaned off from one side to the other in a uniform manner and instead of having the jets blow against the wall the jets blow the soot downward into the clean space below the tubes. It is impossible, in designs of this kind, for the tubes to become clogged full of soot. Scale formation, also, will be uniform from side to side. It has been pointed out that during the scaling process some of the workmen may think that the scale is thicker on one side than on the other. The thickness, it is said, varies directly with the tiredness of the man. There may be some truth in that statement, but it nevertheless does not alter the above.

It has also been said that much depends upon the way in which the fireman shovels coal into the furnace. If he is left-handed he may throw more coal onto one side than the other and thus keep one side of the boiler hotter. There may be some truth in that, but the fact remains that the tubes that evaporate the most water or absorb the most heat are the ones that will have the thickest scale.

Newark, N. J. N. G. NEAR.

## Scale Troubles in the Days Before Water Treatment

In the July issue of THE BOILER MAKER I read with much interest the article on "The Advantages of Treating Locomotive Feed Water," in which the softening compound was fed through the tank to the boiler.

Back in the 80's and 90's when I was actively connected with boiler making there were not many treating plants nor much compound in use. My first experience at boiler making for the railroads was at Preston, Iowa, about 1870. At this place we had mostly Blood engines—eight wheelers; later we had Moguls Baldwins and a few Henckeleys. The water that gave us the most trouble was on the west end of the line; where it contained a great deal of solid matter and some lime which formed a hard scale. It also caused pitting in the bottom tubes and grooving on the front sheets and flanges. We found that this action could be partially stopped by taking off the tubes that were less than 3 inches from the shell and putting in pockets. The cause of pitting in this section was probably due to close spacing in the tubes and the more rapid circulation of the water at this point. Coal mines were located in this region, so that the feed water available contained sulphur.

### DIFFICULTY OF CLEANING TUBES

Another bad feature was to hire men and boys who would properly scale the shell after the tubes had been taken out. Usually they would have their scaling hammers very sharp and literally cut the enamel off the boiler shell so that we had to put new bottoms on most of the shells after ten years of service.

After putting in new fireboxes and tube sheets we laid out the tube holes with uniform spacing from the shell; later, in order to stop solids from collecting direct from the feed, check and return tubes, we put in a shield in the form of a scoop shovel made of 1/8-inch steel and about 30 inches wide. This was placed so that it ran to the bottom row of tubes and prevented the solids from forming scale on the tubes.

In 1881 I was employed at Terrace, Utah, on the Salt Lake Division of the Central Pacific. At that time the Central Pacific was the only through line to California; traffic was heavy because of extra trains of silk, sugar and tea coming from the coast. We had ten-wheel McKay and Aldrus as well as McQueen and Rogers engines for passenger trains while for pushers we used some McQueens; also some old ten-wheel straight type Masons which were used at Promontory Hill, where we had the bad water. This water would make any boiler leak, particularly the Masons, which came into the shop quite often.

An engine from the Well's division which had never leaked in all its service was sent out over the line and after two trips it started to leak; when put back on the Well's division again, by changing the water in the tank and washing the boiler, the leaks stopped. The water on the Promontory would prime as well as pit and was the cause of many crown sheets leaking that had never leaked before. Up to that time the Promontory water had never been analyzed.

### LOCOMOTIVE BOILER IN SERVICE THIRTY-ONE YEARS

While on a visit to Lake Tahoe I saw a boiler that had been in service thirty-one years without ever being washed out or blown down. I had the engineer take out a handhole plate to inspect the interior and there was hardly more than a light lime color on the sheet and no scale. Lake Tahoe is located in the northeast part of California almost at the top of the Sierra Nevada mountains with an altitude of 7,700 feet. The lake is about eight miles wide and about twenty-three miles long and at the middle soundings have never reached bottom; the water is as cold as ice, weighs only 6½ pounds per gallon and extremely pure and clear.

Los Angeles, Cal. JOE HOLLOWAY.

## BOOK REVIEW

THE WELDING ENCYCLOPEDIA, Second Edition. Edited by L. B. Mackenzie and H. S. Card. A reference book on the theory, practice and application of the four autogenous welding processes. Size, 6 by 9 inches. Pages, 388. Illustrations, 550. Chicago, Ill., 1922: The Welding Engineer Publishing Company.

The first half of this book consists of a dictionary of all words, terms and trade names used in the welding industry. Included in this arrangement are instructions for welding operations on the most common types of repair work and production work, descriptions of the modern methods of testing welds, specifications for welding rods and wires for all classes of work, and descriptions of the application of welding to the various industries, such as automobile repairing, refrigerating machinery, structural steel, etc. Following the dictionary section are separate chapters on oxy-acetylene welding, electric arc welding, electric resistance welding and thermit welding. Complete descriptions of each one of these processes are given, followed by general operating instructions and special instructions for the application of each process to every metal which can be welded by it. Separate chapters are included on the subjects of boiler welding, tank welding, pipe welding and rail joint welding. Another section is devoted to the rules and regulations enforced by Federal and State authorities and insurance companies on the construction, installation and operation of welding equipment and on their application to various structures. A special chapter deals with the heat treatment of steel, one of the most important metals which the welder handles. A collection of charts and tables shows the variety of methods of preparing joints for welding, gives information on the characteristics of all the commoner metals, shows how to tell the temperature of metals by a color chart, and also shows a color chart explaining the proper adjustment of the oxy-acetylene flame. The catalogue section at the end of the book describes and illustrates the standard lines of welding equipment and apparatus.

## BUSINESS NOTES

H. A. Matthews, formerly sales manager of the railway division of the U. S. Light & Heat Corporation, Niagara Falls, N. Y., has been elected a vice-president, sales railway division.

W. H. Woodin, president of the American Car & Foundry Company, New York, was appointed fuel administrator of the state of New York on September 5 by Governor Miller under the act of the extraordinary session of the legislature.

The F. S. Pearson Engineering Corporation, Fisk Building, 57th Street and Broadway, New York City, has reestablished its Department for Industrial Management and Technical Auditing of industries and public utilities. This department will be carried on together with the usual work of financing, developing, design and construction of engineering projects and industrial plants.

## ASSOCIATIONS

### Bureau of Locomotive Inspection of the Interstate Commerce Commission

Chief Inspector—A. G. Pack, Washington, D. C.
Assistant Chief Inspector—J. M. Hall, Washington, D. C.

### Steamboat Inspection Service of the Department of Commerce

Supervising Inspector General—George Uhler, Washington, D. C.

Deputy 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—John A. Stevens, Lowell, Mass.
Vice-Chairman—D. S. Jacobus, New York.
Secretary—C. W. Obert, 29 West 39th Street, New York.

### National Board of Boiler and Pressure Vessel Inspectors

Chairman—J. F. Scott, Trenton, N. J.

Secretary-Treasurer—C. O. Myers, State House, Columbus, Ohio.

Vice-Chairman—R. L. Hemingway, San Francisco, Cal.
Statistician—W. E. Murray, Seattle, Wash.

### American Boiler Manufacturers' Association

President—A. G. Pratt, Babcock & Wilcox Company, New York.

Vice-President—G. S. Barnum, The Bigelow Company, New Haven, Conn.

Secretary and Treasurer—H. N. Covell, Lidgerwood Manufacturing Company, Brooklyn, N. Y.

Executive Committee—F. C. Burton, Erie City Iron Works, Erie, Pa.; E. C. Fisher, Wickes Boiler Company, Saginaw, Mich.; C. V. Kellogg, Kellogg-McKay Company, Chicago, Ill.; W. S. Cameron, Frost Manufacturing Company, Galesburg, Ill.; W. A. Drake, The Brownell Company, Dayton, Ohio; Alex. R. Goldie, Goldie & McCullock Company, Galt, Ont., Can.; F. G. Cox, Edge Moor Iron Company, Edge Moor, Del.; J. C. McKeown, John O'Brien Boiler Works Company, St. Louis, Mo.

### International Brotherhood of Boiler Makers, Iron Ship Builders and Helpers of America

J. A. Frank, International President, suite 522, Brotherhood Block, Kansas City, Kansas.

William Atkinson, Assistant International President, suite 522, Brotherhood Block, Kansas City, Kansas.

Joseph Flynn, International Secretary-Treasurer, suite 504, Brotherhood Block, Kansas City, Kansas.

James B. Casey, Editor-Manager of Journal, suite 524, Brotherhood Block, Kansas City, Kansas.

H. J. Norton, International Vice-President, Alcazar Hotel, San Francisco, Calif.

International Vice-Presidents—Thomas Nolan, 700 Court St., Portsmouth, Va.; John Coots, 344 North Spring St., St. Louis, Mo.; M. A. Maher, 2001-20th St., Portsmouth, Ohio; E. J. Sheehan, 7826 South Shore Drive, Chicago, Ill.; John J. Dowd, 953 Avenue C, Bayonne, N. J.; R. C. McCutcheon, 15 La Salle Block, Winnipeg, Man., Can.; Joseph P. Ryan, 7533 Vernon Ave., Chicago, Ill.; John F. Schmitt, 605 East 11th Ave., Columbus, Ohio.

### Boiler Makers' Supply Men's Association

President—W. M. Wilson, Flannery Bolt Company, Pittsburgh, Pa. Vice-President—George R. Boyce, A. M. Castle Company, Chicago, Ill. Secretary—W. H. Dangel, Lovejoy Tool Works, Chicago, Ill.

### Master Boiler Makers' Association

President—Thomas Lewis, G. B. I., L. V. System, Sayre, Pa.

First Vice-President—E. W. Young, G. B. I., C. M. & St. P. R. R., 81 Caledonia Place, Dubuque, Iowa.

Second Vice-President—Frank Gray, G. F. B. M., C. & A. R. R., 705 West Mulberry St., Bloomington, Ill.

Third Vice-President—Thomas F. Powers, System G. F. Boiler Dept., C. & N. W. R. R., 1129 Clarence Ave., Oak Park, Ill.

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Secretary—Harry D. Vought, 26 Cortlandt St., New York City.

Treasurer—W. H. Laughridge, G. F. B. M., Hocking Valley Railroad, 537 Linwood Ave., Columbus, Ohio.

Executive Board—L. M. Stewart, G. B. I., Atlantic Coast Lines, Waycross, Ga., Chairman.

## TRADE PUBLICATIONS

WELDING REPAIRS.—Methods of utilizing welding in repair work in England are outlined in a bulletin recently sent out by Barimar, Ltd., Oxford street, London, England. Details for engine and general machine repairs are explained with photographs of the work in process and in the finished state.

STOKERS.—Bulletin 294 has been issued by the B. F. Sturtevant Company of Boston, Mass., describing the Sturtevant underfeed stokers, which include a centrally located horizontal retort, extending longitudinally with the furnace and provided at its upper edge with tuyeres through which air is introduced to the fuel as it rises into the fire. A complete explanation of the operation is given with illustrations.

GALVANIZING EQUIPMENT.—Apparatus of the moving cathode type for galvanizing and plating has been developed by the U. S. Galvanizing and Plating Equipment Company, 32 Stockton street, Brooklyn, N. Y. The arrangement of the apparatus, its value in a variety of plating work, together with numerous illustrations and diagrams, make up the pamphlet.

HEAVY DUTY DIESEL ENGINES.—Atlas Imperial mechanical injection fuel Diesel engines are described in a catalog issued by the Atlas Imperial Engine Company, Inc., Oakland, Cal. An explanation of the mechanical problems met in Diesel engine design with illustrations and characteristic details of engines in small and large power units are given together with numerous views showing application of these engines in stationary and marine practice.

INSULATING COMPOUNDS.—A booklet has been issued by the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., which describes insulating and soldering compounds manufactured by that company. The materials treated are baking varnishes, air-drying varnishes, insulating compounds, finishing materials, soldering flux, and lubricating oil.

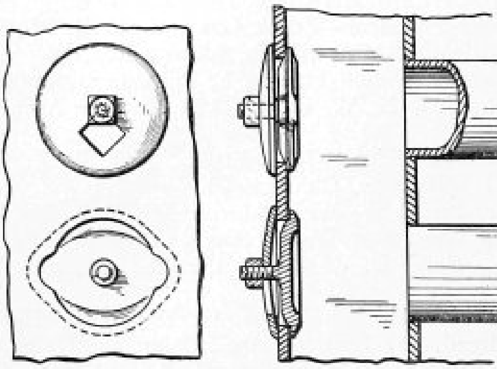
# SELECTED BOILER PATENTS

Compiled by
GEORGE A. HUTCHINSON, Patent Attorney,
Washington Loan and Trust Building
Washington, D. C.

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

1,424,930. GASKET FOR HANDHOLE PLATES FOR WATERTUBE BOILERS. PATRICK H. MAHONEY, OF CHICAGO, ILLINOIS.

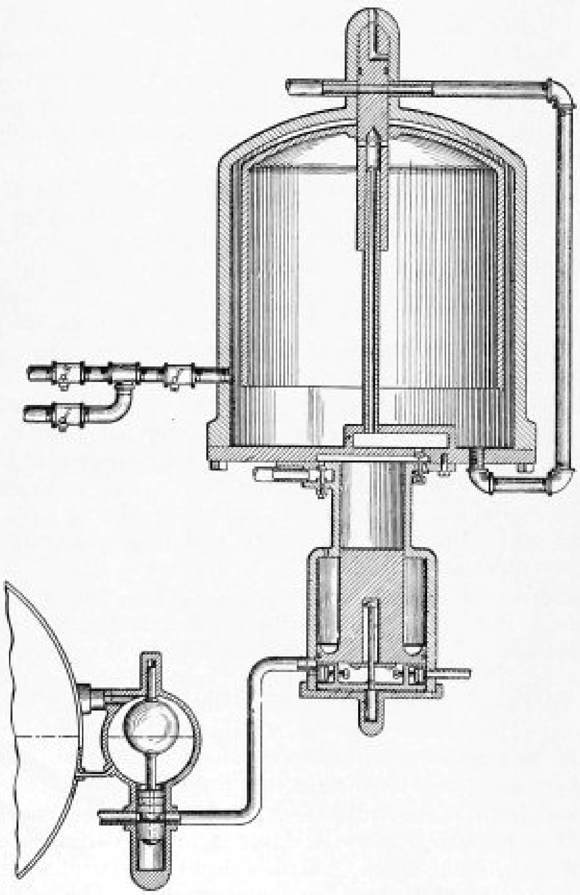
*Claim* 1.—A lead gasket for a hand-hole plate, said gasket being substantially circular in form and outwardly bulged at diametrically opposite points,



said gasket having a circumferentially extending ridge located on both sides. Three claims.

1,425,394. AUTOMATIC BOILER FEED. JOHN S. LEE, OF NEWTON, IOWA.

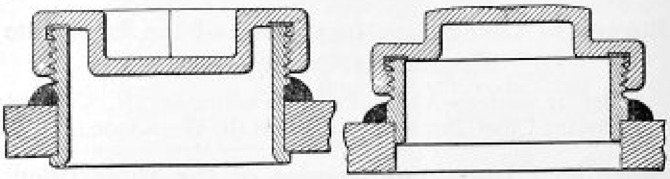
*Claim* 1.—An automatic boiler feed comprising a trap casing, a float mounted therein, mechanism controllable by the position of said float for admitting water into said trap casing, a pump located between said trap casing and the boiler for forcing water into the boiler, steam connections from the



boiler to said pump for enabling said pump to be actuated by steam, a valve connected with said steam connections for controlling the flow of steam through said steam connections, and a float connected with the boiler and controllable by the level of water therein, said float being connected with said valve for the purpose of actuating the same. Eight claims.

1,424,559. STEAM BOILER. ETHAN I. DODDS, OF PITTSBURGH, PENNSYLVANIA, ASSIGNOR TO FLANNERY BOLT COMPANY, OF PITTSBURGH, PENNSYLVANIA.

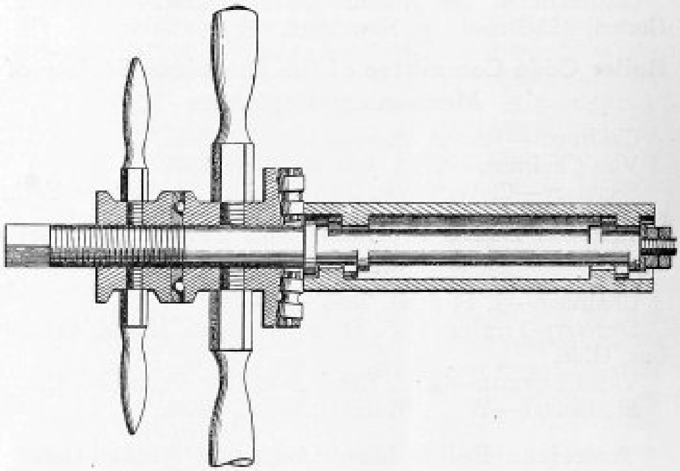
*Claim* 1.—The combination with a boiler having a cleaning-out opening, of



a nipple, said nipple being exteriorly threaded at one end and having a watertight connection with said cleaning-out opening. Four claims.

1,420,383. TUBE BEADING OR FLANGING MACHINE. EVERMONT BLEVINS MINER, OF PORTLAND, OREGON.

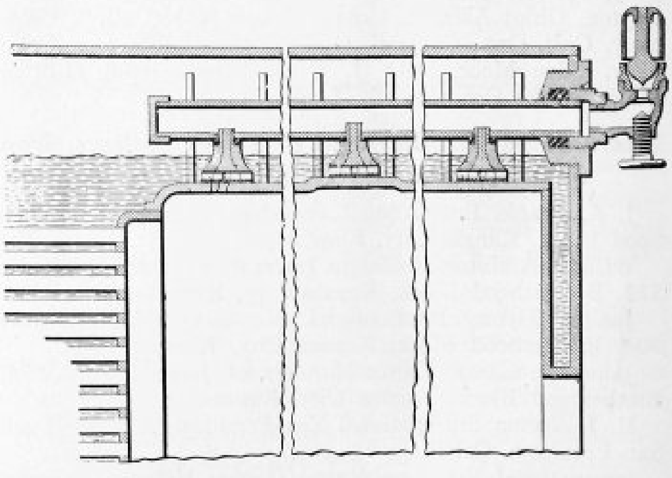
*Claim* 1. In a device of the character described, a rotatable shaft, a mandrel arranged on said shaft consisting of sections, means for retaining said sections against radial displacement while permitting expansive movement, means for retaining said sections against longitudinal displacement, means



operable by said shaft for expanding said sections, beading rollers arranged on said shaft adjacent said mandrel, a cage for said rollers, a working head arranged on said shaft and having a working face against which said rollers bear, means for rotating said working head, feeding mechanism comprising a rotatable block threaded on said shaft and means for rotating said block, and a thrust collar arranged on said shaft, between said rotating block and said working head. Four claims.

1,424,313. SAFETY SIGNAL DEVICE FOR BOILERS. JULIUS C. LUEDKE, OF CEDAR RAPIDS, IOWA.

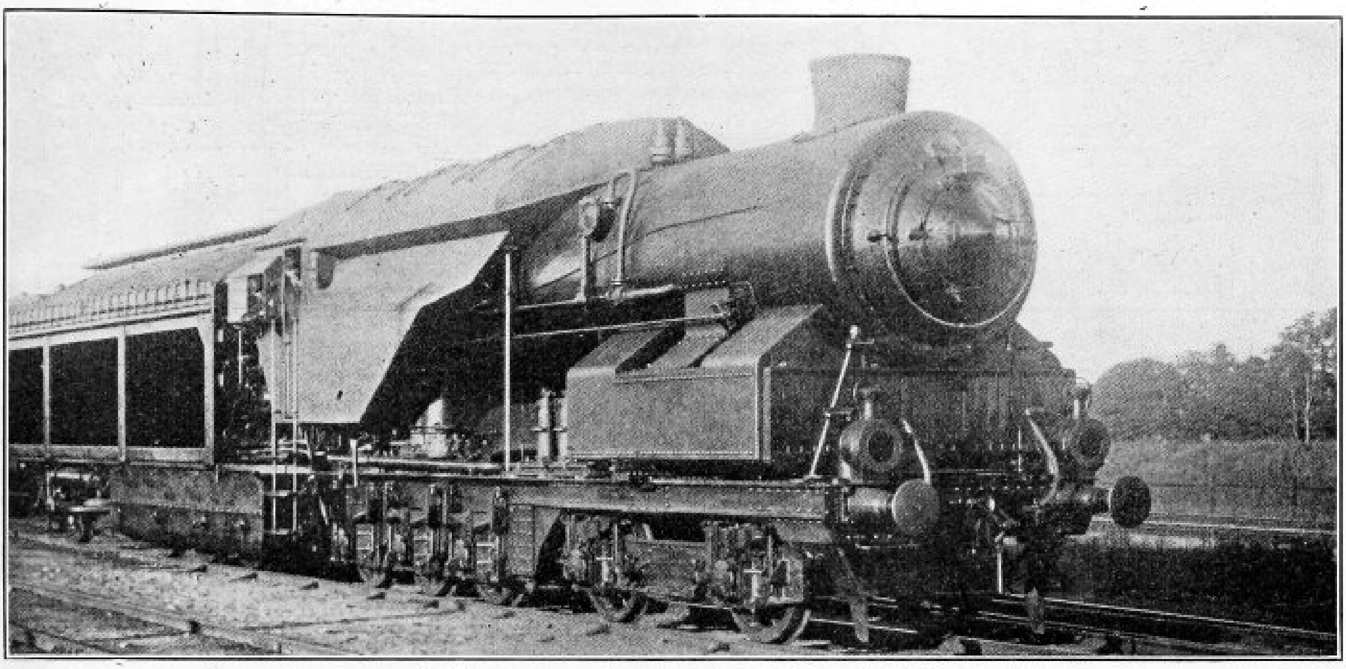
*Claim* 1.—In a low water indicating system, the combination with a signaling element located externally of the back head sheet of the boiler, the said element including an externally threaded member, the said head having an opening located between the crown sheet of the boiler and the top of the



boiler casing; of a tubular member insertable through the opening in the said back head of the boiler, the said member being closed at one end, coupling devices engaging the externally threaded member of the signaling element and the open end of the tubular member, the said coupling devices constituting a closure for the opening in the aforesaid back head of the boiler, and a fusible button having a steam-tight connection with the tubular member and supported therefrom to position the lower end in close relation to the aforesaid crown sheet. Three claims.

# The Boiler Maker

NOVEMBER, 1922

Ljungstrom Turbine Locomotive Showing Boiler and Condenser Units

# Boilers of the Ljungstrom Turbine-Driven Locomotive

### High Efficiency of Swedish State Railway Locomotive Due to Special Boiler Features Including Air Heater and Feed Water Heaters

WHEN it is recalled that the superheated-steam locomotive converts only about six to eight percent of the heat value of the coal consumed into useful work, whereas from 15 percent to 19 percent is converted in modern power plants, it is apparent that there is room for large improvements in locomotive efficiency. The importance of the matter stands out prominently at the present time on account of the world-wide increasing cost of fuel. While this increase has not been as pronounced in this country as in Europe, fuel is still one of the largest items of railroad operating expenses.

At the present time the steam turbine is the most generally used prime mover in important stationary plants and is being extensively applied in the marine field, despite the efficiency of the compound or triple expansion engines formerly used. In any consideration of radical changes in locomotive design, one thus naturally turns to the steam turbine. As an evidence of this trend of design, three turbine-driven locomotives are now in operation in Europe, including the Ljungstrom geared-turbine locomotive of 30,000 pound tractive force on the Swedish State Railways. A very complete description of the Swedish design has been given in recent issues of *Engineering* (London) to which THE BOILER MAKER is indebted for most of the information and illustrations used for this article.

The design is largely the work of Fredrik Ljungstrom, assisted by his older brother, Birger Ljungstrom, general manager of Aktiebolaget Ljungstroms Angturbin, at whose factory near Stockholm the work of construction was carried out. In regard to running gear, boiler design, locomotive practice and requirements, the engineers of the Swedish State Railways collaborated with the builders. By combining the knowledge of an old established manufacturer of turbines and power plant equipment with that of practical railroad engineers, an epoch marking locomotive has been brought out after a vast amount of investigation and preliminary experimental work. In working out the details the object aimed at was to adapt the most advanced power station practices to the space and weight limitations of an ordinary locomotive and still retain the relatively high efficiency, reliability and possibility of long continued operation without inspection or withdrawal from service for repairs to boiler or machinery.

The feed water is used over and over, thus reducing the amount of scale and necessary boiler work to a minimum. Tests in regular service have shown a fuel consumption of less than half that of standard type locomotives of a similar capacity when hauling the same trains. The small size of the boiler and the little coal required are striking proofs of increased efficiency.

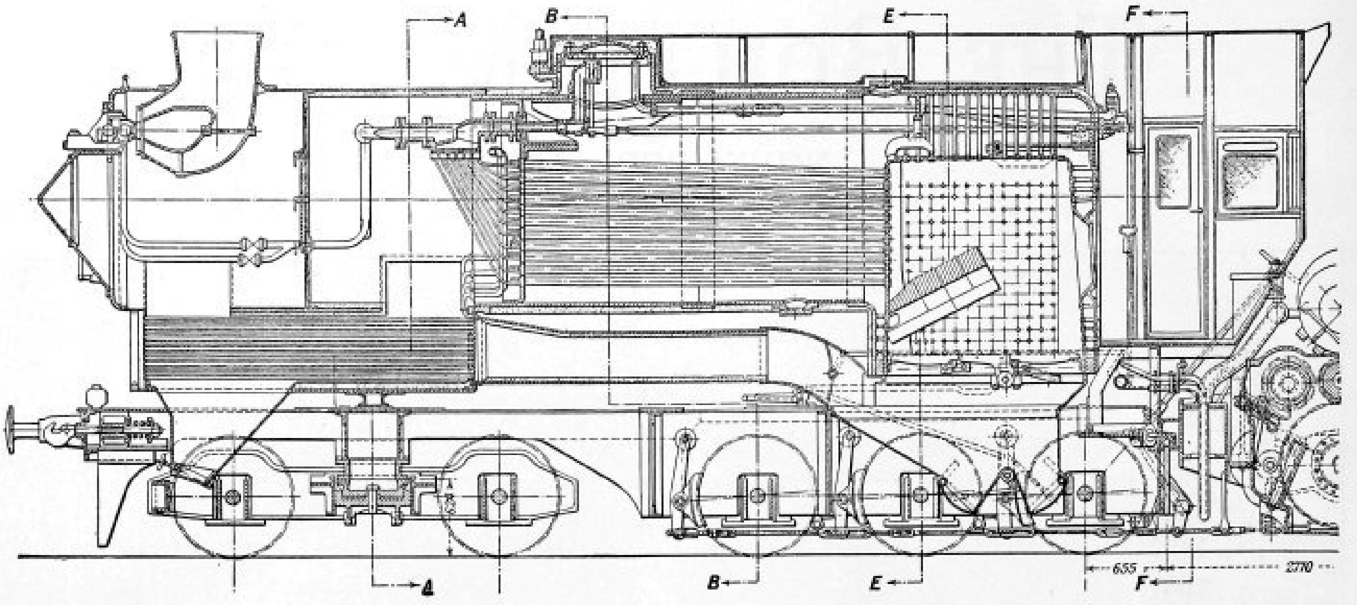



Fig. 1.—General Details of Boiler Unit

It will be noted from the drawings that the locomotive consists of two parts, a boiler unit and a condenser unit. The forward half, containing the boiler and coal bunker, weighs 138,800 pounds and is carried on a four-wheel leading truck and three pairs of wheels with boxes and pedestals of ordinary European design. All ten wheels are of 38¼ inch diameter and are used simply for carrying the weight. The rear unit, in addition to the condenser, carries the turbine, reduction gear and part of the auxiliary machinery. It weighs 143,360 pounds and is carried on three pairs of coupled driving wheels, 56¼ inch diameter, and a two-wheel trailing truck with 43¼ inch wheels. The weight on the driving wheels is 107,520 pounds and on the trailing truck, 35,840 pounds.

### Boiler and Air Heater

The boiler carries 285 pounds steam pressure and is of the straight top type, 66 inches outside diameter, with a firebox 63 inches long by 63 inches wide which gives a grate area of 28 square feet. There are 160 tubes, 3 inches outside diameter and 9 feet 10⅛ inches long between the tube sheets. The evaporative heating surface includes 108 square feet in the firebox and 1,130 square feet in the tubes, a total of 1,238 square feet.

The length of the tubes is only about two-thirds that of ordinary locomotive boilers. This was decided upon because it was thought that greater economy could be secured by utilizing the surplus heat contained in the gases for preheating the air required for combustion. This is believed to be the first instance in which an air preheater has been used on a locomotive.

The smokebox is divided into two portions by a transverse diaphragm which causes the gases to pass down and through the air heater before going to the stack. This heater, which is located beneath the smokebox, contains 650 longitudinal brass tubes, 1.3 inches outside diameter, 8 feet 11¼ inches long and with a heating surface of 1,787 square feet. The gases leave the boiler tubes at about 610 degrees F. and are cooled to about 300 degrees F. in passing through the air heater while the air for combustion is raised to about 300 degrees F.

The front portion of the air heater casing is extended downward to form a hopper in which soot and dust can collect and from which they can be discharged at will. A large duct connects the rear end of the air heater to the closed ash pan. The supply of air to the ash pan is controlled by a series of vertical shutters or dampers which cover the front end of the heater and can be opened and closed from the cab. The handle by which they are operated is interlocked with the firedoor in such a way that they are closed automatically when the firedoor is opened, thus avoiding the danger of flame or gases being blown back into the cab when the door is opened, while the locomotive is running. There is also an additional damper in the duct to the ash pan for further regulation. The coal is carried in a saddle bunker of seven tons capacity, mounted on top of the boiler and extending from the front of the dome to the cab. Its tapered form serves to bring the coal to doors opening to the foot plate on each side of the firebox where it is most convenient for the fireman.

### Induced Draft Fan

As the exhaust steam is all condensed, it becomes necessary to use a fan to create the required draft. As will be noted from the drawings, the stack has an extension reaching down into the front compartment of the smokebox, and carried forward where it terminates in an annular opening with a horizontal axis. A turbine-driven fan is mounted on the front of the locomotive with the fan blades close to the annular opening to the stack and serves to draw the gases from the smokebox and force them through the stack. The cooling of the gases to 300 degrees F. while passing through the air heater also reduces their volume, both of which simplify the fan problem. The maximum speed of the fan is 10,000 revolutions per minute, at which speed the turbine develops 40 horsepower. The front end projects from the smokebox and contains an oil reservoir and pump.

The turbine consists of a single impulse wheel with two rows of rotary blades. The blades are welded up into a complete ring and clamped to the center disc by two plates. The turbine shaft is hollow and carries a central spindle to which the fan is attached. The turbine works at full boiler pressure and exhausts against a back pressure of 75 pounds to the high pressure feedwater heater or to the main turbine.

The fan impeller is machined from a solid steel disc and the hub is counterbored from both sides to give a flexible connection and permit the rim and blades to rotate about their own center of gravity and run without vibration.

### Superheater and Tube Blower

All tubes contain superheater elements. Each element is heated by the gases passing through two tubes, the super-

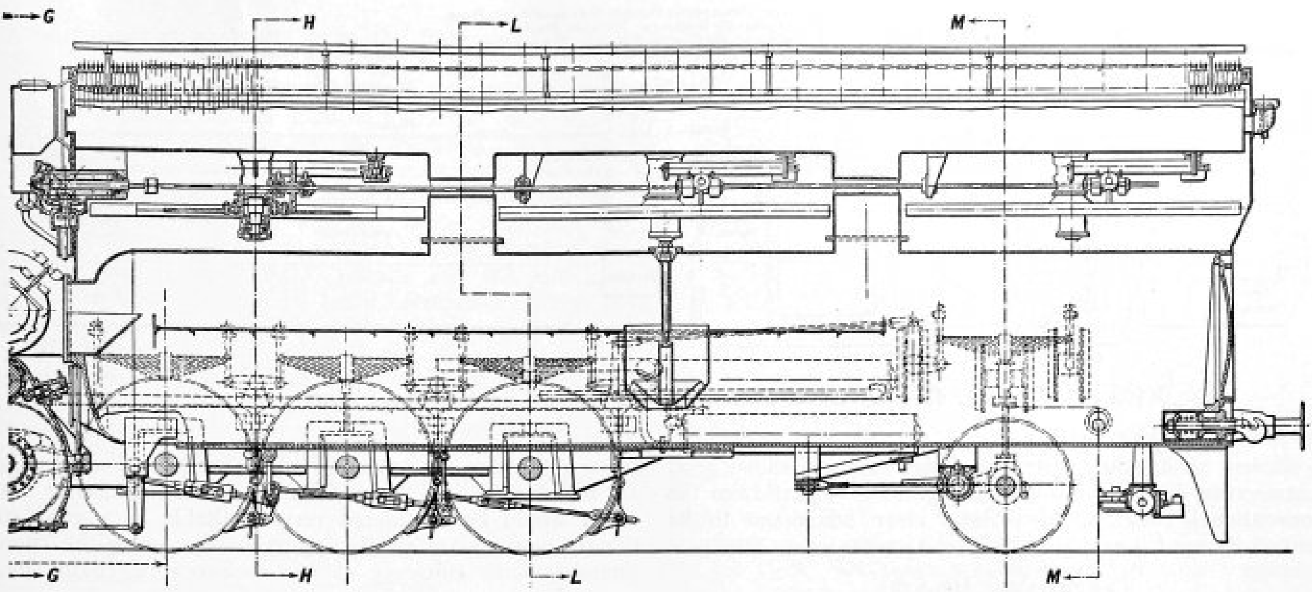


Fig. 2.—Turbine and Condenser Unit of Ljungstrom Locomotive

heater pipes making four passes through the first tube and then four through the second tube before returning to the header. The length of each pass is shorter as the steam becomes superheated. The superheating surface is 861 square feet.

Provision has been made for blowing the soot out of the tubes, the mechanism being operated from the cab. A horizontal steam pipe extends across the front tube sheet above the top row of tubes, and to this pipe is connected a series of smaller vertical pipes between each alternate row of tubes. These small pipes have drilled holes opposite each tube opening. When the engineman desires to remove the soot from the tubes he can admit steam to each one of the vertical pipes in succession. As extensions of the pipes pass down into the air heater, boiler tubes, superheater elements and air heater tubes are all cleaned at the same time. The tubes being blown in small sections, there is no appreciable interference with the draft, such as would result if all tubes were blown at the same time.

### The Main Turbine

The main turbine is of the impulse-reaction type with axial steam flow and develops 1,800 brake horsepower at the maximum speed of 9,200 revolutions per minute, which corresponds to a locomotive running speed of 68.3 miles per hour. Superheated steam is carried from the boiler unit to the turbine by a steel pipe with a U-shaped bend to obtain the required flexibility between the two units of the locomotive.

### The Condenser

The efficiency of a steam turbine depends upon the employment of a condenser which will ensure the maintenance of a high vacuum. The ordinary type of condenser used in stationary and marine installations with a large number of water tubes was considered to be impractical on account of the size, weight and large quantities of cooling water that would be required. An air-cooled condenser was consequently decided upon as the most suitable for locomotive use. In the

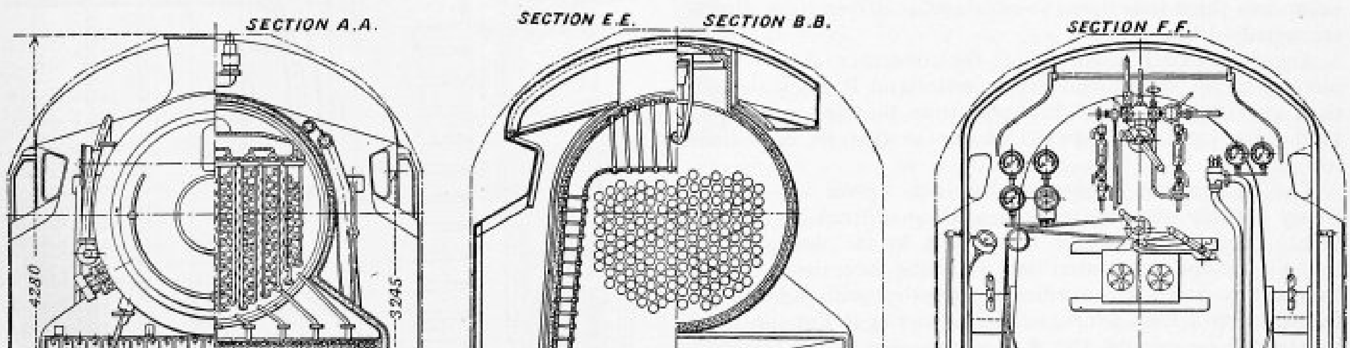


Fig. 3.—End Views and Sections of Boiler Unit

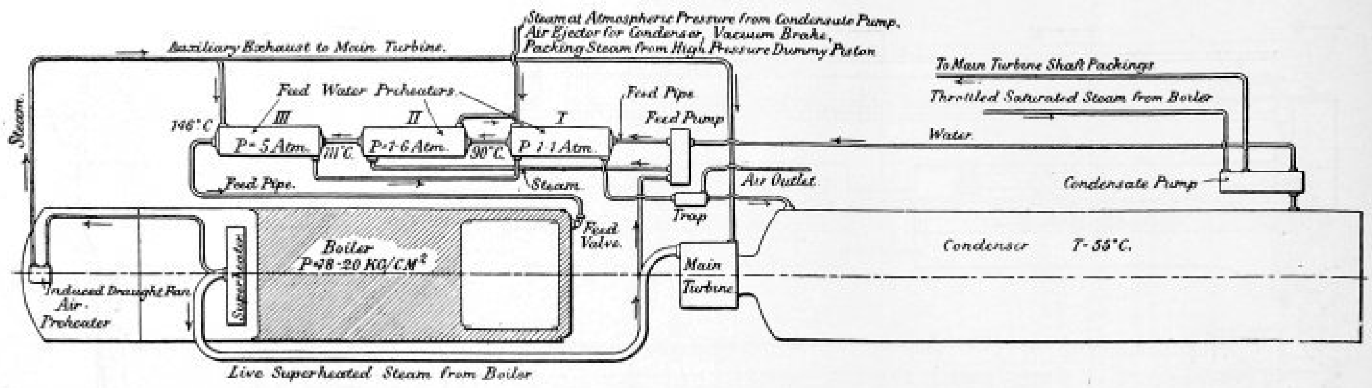



Fig. 4.—Diagram of Boiler, Condenser, and Feed Water Piping

condenser as in other parts, the design adopted shows good engineering, ingenuity and a willingness to depart from the conventional provided there is a clear advantage to be gained by so doing.

### Feedwater Heaters

After the steam has been condensed, it is fed back to the boiler and on the way passes through three feedwater heaters arranged in series. Each heater is supplied with exhaust steam at a different temperature so that the feedwater is heated progressively from about 120 degrees F. to 300 degrees F. The heaters are circular and contain a series of brass tubes, surrounded by exhaust steam. The first heater is supplied with steam at approximately atmospheric pressure and 195 degrees F. from the condensate pump turbine, the air ejector for the condenser, the vacuum brake ejector, leakage from the dummy piston of the main turbine and steam from the other heaters. The intermediate heater is supplied with steam at approximately 9 pounds pressure and 230 degrees F. from the turbine boiler feed pump. The high pressure heater is supplied with steam at approximately 60 pounds pressure and 295 degrees F., being the exhaust from the induced draft fan turbine.

### Pumps and Air Ejector

The condensed water is taken by a condensate pump and delivered to a boiler feed pump which forces it through the feedwater heaters into the boiler.

The boiler feed pump is of the rotary type. This feed pump has three impellers in series and is driven by a direct-connected turbine.

An air ejector is used to free the condenser of air. This has two steam jets which work in series and is much simpler than an air pump. The discharge from the ejector is piped to the low-pressure feedwater heater so that there is little loss of heat.

The Ljungstrom locomotive does not depend for its efficiency entirely upon the great heat drop utilized by the turbine. The employment of waste heat in the flue gases to heat the air for combustion with resulting increase in firebox temperature and furnace efficiency together with heating the feedwater to a high temperature by passing it through three heaters fed by exhaust steam at successively higher temperatures add materially to the efficiency of the locomotive as a whole. There is also an important gain in continued freedom from scale obtained by using pure condensate only for feedwater. Of every 100 heat units contained in the coal, 18 are lost in gases passing out of the stack, unconsumed fuel in the ashes and by radiation. The boiler actually delivers more steam than would be represented by the remaining 82 units because of the 7 units returned to the boiler by the air preheated and the 14.1 units by the feedwater heaters. The losses due to gland leakage, radiation, etc., are 3.5 units. The condenser fan requires 3.3 units and 60.5 units are necessarily rejected to the condenser. This leaves 14.7 units which are transformed into the useful work of the locomotive. This result would be considered very creditable in a good stationary power plant and is approximately double the known thermodynamic efficiency of any reciprocating engine locomotive.

### Tests and Performance

Fuel economy is one of the strong claims for the Ljungstrom locomotive although low maintenance costs, large starting torque and evenness of turning effort also are advanced. The ordinary Swedish locomotive with about 145 pounds boiler pressure, steam superheated to 650 degrees F. and expanded down to an exhaust pressure of six pounds above atmosphere, will convert about 200 B.t.u. into useful work for every pound of steam used. The Ljungstrom locomotive with its higher pressure and steam expanded down to 2.1 pounds absolute converts about 400 B.t.u. into useful work. The fuel consumption is thus only 50 percent as much as with an ordinary locomotive. In addition there are further economies resulting from preheating the air for combustion and from feedwater heating.

Before the locomotive was placed in service it was submitted to tests on a specially constructed dynamometer, which tests extended over several months and were carried on under

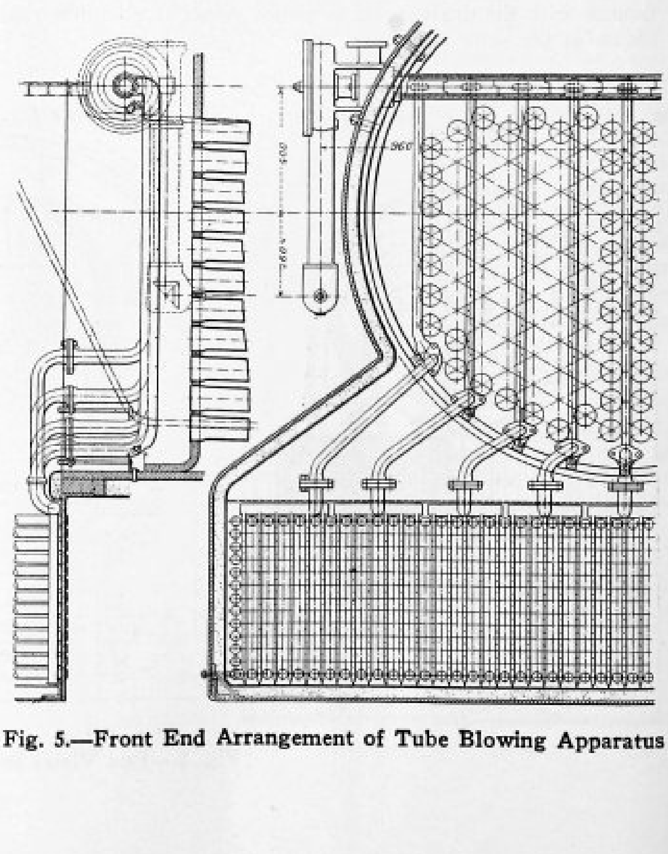


Fig. 5.—Front End Arrangement of Tube Blowing Apparatus

the supervision of engineers from the Swedish State Railways.

Following these successful tests, it was turned over to the railroad and has since been used on numerous runs, hauling heavy trains and conforming to the operating conditions of other locomotives, the firing and running being performed by ordinary railway employees. In repeated instances a dynamometer car has been attached to the train and full records of performance thus obtained. The drawbar pull repeatedly has reached 30,000 pounds and the work performed has been in excess of 1,500 horsepower. These test records bear out the claims for fuel economy.

Coal consumption has been reduced 50 percent and as there is very little loss of water, the supply lasts for a considerable time before replenishing is necessary. The continued performance of this remarkable locomotive will be watched with the greatest interest.

In the drawings included with the general description, all

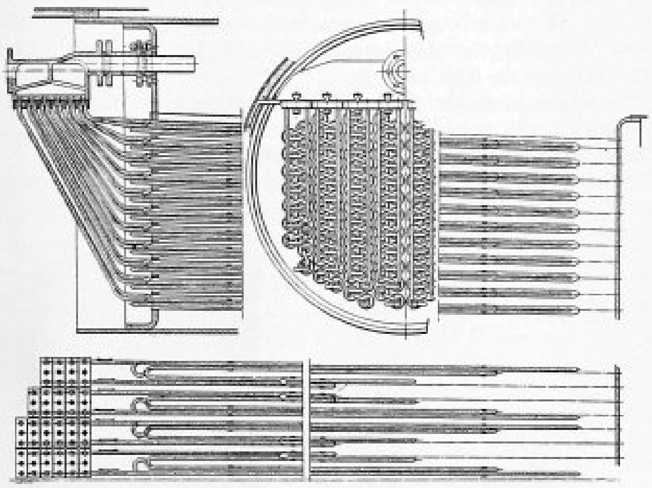


**Fig. 6.—General Details of Superheater**

dimensions were given in millimeters. The accompanying data sheet shows dimensions and weights in both metric and English measures and also includes considerable general information not otherwise given.

General Locomotive Data

| | | |
|---|---|---|
| Builder | Aktiebolaget Ljungstroms Angturbin | |
| Railroad | Swedish State | |
| Service | Passenger | |
| Track gage | 4 feet 8½ inches | |
| Wheel arrangement, boiler unit | 4-6-0 | |
| Wheel arrangement, condenser unit | 0-6-2 | |
| Weights in working order: | | |
| Boiler unit | 62 tons | 138,880 pounds |
| Condenser unit | 64 tons | 143,360 pounds |
| Locomotive complete | 126 tons | 282,240 pounds |
| On drivers | 48 tons | 107,520 pounds |
| General dimensions: | | |
| Length over buffers | 21,915 m.m. | 71 ft. 11 in. |
| Rail to top of stack | 4,280 m.m. | 14 ft. 0½ in. |
| Width overall | 3,100 m.m. | 10 ft. 2 in. |
| | Impulse-reaction, non-reversing | |
| Nozzles | 5 | |
| Speed, maximum | 9,200 r.p.m. | |
| Rated capacity | 1,800 b.h.p. | |
| Reduction gear, type | Double-reduction, reversing | |
| Reduction ratio | 9,200 to 420 or 22 to 1 approx. | |
| Boiler, type | Straight top | |
| Steam pressure | 285 pounds | |
| Fuel | Bituminous coal, 11,900 British thermal unit | |
| Diameter, outside | 1,675 m.m. | 66 inches approx. |
| Firebox, length and width | 1,610 m.m. by 1,610 m.m.— | 63 inches by 63 inches approx. |
| Tubes, number and diameter | 160 — 75 m.m. | — 3 in. |
| Tubes, length | 3,000 m.m. | 9 ft. 10⅛ in. |
| Grate area | 2.6 sq.m. | 28 sq. ft. |
| Heating surfaces: | | |
| Firebox | 10 sq.m. | 108 sq. ft. |
| Tubes | 105 sq.m. | 1,130 sq. ft. |
| Total evaporative | 115 sq.m. | 1,238 sq. ft. |
| Superheating | 80 sq.m. | 861 sq. ft. |
| Comb. evaporative and superheating | 195 sq.m. | 2,099 sq. ft. |
| Coal capacity | Saddle bunkers, 7 tons | |
| Special equipment: | | |
| Condenser, type | Air cooled | |
| Condenser surface | 1,000 sq.m. | 10,764 sq. ft. |
| Condenser vacuum | 24.25 in. nominal—26 to 27 in. test | |
| Condenser fans | 3 of variable speed | |
| Air heater | 166 sq.m. | 1,786 sq. ft. |
| Induced draft fan | Turbine, 10,000 r.p.m., 40 hp. | |
| Superheater | In all tubes | |
| Tube soot blower | Operated from cab | |
| Feedwater heater | 3 units in series | |
| Condensate pump | Turbine, direct driven, 3 impellers | |
| Boiler feed pump | Turbine, geared, single impeller | |
| Air ejector | 2 jets | |
| Data and proportions: | | |
| Normal speed | 70 km.p.h. | 43.5 m.p.h. |
| Maximum speed | 110 km.p.h. | 68.3 m.p.h. |
| Maximum legal speed in Sweden | 90 km.p.h. | 55.9 m.p.h. |
| Total weight per horsepower | 156.7 pounds | |

# Working Inside of Boilers

SOME time ago, two boiler makers were badly scalded while working inside of the mud drum of a watertube boiler. A new mud drum had been connected to the boiler, and when it was tested leaks were found, and it was necessary to do some calking and riveting in order to make the job tight. The boiler was set in battery with a number of others which were under steam, and all the boilers were connected to a common main blowoff pipe. The stop-valve in the blowoff pipe leading to the new mud drum had been closed, but for some unknown reason it was afterward opened and left open. This latter fact was not known to the man in charge of the boiler plant, however, and he, assuming that the stop-valve was still closed, proceeded to blow down one of the other boilers. Some of the escaping steam entered the new mud drum through the open blowoff valve and caused the accident of which we are speaking. The cries of the scalded men were unheard, but one of the victims succeeded in crawling out of the drum and he then closed the valve and so made it possible for his companion to escape although badly hurt.

### Boiler Accidents Frequent

Unfortunately, accidents of this general nature occur every little while. They are wholly unnecessary, because they can be prevented by merely closing, and *keeping closed*, all valves which may admit steam or water to a boiler in which men are inspecting, cleaning, making repairs, or doing other work. The mere *closing* of the valves is not enough. That is quite evident, without any argument; and if it were not, the example we have given, above, would prove it. The valves must be *kept closed*. In practice, too many men have access to them. If only one man were allowed to operate them, and he were known to be thoroughly competent and responsible, the possibility of accidents would be greatly reduced; but the moment we depart from this principle, and let two or more men tinker with the valves at will, the hazard becomes very real and serious, because each man is altogether too likely to assume that somebody else has taken the necessary precautions.

There ought to be a cast-iron rule in every plant, requiring men who are about to enter a boiler to give notice of their intention, first of all, to the chief engineer, or the person in charge of the boiler-room. The man in authority should then close the valves himself, or name some one particular individual and instruct him to do so; and the man in charge should also take effective measures to prevent anybody else from touching the valves again, until he gives further orders. After the valves have been closed they should be locked, or protected by placing locked shields or covers around the valve wheels or handles. When the work inside the boiler has been completed, and all the tools and materials have been removed, and the men have come out for the last time, they should report to the man in charge of the valves. Then, and only then, the valves may be opened without danger of scalding somebody.—*The Travelers Standard.*

# Determining the Crushing Strength of Boiler Seams

## Conclusions Drawn From Test Results Indicate Proportions for Lap Seams Subjected to Double Shear Loads

**By Thomas H. Walker**

In works on boiler construction it is not unusual to find the crushing strength of steel rated at 95,000 pounds or 96,000 pounds, without qualifying clauses, just as 55,000 pounds is assumed as the minimum tensile strength of steel.

This is a rather loose way of expressing this factor of boiler strength. Steel does not act in the same way under compression as it does under tension. It makes quite a difference in compressive loading when the column is short and when it is long, as to whether the load is central or whether it is eccentric and still more as to whether the steel is supported or is unsupported at the sides.

That the circumstances of load application make a radical difference, take the very common illustration shown in Fig. 1 where we have a pile of sand unconfined. How many bricks can you place upon it without crushing? Take the same sand and fill a metal ring with it. Now it will carry many times the number. So with steel. What it will carry in compression when free is one thing and what it will bear when confined as is the rivet in the center of a double butt seam is quite another thing.

### Early Tests on Boiler Seams

The series of tests on boiler seams made by professor Kennedy in England in the years 1881 to 1885 would appear to be the authority on which this idea rests.

His conclusions published in *Engineering*, July, 1885, express the view that bearing pressures in seams should not exceed 43 (English) tons per square inch that is 96,820 pounds, which view he bases on the results shown in his series X tests.

When we turn to these, however, we discover that his experiments on compression were made with lap seams, in which of necessity, the load on the rivet was eccentric and in which the plate could freely spread on either side under the load. Thus, from conditions which were essentially different, he draws conclusions respecting rivets in double butt seams in which the rivets were centrally loaded and the plate entirely enclosed between the butt straps, and therefore we question the soundness of these conclusions, so far as they are applied to rivets in double shear.

He does indeed concede that with certain types of butt seams the bearing load might be increased to 100,080 pounds. But in this case he adds, it would be probably wise to increase the margin of the lap, with which latter conclusion we readily agree.

Prof. Lanza in his Applied Mechanics Edition, 1908, page 638, refers to Kennedy's tests and while agreeing "that it would seem best to limit our estimate of the ultimate compression to from 90,000 to 100,000 pounds per square inch until we have further light on the subject derived from experiment; and it is not at all improbable that when we do obtain further light we may find ourselves warranted in using a somewhat higher value."

He then cites a number of tests which he says tend to show "that with good wrought iron rivets it would be perfectly safe to use a considerably larger number for compression on the bearing surface, at least 110,000 pounds per square inch and probably more."

At a conference on this question which we had with professor Lanza a little over a year ago after going over the evidence, he emphasized the opinion expressed above.

The United States Government has made at Watertown Arsenal over 600 tests on boiler seams and out of these we found 19 cases of double butt seams made with steel plate and iron rivets which failed by tearing out the plate in front of the rivets.

Of these, there were 15 cases, which when figured showed insufficient lap, thus leaving only 4 cases out of over 600 that, in the opinion of professor Lanza expressed to the writer, were probably due to crushing. These are numbered 4915, 4916, 4917 and 4918. The bearing pressure on these at failure in pounds per square inch being 151,780 for the first, 142,570 for the second, 158,150 for the third, and 152,110 for the last.

It seems probable that with steel rivets even higher compressive loads would have been obtained, the stiffer metal in the rivet giving more uniform distribution of the load.

The Pennsylvania Railroad made three tests at Altoona

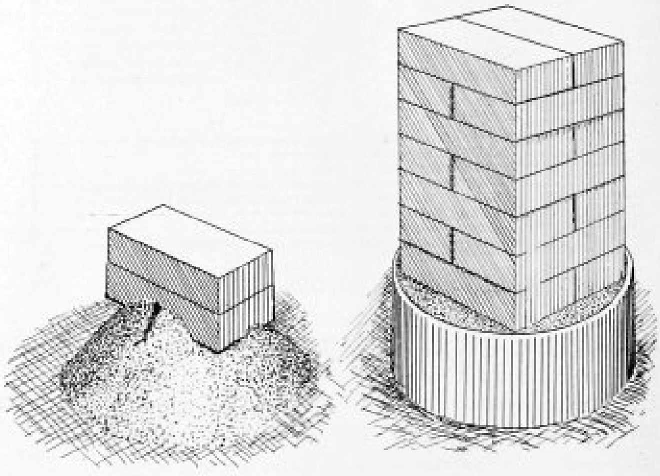


**Fig. 1.—Demonstration of Compressive Resistance of Confined and Unconfined Materials**

on July 27, 1916, with two 1¼-inch diameter rivets in double shear in a ⅜-inch thick steel plate in each test. These showed loads of 140,358, 159,978, 147,340 pounds respectively or an average of 149,225 pounds per square inch. The failure in each case being tearing of the plate immediately below the grip of the testing machine and the seam being undisturbed.

The average of the four cases at Watertown Arsenal already mentioned being 151,152 pounds per square inch, which compares very well with the Altoona results but is far above the 95,000 pounds usually allowed.

Inasmuch, however, as the Watertown tests were all made on ¼-inch thick plate and as the Altoona tests on ⅜-inch thick plate evidently did not reach the compressive limit, it was thought desirable to continue these investigations.

A test piece was therefore prepared having two 1 5/16-inch finished diameter steel rivets in double shear in a steel plate 0.381 inch thick. This was made with what was thought to be ample lap to determine the compressive limits of this combination. Two 1½-inch finished diameter rivets were driven in a similar manner in double shear in a ½-inch thick plate. The steel in both rivets and plate being of the regular quality used in boiler work and made to A. S. T. M. specification.

On being pulled on the Olsen testing machine, each failed by pulling out the plate in front of the rivets as shown in Fig 2 (a) and Fig. 2 (b) the loads being 179,700 pounds on the 0.381 inch thick plate and 243,900 pounds on the ½-inch thick plate.

As the projected area of the two rivets in the thin plate is exactly one square inch and that in the thicker plate exactly 1½ square inches the bearing loads are therefore 179,700 pounds per square inch in the one case and 162,600 pounds per square inch in the other.

To check these results duplicate pieces were made in every respect, the same except an increase in lap, which resulted in an increased load and a somewhat different mode of failure. The 0.381 inch plate on test, tearing out the whole central section in front of the rivets at 201,000 pounds load and the ½-inch plate double shearing the two 1½-inch rivets at 257,300 pounds, the bearing loads being 201,000 and 171,533 pounds per square inch respectively. Fig. 2 (c) and Fig. 2 (d) show these specimens after pulling.

It was noted in all these latter tests that at about 88 percent to 92 percent of the final load a visible distortion took place in the seams which opened the joint about ⅛ inch. After the test the corner of one specimen was sawed through the center of the rivet, which was found to be remarkably straight, although it had stretched an amount corresponding to the distortion of the seam, the ½-inch plate having upset below the bearing of the rivet just previous to the point of failure. Evidence of the same action was observed in the case of the rivets that sheared. The spreading of the cover plates permitting the plate in the middle to so press into the rivet that its cross sectional area was reduced to the point at which the increasing load was able to shear the rivets; shearing taking place at a little over 44,000 pounds per square inch of the area actually sheared.

### Making Results Consistent

This may seem contrary to professor Kennedy's observation on this matter, but we think he must have based his conclusions regarding a lowering of the shearing and tensile strengths when under high compression, on the original sections in each case; without noting or perhaps we should say without recording, what must have been true in his tests; that the failure was in two stages, first a reduction of section dependent upon the support furnished to the parts under compression, followed by the shearing of the rivets or the tearing of the plate whichever was the direction of least resistance.

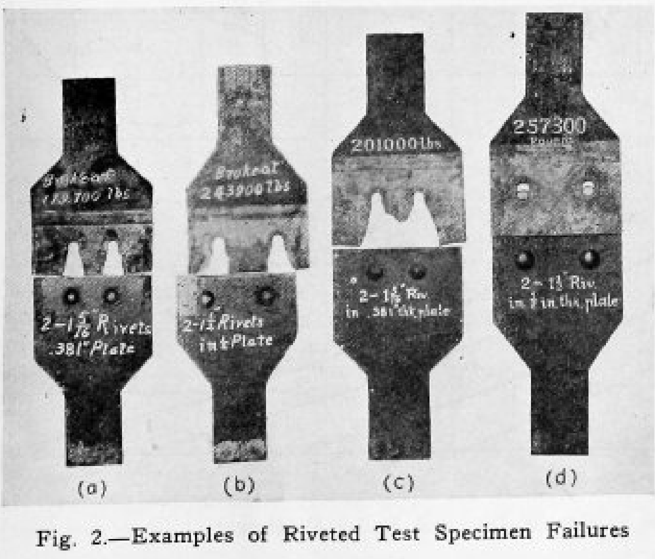



Fig. 2.—Examples of Riveted Test Specimen Failures

To recapitulate, we have records showing bearing loads as follows:

| | |
|---|---|
| Pennsylvania Railroad | 140,358 pounds |
| Pennsylvania Railroad | 147,340 pounds |
| Pennsylvania Railroad | 159,978 pounds |
| Watertown Arsenal | 142,570 pounds |
| Watertown Arsenal | 151,780 pounds |
| Watertown Arsenal | 152,110 pounds |
| Watertown Arsenal | 158,150 pounds |
| Baldwin Locomotive Works. Eddystone | 162,600 pounds |
| Baldwin Locomotive Works. Eddystone | 171,533 pounds |
| Baldwin Locomotive Works. Eddystone | 179,700 pounds |
| Baldwin Locomotive Works. Eddystone | 201,000 pounds |

Thus it will be seen that the bearing value of steel may reach very high figures and that these very largely depend upon the support furnished to the parts that are under compression. It will also be evident that so far as seams of double butt strap construction are concerned, there need be no fear of failure from bearing loads considerably in excess of 95,000 pounds provided that the lap of the seam and the proportion of the rivet to the plate are reasonably correct. Nor is it at all necessary to go to the extreme limit in this

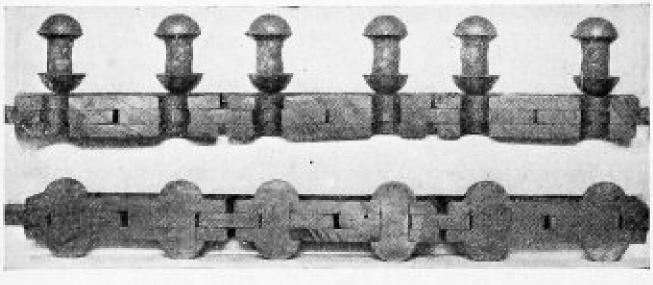


Fig. 3.—Sectional Views of Riveted Joint After Failure

matter inasmuch as an increase to 120,000 pounds or 130,000 pounds will provide for nearly all reasonable proportions in seam design.

### Effect of High Bearing Load

In Fig. 3 we can observe the effect of a bearing load of 120,000 pounds the relation of rivet diameter, plate thickness and seam lap being such as we would use in a normal boiler seam. This was one of three pieces in the form of a chain, two with four and one with six rivets of 0.92 inch diameter arranged tandem fashion; the central plates being about 7/16 inch thick steel with ⅜ inch thick cover plates on each side.

The first two of these were loaded to 58,000 pounds and 57,200 pounds respectively, at which one rivet in each failed by double shearing. Bearing loads of 145,000 pounds and 143,000 pounds were carried by 3 rivets out of 4 in either case. The shearing loads based on the original area of the rivets were 87,250 pounds and 86,250 pounds respectively for double shear.

The third test piece, which is the one shown in Fig. 3, was loaded to 48,000 pounds which gave a bearing load of a little over 120,000 pounds per square inch of projected area of rivet on the central plate.

When we remember that this test piece still had a margin of 9,000 or 10,000 pounds before failure and that the working load would be 120,000 divided by 4½ or 26,666 pounds, it will be evident that otherwise properly proportioned seams are in no danger whatever of failure.

### Conclusions From Tests

From our observation of these tests we conclude that when double shear loads are to be carried, the lap of the seam should be at least one and three quarter times the rivet hole diameter and that twice the nominal rivet diameter would not be an excessive lap. As a double shear load never comes on the calking edge, the extra lap will not interfere with the tightness of the joint. With the loading which we believe has been demonstrated to be safe in this article, it is possible to construct seams that are better proportioned and that are of higher efficiency.

This increased efficiency is a clear gain to the shell plate on which must fall whatever loss of strength is due to corrosion. The rivets entirely surrounded by the plates suffer no such loss, hence as every practical man knows, a seam failure through the giving way of the rivets is unknown in modern practice.

We have spoken of reasonable proportions between plate thickness and rivet diameter. What should this ratio be? The old time boilermakers used to call for a rivet diameter of twice the plate thickness. Such a proportion does very well on thin plates, says of 1/4 to 7/16 inch in thickness but on heavier plates the rivets become quite too large. If we make the rivet shear always equal to the loss of strength in the plate due to the rivet hole we will have a relation that is generally satisfactory.

That is $D^2 \times 0.7854 \times 44{,}000 = D \times t \times 55{,}00$. This reduces to $\frac{5 \times t}{3.1415} = D$, $D$ being diameter of rivet hole and $t$ being the plate thickness in inches. Or to this rule the number of sixteenths in the thickness of the plate divided by ten equals the diameter of the rivet.

# Chart Developed for Use in Designing Diagonal Boiler Patches

**By Edward Hall**

THE accompanying chart is invaluable to boilermakers and boiler inspectors, who work under the boiler code of New York State. (This code is similar to the A. S. M. E. Boiler Code). The chart is used for determining the various factors involved in the design of a diagonal patch mentioned in Rule 818 of the New York Code.

The chart is used as follows: The curve on the extreme left is called the "Factor Curve;" this curve is used in conjunction with the degrees of angle on the left side of the chart. For example: By what factor must the efficiency of the patch seam and the girth seam equal 55 degrees. First locate 55 degrees on the chart and run a horizontal line from this point to the "Factor Curve;" from this point on the "Factor Curve," erect a perpendicular to the horizontal line, until this perpendicular reaches the top of the chart, when we find that the required factor is 1.15.

If the angle the patch seam makes with the girth seam is not known, it may be found as follows: Note the dimensions *A* and *B* in the sketch. The curves denote the length of the patch in a longitudinal direction, while the figures at the bottom show the length of the patch in inches, as denoted by *B* in the sketch.

Assuming that *B* equals 35¾ inches and that *A* equals 30 inches, it is required to find what angle is formed by the girth seam and the patch seam. Locate 35¾ inches on the bottom of the chart, and run a perpendicular line up until it meets the curve *A* = 30 inches, from this point run a horizontal line over to the left. In this case, we find that the required angle equals 40 degrees.

By reversing the process, the length of *A* may be found, if the angle and *B* are known. In addition to this use of the method the length of *B* may be found, if the angle and *A* are known.

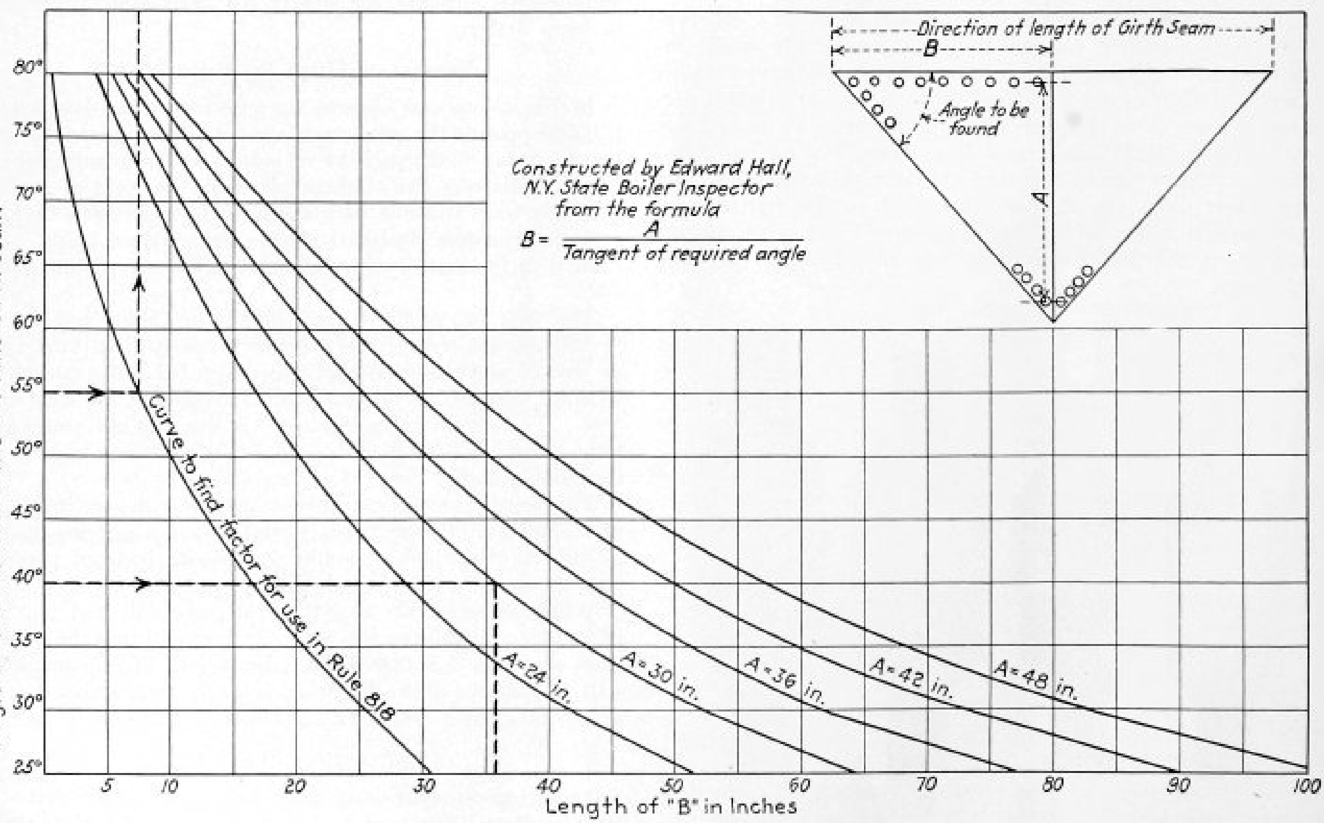
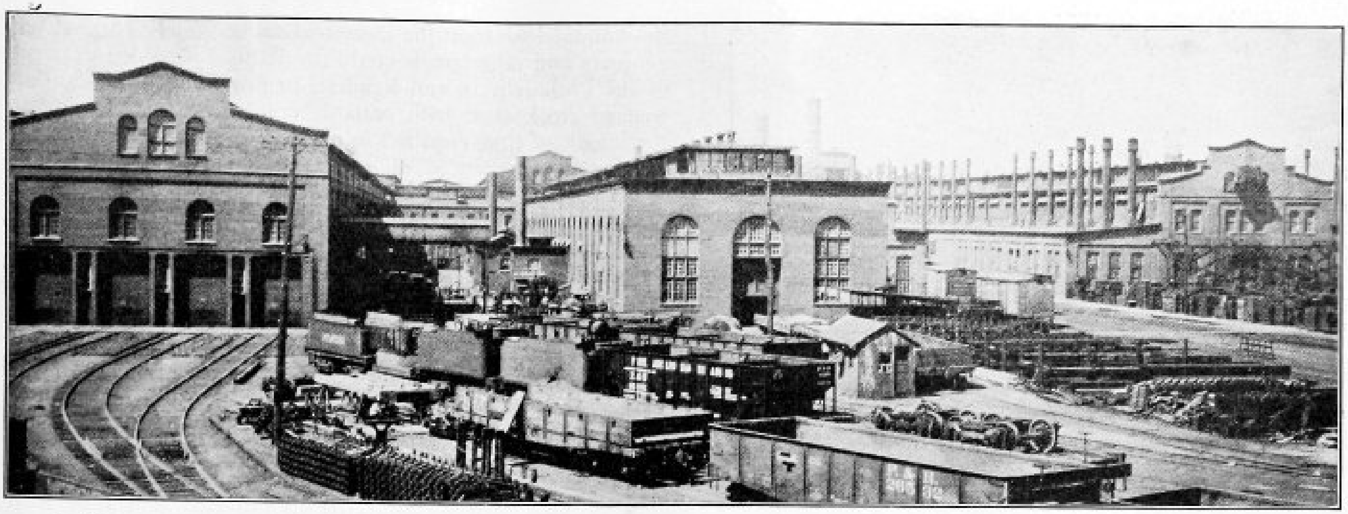



Chart to Determine Factors Involved in Designing Diagonal Boiler Patches



Philadelphia & Reading Locomotive Shops, Including Boiler Shop, Blacksmith Shop, Foundry and Erecting Shop

# Locomotive Construction and Repair at Reading Shops

## Special Details of Machine, Blacksmith, Boiler and Erecting Shop and Features of Boiler Shopwork

As a background for the following description of locomotive shop work, it should be remembered that the Philadelphia & Reading owns 1,093 locomotives and slightly over 43,000 cars, practically all heavy locomotive repairs and a considerable proportion of car repairs being made in extensive repair shops located at Reading, Pa. Obviously this large concentration of work at a single point results in certain important advantages such as relatively low cost of supervision, quick communication between departments, and the use of production machinery and methods inclusive; also in spite of short time, the men working eight hours a day. Six new locomotives are now under construction. In addition to this work the Philadelphia & Reading operates its own foundry, making all kinds of gray iron castings, including cylinder castings. The railroad is particularly fortunate in the operation of this foundry which is located near the mines and produces good quality castings at low cost. The ordinary manufacturer's selling cost and profit are of course eliminated and there is the other great advantage of getting prompt delivery of castings as needed.

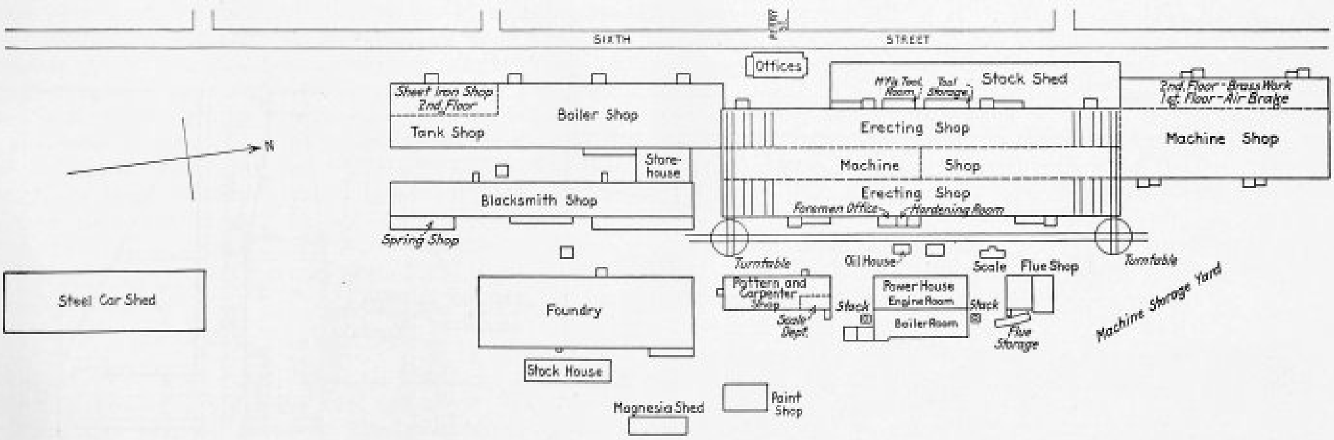



Fig. 1.—Diagram Showing the Location of Various Departments of the Reading Locomotive Shops

which would not be warranted in a shop of small capacity. The work at Reading shops is performed under the supervision of I. A. Seiders, superintendent of motive power and rolling equipment, and W. L. Rice, superintendent of shops, through whose courtesy the photographs, drawings and data used in this article were obtained.

In 1921 a total of 771 locomotives were given heavy general repairs at Reading and 20 new ones built, including five Pacific type, five Atlantics and ten switchers. This output was obtained in spite of the shops being closed from March 8 to April 11 and December 24 to the end of the year

The shop buildings, completed in 1906, are of substantial brick construction, as indicated in the leading illustration showing (from left to right) the boiler shop, blacksmith shop and foundry, with the roof of the erecting shop and two smokestacks from the powerhouse in the background. From the ground plan, illustrated in Fig. 1, the location of the various departments and their relation to each other will be evident. The main offices are at the junction of Sixth and Perry streets, Reading, Pa.

It will be noticed that the machine, erecting and boiler shops are practically in one continuous building, the boiler

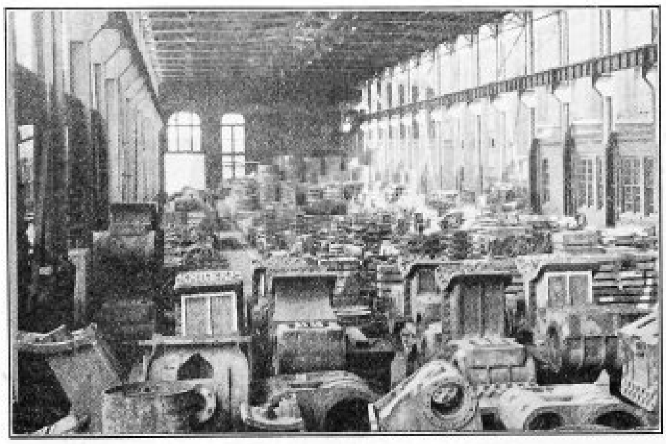


Fig. 2.—A Valuable Asset—The Large and Orderly Stock Shed

shop and blacksmith shop being connected at one end by the storehouse. Only a short space separates the blacksmith and erecting shops. All departments are thus brought relatively close together and this tends to conserve both time and labor in transporting material between the various departments.

The erecting shop is laid out in two sections, east and west, with a total of 64 transverse working pits with several additional pits devoted to electric welding and other work. The erecting shops are provided with ample crane capacity to handle the heaviest locomotives, with the exception of the Mallets which are unwheeled on a Whiting hoist in the north machine shop.

The boiler shop is equipped with a large amount of sheet metal working machinery, including a 500-ton hydraulic press which greatly facilitates the manufacture of parts for car repair work.

A feature worthy of special attention is the stock shed (Fig. 2), the location of which is shown in Fig. 1. This shed is 548 feet long by 67 feet wide, being made with a substantial roof but no side walls. Two 10-ton traveling cranes are provided to handle the material which is carefully stored and protected from the weather. It is difficult to estimate the annual loss from the deterioration of material stored out of doors and other roads could profitably follow the example of the Philadelphia and Reading in providing a substantial, covered stock shed with suitable crane facilities. Owing to the length of time required to make cylinder castings, for example, one or two of each type must be made up in advance and it is an important advantage to be able to store these and other locomotive parts where they will be protected from the weather and can be obtained readily as needed. The north end of the stock shed, shown in the background of Fig. 2, is provided with two lye vats large enough to take driving wheels when necessary and it is here that locomotive parts are cleaned of grease and dirt. One of the stock shed cranes is available for lifting heavy parts in and out of the vats.

### Operating Staff

The Reading shops are now operating with about 85 percent of their normal force. Two hundred and nine men are employed in the steel car shed, 127 men in the foundry,

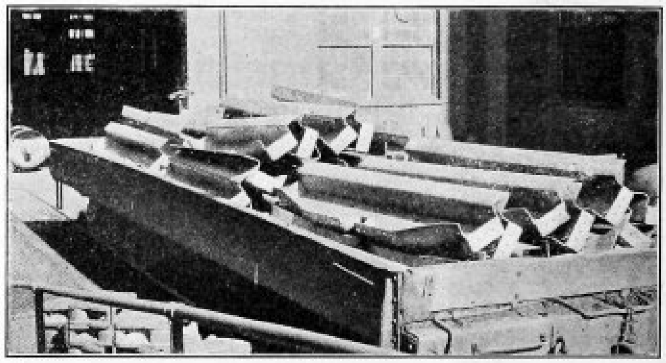


Fig. 3.—Car of Steel End Sills Leaving Boiler Shop

77 men in the electrical repair department and 30 men on outside construction work. The men employed in what may be called strictly locomotive departments are shown in the following list:

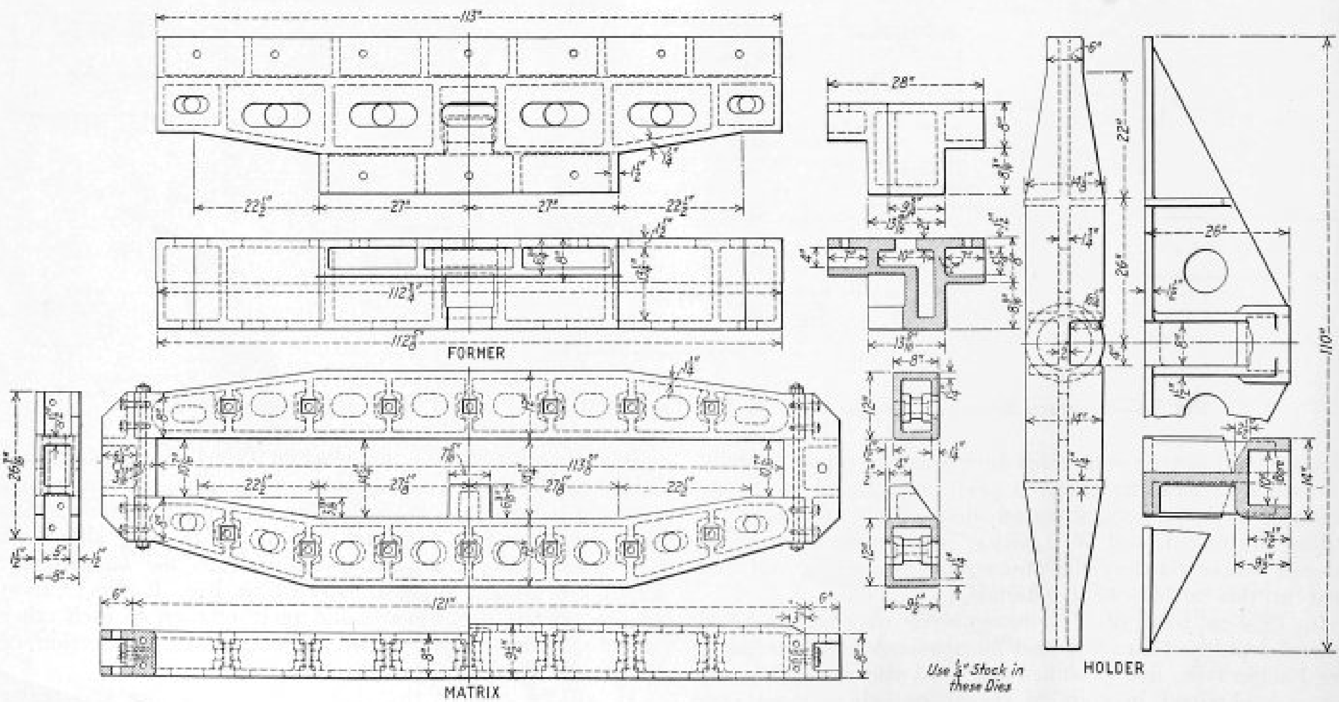



Fig. 4.—End Sill Forming Dies

| Locomotive shop Department | Number of Men Employed | |
|---|---|---|
| Machine shop | 596 | |
| Erecting shop | 318 | (four gangs) |
| Wheel shop | 60 | |
| Boiler shop | 278 | |
| Tank shop | 103 | |
| Flue shop | 42 | |
| Blacksmith shop | 128 | |
| Forge shop | 39 | |
| Sheet iron shop | 110 | |
| Powerhouse | 42 | |
| Laborers | 159 | |
| Total | 1,875 | |

As stated, this force is about 85 percent of normal. The men are working eight hours a day, five days a week, 200 men being employed nights, watching, wheeling and unwheeling engines, and for emergency work.

### Hydraulic Press Work in Boiler Shop

Obviously with the large amount of locomotive repair work centralized at Reading, it is necessary to have a large and well-equipped boiler shop. Perhaps the most distinctive feature of the boiler shop at Reading is the R. C. and W. H.

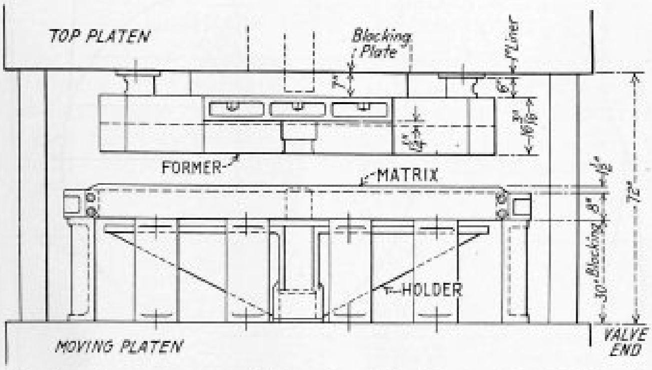



**Fig. 5.—Arrangement of Forming Dies in 500-Ton Hydraulic Press**

Wood, 500-ton hydraulic press used for forming steam domes, flue sheets, throat sheets, door sheets, cylinder head casings, air reservoir heads and steel car parts, such as bolster center plates, draft arms, end sills, side sills, etc. Six men are required for the efficient operation on this press. A complete set of dies has been developed for the work and wherever enough parts are to be formed, the dies are assembled in the press and the various operations carried through on a number of pieces of stock with very satisfactory results both as regards the quality and cost of the work. The location of the steel car shed within a comparatively short distance of the boiler shop is an important advantage as the heavy hydraulic press is particularly adapted to forming pressed steel shapes and not many steel car shops have such machines available.

### End Sills Formed on Press

A car of end sills, for example, is shown in Fig. 3 just leaving the boiler shop for the steel car shed. The dies for forming these sills are shown in Fig. 4 and their arrangement, assembled in the hydraulic press, in Fig. 5. These end sills are made of 1/4-inch steel plate which is cut out to the proper size and shape and heated in a furnace adjacent to the press. With the flanging dies in the proper position each plate is then transferred to the press, properly alined, and one stroke of the press forms the entire sill with the exception of turning down the back flange. Referring to Fig. 5, the lower platen is the one which moves as the press is operated, the matrix and holder being firmly bolted to it. The former with its backing plate is solidly bolted to the top platen.

As in the case of most automatic and production machinery, this 500-ton press cannot be equipped with dies

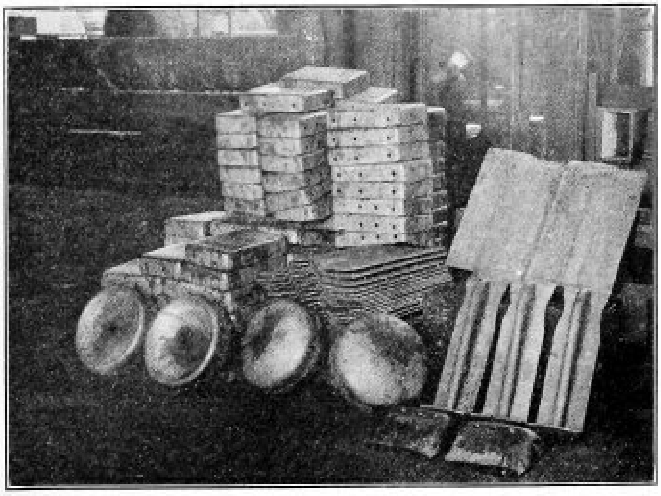


**Fig. 6.—Miscellaneous Small Pressed Steel Parts**

properly alined without considerable effort and time spent on the operation. As a result, it would not pay to use the press for two or three parts. A certain number of parts must be made in order that the saving may balance the cost of setting up the dies. Any parts made in excess of that number represent an increasingly large profit.

Many other pressed steel parts besides end sills are made under this press, a group of smaller parts being shown in Fig. 6. These parts include diaphragms for steel car center sills, side stakes for low side gondola cars, protection plates, draft gear stops for steel cars and air reservoir heads. The press is one of the busiest tools in the Reading shops, so much so in fact that it is often difficult to get necessary straightening and other similar work done. Perhaps the most impressive work done under this hydraulic press is the manufacture of steam domes which, for one of the heavy class locomotives, are 23 inches high with a diameter of 31½ inches. These domes are made of 1¼-inch stock, requiring five operations under the press.

### Special Welding Work

Another phase of work at the Reading shops, which comes under the direction of the boiler shop foreman, G. L. Young, is the welding of frames. The acetylene process is used for this work with very great success; of over 200 frames reconditioned and in service only 5 failures have been recorded out of the whole number.

In general the boiler shop at Reading is called upon to do a variety of repair jobs not usually considered as coming under the head of boiler work. The fact that the work is so successfully carried out by the staff speaks well of the all around ability of the boiler shop force.

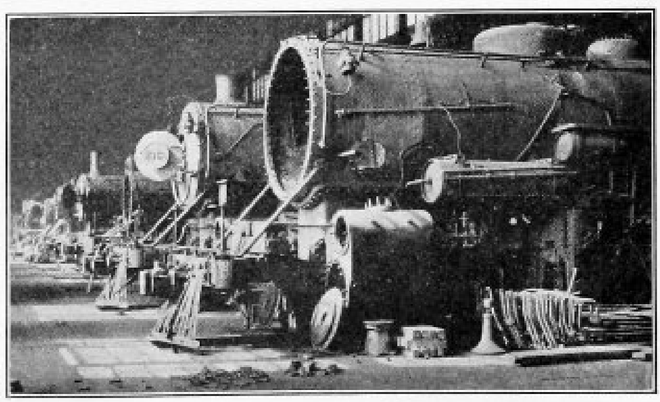
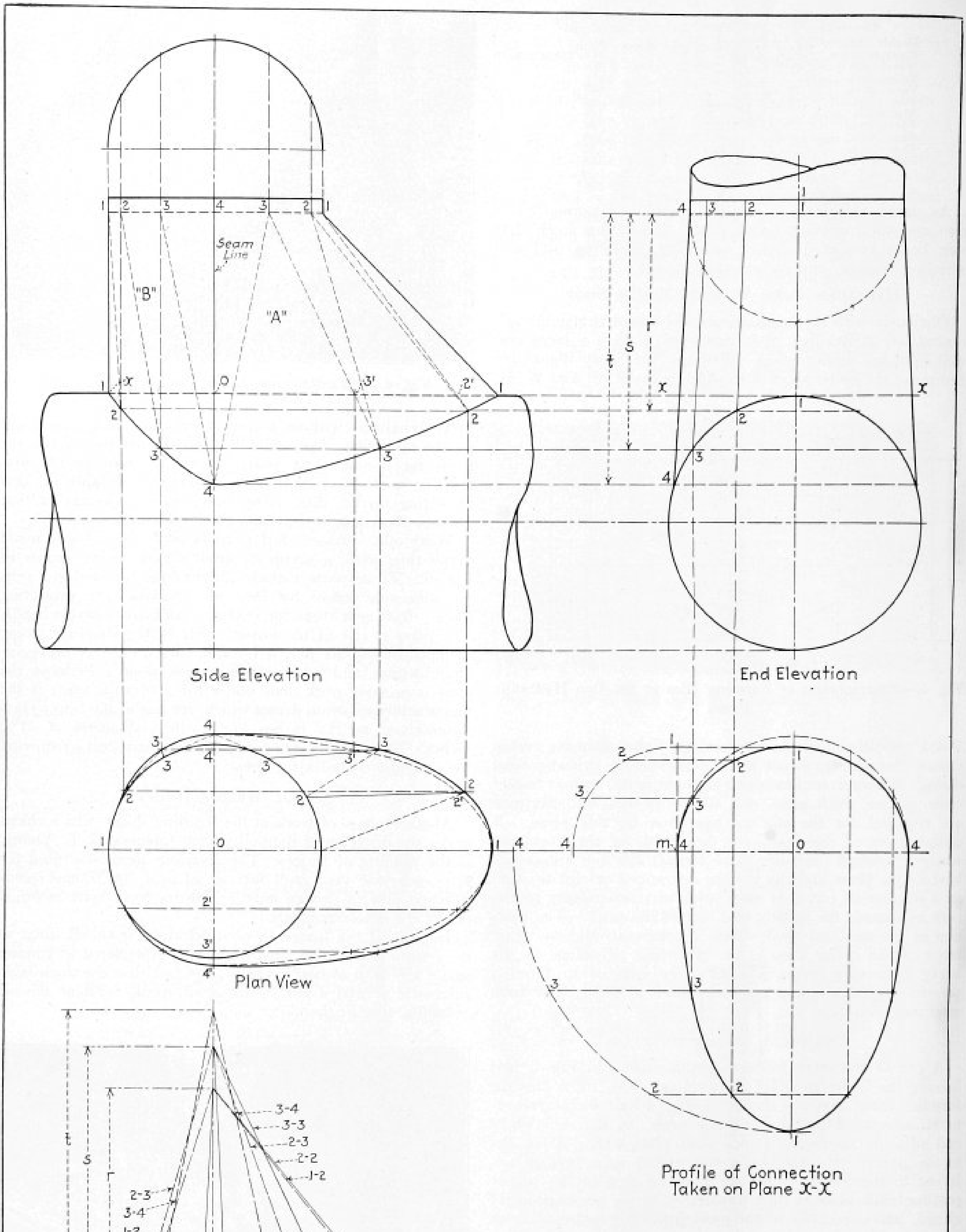


**Fig. 7.—Partial View of East Erecting Shop**




**Layout of Conical Connection Forming a Right Angle Elbow**

# Developing a Transition Hood for An Elbow Connection

## Method of Laying Out a Conical Connection to Form a Right Angle Elbow

**By C. B. Lindstrom**

TRANSITION layout problems in connection with sheet metal and pipe work are constantly occurring in the shop and although general principles govern their development, the application of these to specific problems offer complications that make many of the layouts of interest to the entire trade.

The solution of the problem given herewith, of developing a conical connection to form a right angle elbow was requested by one of our subscribers and is repeated for the benefit of all our readers engaged in work at the bench.

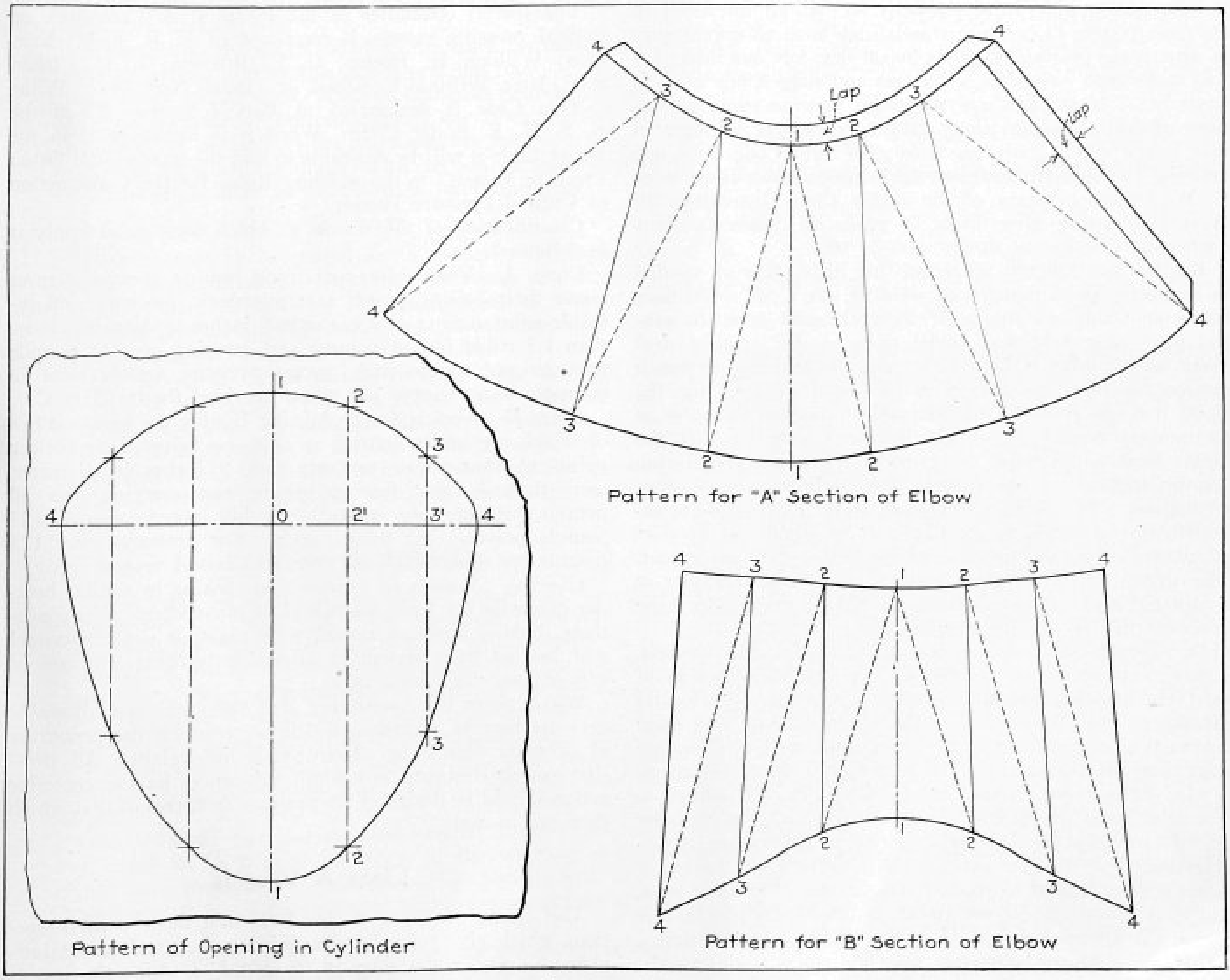
### Details of Hood Construction

In Fig. 1 are produced the various views essential for developing the patterns of the sections *A* and *B*. The seam line is arranged on the sides and by making the connection in two parts makes the assembly of the fitting easier to handle. Reproduce the plan, end and side elevations, but before the plan can be laid off, the profile of the fitting as taken on the line *x - x* is required for determining the location of radial lines *2 - 2* and *3 - 3*.

It will be noticed that this profile view is egg-shaped owing to the arrangement of two different sections of ellipses, thus the major axis of the ellipse section *4-1-4* is the minor axis of the ellipse section *4-1'-4*.

### Profile of Branch Intersection

The profile on *x-x* is produced as follows: On the line *4-0-4* of the profile view draw a semi-circle with *1-4* of the end view as a radius. With point *n* as a center, and *o-x* of the side view as a radius draw a quadrant. Divide the semi-circle into a number of equal divisions, in this case 6. Space off the quadrant into 3 parts as *1-2*, *2-3*, *3-4*. The intersection of the projectors drawn from the points on the semi-circle and quadrant establishes points as *1-2-3-4* of the upper part of the ellipse. The lower part is developed in a like manner, using in this construction a quadrant




Patterns for Transition Problem

drawn with *o-1* of the side view as a radius. Reproduce the profile view in the plan as indicated by the dotted outline and extend the projectors to the line *x-o-x* of the side elevation locating points *2'-3'*. Draw lines *2-2'* and *3-3'*. Where the horizontal projection lines *2*, *3* and *4*, drawn from the end view, intersect the radials *2-2'*, *3-3'* of the side elevation fixes the required points on the miter line.

FINDING TRUE LENGTHS OF CONSTRUCTION LINES

In the plan draw a circle representing the upper base of the fitting and divide its outline into the corresponding number of equal divisions as the lower base. From the points *2*, *3* on the miter line of the elevation draw vertical projectors to intersect the corresponding lines in the plan, thus locating in this view the required points on the miter. Triangulation lines are drawn in and their true lengths established as indicated in the triangle constructions.

PATTERN DEVELOPMENTS

Before the patterns of *A* and *B* are developed lay off the opening in the pattern of the cylinder as shown in Fig. 2. On the line *4-4* of this view set off from point *o* the arc lengths, *1-2*, *2-3*, *3-4*, of the end view of the cylinder, Fig. 1. Make the respective lengths *o-1*, *2-2'*, *3-3'* equal those of the plan view. The arc lengths of the cylinder opening are used for the stretchout of the patterns *A* and *B*. Since the construction lines are numbered in these patterns and the other views are fully developed, no further explanation seems necessary. The lap for seams in *B* are laid off similar to those indicated in *A*.

# Rules For Construction of Unfired Pressure Vessels

## Preliminary American Society of Mechanical Engineers' Report Submitted to the Pressure Vessel Manufacturing Industry for Discussion

THE special committee of the American Society of Mechanical Engineers' Boiler Code Committee on unfired pressure vessels has recently completed a progress report covering the Code for this class of vessels. This Code is being given widespread publicity so that all interested in the manufacture of pressure vessels may have an opportunity to discuss the provisions. It is hoped that any one interested will make such comments, criticisms and suggestions as seem advisable. If changes are advocated specific recommendations of substitute provisions should be made. As space in this issue permits only an outline of this Code, any one desiring the rules in complete form may obtain them from C. W. Obert, secretary of the Boiler Code Committee, 29 West 39th Street, New York, to whom all communications containing discussions should also be sent.

But for the difficulty in reconciling differences of opinion in connection with autogenous welding, the Code could have been completed some time ago. Several hearings on the subject have been held and, while there is still a great deal about which there is lack of accord, the situation is much cleared, so that, in view of a persistent demand for the Code, it seems possible and advisable to present the rules in preliminary form. It is said by the Committee that the intent is not to impose too great restrictions by outlining specific methods to an extent that might eliminate other methods equally good or better, but as far as possible to establish fundamentals applicable to any method and to safeguard by inspection and test to the fullest possible extent. The advance that is being made in autogenous welding is recognized and without doubt more liberal rules than those proposed will eventually be permitted.

In view of numerous reported failures of welded vessels, it has been deemed advisable to lean toward the side of safety in bringing out rules governing a relatively new and rapidly growing industry with the idea of broadening them out as the art advances rather than to be so lenient at the start that resulting accident might set back its development.

Also it has been deemed advisable by the Committee to formulate rules which will not unduly handicap the smaller manufacturers of welded tanks; for it would be readily appreciated that what might not be objectionable to larger manufacturers might be unduly burdensome to smaller ones, and it is the intent not to impose undue hardship. In this connection attention is called to the provision permitting a higher pressure for ammonia vessels than for air vessels. This is done in recognition of the extent to which the manufacture of ammonia containers has been perfected by the larger manufacturers and which degrees of perfection can hardly be hoped for in the case of air and other pressure vessels built by less completely qualified makers.

The special committee of the Boiler Code Committee on unfired pressure vessels is composed of E. R. Fish, chairman; William H. Boehm, C. E. Bronson, E. C. Fisher, S. F. Jeter, William F. Kiesel, Jr., James Neil, H. V. Wille.

This Code is designated as Part I Section VI of the A. S. M. E. Boiler Code. When it is incorporated in the Boiler Code it will be desirable to add the words "and Other Pressure Vessels" to the wording Rules for the Construction of Unfired Pressure Vessels.

Classification of the vessels to which these rules apply is as follows:

*Class A.* Vessels for containing liquids at temperatures above their boiling points at atmospheric pressure, inflammable substances or any gas over 6 inches in diameter, more than 1.5 cubic feet in volume and carrying over 15 pounds pressure per square inch, except pressure vessels used in domestic water supply and those provided for in Class C.

*Class B.* Vessels for containing liquids the temperatures of which are under control so as to be below their boiling points at atmospheric pressure over 9 inches in diameter, more than 4 cubic feet in volume and carrying over 30 pounds pressure per square inch but not to exceed 125 pounds pressure per square inch. For pressures over 125 pounds per square inch the rules in Class A vessels apply.

*Class C.* Vessels for carrying on cooking or similar heating processes for food, medicinal or other chemical preparations, having surfaces coated with glass or similar enamel and limited to a maximum allowable working pressure of 150 pounds per square inch.

Where there is a possibility that the maximum allowable pressure may be exceeded, a rule is given for the protection of pressure vessels by safety and relief valves. All pressure vessels designed to contain substances having corrosive action should be designed for pressure in excess of that which they are to carry.

### Class A Vessels

The design of Class A vessels is first dealt with in sections which give rules for determining the maximum allowable unit working stresses in the metal of which the vessels are composed and stresses in rivets. When materials are used similar to those included in the rules for power boilers such rules shall apply to unfired pressure vessels.

The requirements for ultimate strength of materials used in computing joints deal with the tensile strength of steel plate, the crushing strength of plate, the strength of rivets in shear, the thickness of plates and the thickness of butt straps.

Rules are given for the construction of pressure vessels, the basis being the maximum allowable working pressure; joint efficiencies; spaces between rivets; strength of circumferential joints meeting different requirements of design and those for riveted longitudinal joints.

The size of domes and method of attaching to the shell are designated.

### Dished Heads

Formulas governing thickness required in an unstayed dished head with the pressure on the concave side when it is a segment of a sphere are given, together with the rules for determining the working pressure allowable on concave heads. Methods of applying the rules where the construction of head varies are included in this section.

The subject of braced and stayed flat surfaces with adequate formulas for determining the allowable working pressure for plates of varying thicknesses is taken up, together with rules for staybolts and structural reinforcements with the rivet sizes and spacing required. In this section a table of maximum allowable pitch of screwed staybolts with the ends riveted over is given.

Riveting is discussed in a section which includes drilling of holes, length of rivets, forms of rivet heads which are acceptable, and the like.

A paragraph is also included on the rules for calking the edges of plates, butt straps, heads and the like.

Openings in the shell, such as manholes and handholes, with the methods of reinforcing and the rules for riveting are taken up as well as the requirements for pipe connections and threaded openings. This section includes a table of minimum number of pipe threads for connections.

### Supports

Vessels must be supported as to properly distribute the stresses arising from the weight of the vessel and contents. In this section is included the arrangement of vessels for both interior and exterior inspection, the attachment of supporting lugs or brackets, rivet strength, etc.

The remainder of the section covering Class A vessels is devoted to the layout of plates, which must show at least one of the stamps required in the specification for boiler plate steel so located as to be plainly visible when the vessel is completed and alternative measures covering this requirement. Other paragraphs give rules for inspection, stamping and the like.

## Class B Vessels

Vessels of this class may be constructed of untested open hearth steel, in which case the maximum allowable unit working stress shall be 10,000 pounds per square inch.

Crushing strength, maximum allowable working pressure, longitudinal joint construction, thickness of heads, the design of braced and stayed surfaces, requirements for rivet and staybolt holes, length of rivets, calking, provision for manholes and handholes, manhole plates, pipe connections and safety appliances are referred to in this section of the rules.

In addition, vessels constructed under these rules must be tested to 50 pounds in excess of the working pressure when such pressure does not exceed 100 pounds and to one and one-half times the working pressure to pressures above 100 pounds.

The remainder of this section takes up the stamping and recording of construction data of this class of vessels.

## Class C Vessels

Vessels in this classification are made of steel plate not under 1/4 inch nor more than 5/8 inch in thickness and welded by the oxy-acetylene, electric arc or forge welding process. Specifications for plate, giving the physical properties and chemical analyses are included in this section, with a formula for the allowable working pressure and other design data. Instructions for preparing surfaces to be welded, the chemical composition and specifications for welding wire to be used are stated.

Class C vessels are considered under two types—single shell vessels and jacketed vessels. Seams of single shell vessels welded by either the oxy-acetylene or electric arc process are to be double-V welded. The inside of the weld of such vessels may be ground flush with the surface of the plates.

The jacketed or double shell vessels may be of two types, but in all cases the inner shell shall have the same construction as the single shell tank. Details of welding methods to be used in the case of jacketed vessels are taken up quite fully.

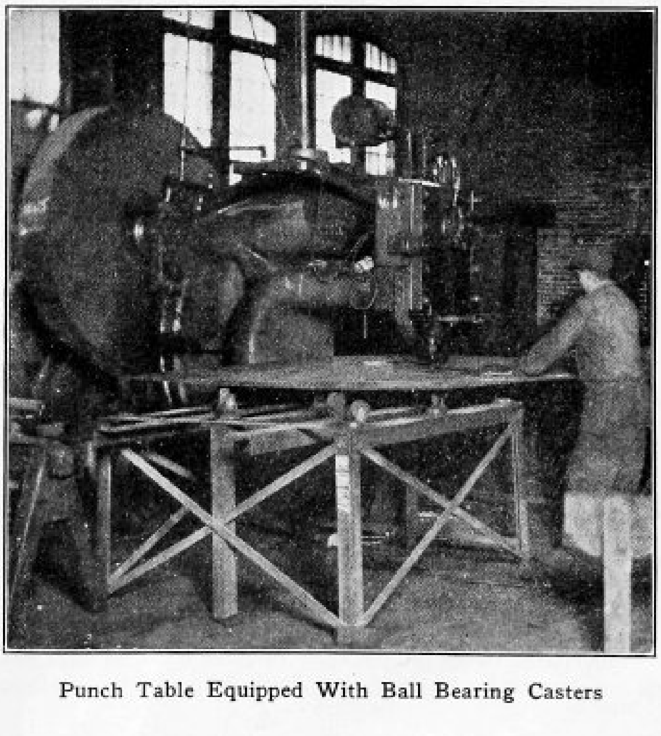
Complete rules for autogenous welding, forge welding and brazing joints in the cases of all Class B vessels and certain Class A vessels are included and these rules will be published in full in the December issue of The Boiler Maker.

As stated at the beginning of this summary, the outline is intended to serve only as an indicator of the subject matter taken up in the rules formulated by the Boiler Code subcommittee on Rules for the Construction of Unfired Pressure Vessels. Those who are interested in this matter may obtain the complete rules for discussion in pamphlet form from the secretary. All written discussions prepared on the subject matter with constructive suggestions should also be sent to the secretary's office, 29 West 39th street, New York.

# Ball-Bearing Casters on Punch Table Facilitate Handling Boiler Plates

A DEVICE which will save considerable labor in boiler shops and steel car shops consists of the punch table provided with ball-bearing casters as illustrated. In shops where jib or overhead traveling cranes are not avail-

(*Continued on page 324*)



Punch Table Equipped With Ball Bearing Casters

# Calculating Stresses in Horizontal Circular Tanks

## Application of Uniformly Loaded Beam Formula to Problem of Designing Open Tanks

By John S. Watts

A CIRCULAR tank placed with its axis horizontal and open to the atmosphere so that there can be no greater pressure in it than that due to the head of fluid it contains when it is full to the top, is an entirely different problem, as regards calculating the plate required, to a similar tank under pressure; that is a closed tank connected to a source of pressure.

The thickness of shell plate in a closed tank is generally calculated to withstand the stress due to the bursting pressure only, as the other stresses are so small in relation to that from the bursting pressure as to be negligible.

In the open tank, the conditions are exactly reversed, the bursting pressure being practically nil, and hence to determine what thickness of plate to use, it is necessary to determine the stresses imposed upon the plate. Generally speaking for the smaller sizes of tanks these stresses are low and it frequently happens that a thickness of plate could be used which would satisfy all requirements for strength but would be too thin to stand calking. For this reason a minimum thickness of 3/16-inch should be used, as plates any thinner than this cannot be calked to remain water-tight for long.

Considering the stresses on the shell plate, we know that there is a tendency for a horizontal tank to be deformed from its circular shape by the weight or pressure of the fluid in it as indicated in Fig. 1, the dotted line showing the shape which it would assume under an overload. Unfortunately it has so far been impossible to work out a mathematical formula which would satisfactorily indicate the resistance of the plate to this deformation, owing to the complexity of the problem. However, practical experience seems to prove that in tanks of ordinary size, the stress incurred in resisting this deformation is less than the other stresses which the plate has to resist. This stress not being additional to these latter stresses, that is not acting in the same direction may be neglected.

The important stress is the one we will consider next and is that imposed on the shell plate by reason of the tank carrying its contents as a beam uniformly loaded and supported at two or more points. Regarding the tank as a beam I have shown the various conditions diagrammatically in Figs. 2, 3 and 4. Fig. 2 shows the supports at the extreme ends of the tank; Fig. 3 shows the supports placed so as to reduce the stress to the lowest possible point with two supports; and Fig. 4 shows a tank with 3 supports.

A formula for thin hollow tubes, loaded with a concentrated weight in the center and supported at the ends, given by D. K. Clark, is as follows:

$$W = \frac{3.14\ L^2\ t\ S}{L}$$

Where; $W$ = breaking weight in the center in pounds.
$D$ = Diameter in inches of the tank.
$t$ = Thickness of shell plate in inches. Solid not riveted.
$L$ = Length in inches, see Figs. 2, 3 and 4.
$S$ = Stress in pounds per square inch due to $W$.

In the case of a tank the load is uniformly distributed and when so distributed the resulting bending moment is only half that due to an equal concentrated load. Hence $W$ in the above formula becomes $2W$ for our case.

For riveted tanks the thickness of plate 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 make $T = t/e$, $e$ being the efficiency of the circumferential joints. Therefore for $t$ in the above formula we substitute $T \times e$.

For Fig. 2, the formula will be revised to:

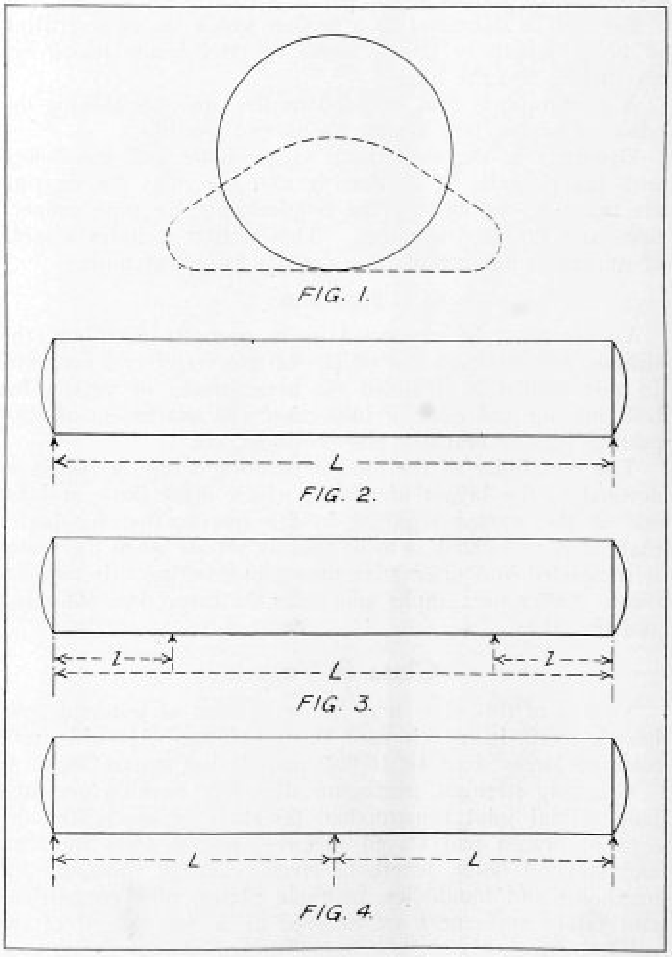
$$W = \frac{6.28 \times D^2 \times T \times e \times S}{L}$$

For Fig. 3, being differently supported the formula becomes,

$$W = \frac{36.61 \times D^2 \times T \times e \times S}{L}$$

provided that $1 = 0.207\ L$, which position of the supports gives the greatest strength. For Fig. 4 the formula is the same as for Fig. 2.

When working out the weight $W$, care must be taken to include the weight of the tank as well as the weight of the




**Problems in Circular Tank Design**

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 impedimenta that may hang upon the tank must also be considered. The working stress should not exceed 12,000 pounds per square inch.

# Heating Boiler Section of the Boiler Code Revised

## Preliminary A. S. M. E. Report on Rules for the Construction of Boilers for Low Pressure Steam and Water Heating Service

IN accordance with the practice of the American Society of Mechanical Engineers' Boiler Code Committee to hold a hearing every four years on the revision of the Boiler Code, the hearing this year will be held at the annual meeting of the Society in December.

In the course of the Boiler Code Committee's work during the past four years, many suggestions have been received for revision of the heating boiler section as a result of interpretations issued. In order that due consideration might be accorded these recommendations, the Committee began in the early part of 1921 to devote special consideration to the proposed changes. As a result of this many of the recommendations have been accepted and revisions of the paragraphs formulated.

An outline of these revisions and rules is given below. The complete rules, however, in pamphlet form, may be obtained from the secretary of the Boiler Code Committee, C. W. Obert, 29 West 39th Street, New York, to whom also discussions should be mailed in order that they may be presented to the Boiler Code Committee for consideration. The rules are divided into two sections; the first, on steel plate boilers, applies to steam boilers operating at pressures not exceeding 15 pounds per square inch and to hot water boilers working under pressures up to 160 pounds and not exceeding 250 degrees F.; the second applies to cast iron boilers. In no case, however, do the rules apply to economizers or feed water heaters.

### Steel Plate Boilers

Under "Materials" reference is made to specifications given in paragraphs 23 to 178 of the rules for power boilers which also govern the construction of heating boilers except as particularly specified for autogenously welded boilers.

In determining the maximum allowable working pressure the tensile strength used is that stamped on the plate with the minimum of 55,000 pounds per square inch for all steel plates except for special grades having a lower tensile strength. Resistance to crushing is taken as 95,000 pounds per square inch of cross sectional area. The table of rivet strength and shear is also given. An outline is included of the minimum allowable thickness of shell plates, heads, tube sheets and butt straps as well as tube thicknesses for watertube and firetube boilers measured by the Birmingham wire gage.

A section is devoted to the determination of joint efficiencies, the design of longitudinal lap riveted joints, rivet spacing, butt strap design and the like.

#### Braced and Stayed Surfaces

An explanation of the application of the formula $P = C \times \frac{T^2}{p^2}$ for use in determining the maximum allowable working pressure for various thicknesses of braced and stayed flat plates or those which require staying, as flat surfaces, is given. The letters in the formula are:

$P$ = maximum allowable working pressure pounds per square inch (not less than 30 pounds).

$T$ = thickness of plate in 16th's of an inch.

$p$ = maximum pitch between straight lines passing through the centers of staybolts in different rows.

$C$ = 112 for stays screwed through plates not over 7/16 inch thick for ends riveted over or for stays welded into such plates.

$C$ = 120 for stays screwed through plates over 7/16 inch thick.

$C$ = 135 for stays screwed through plates and fitted with single nuts outside of plate.

$C$ = 150 for stays with heads not less than 1.3 times diameter of the stays screwed through plates.

$C$ = 175 for stays fitted with inside and outside nuts.

This section also includes rules for determining the area of heads to be stayed; the determination of proper diameter of screw stays and the maximum allowable stress per square inch allowed at point of least net cross sectional area.

#### Boiler Openings

Under the heading of boiler openings, manhole, handhole and washout plug openings to permit inspection and permit removal of any sediment which may accumulate in a boiler are discussed. The location of these openings and their dimensions in horizontal return tubular boilers and in locomotive or firebox type boilers, vertical firetube or similar type boilers, are taken up in detail. Where openings in a boiler are tapped, a table of minimum thicknesses of material governs the determination of threads allowed for standard pipe sizes. A paragraph is included on openings in boilers having flange connections.

#### Supports

Horizontal return tubular boilers over 78 inches in diameter are to be supported from steel lugs by the outside suspension type of setting independent of the boiler side walls. Between 54 inches and 78 inches diameter, horizontal boilers are to be supported by the outside suspension type of setting or at 4 points by not less than 8 steel or cast iron brackets set in pairs. Lugs or brackets when used to support a boiler of any type shall be properly fitted to the surfaces to which they are attached. Part of the section on supports gives the requirements for shearing and crushing stresses on rivets.

#### Setting and Installation

Under this heading several paragraphs give the requirements for minimum distance between the bottom of the boiler and the floor line, the minimum size of access door used in boiler settings, provisions for the expansion and contraction of steam mains connected to boilers, the requirements for discharging feed water into boilers where the part of the boiler is exposed to the direct radiant heat from the fire. The installation of hot water heating systems so that no opportunity is given for the fluid relief column to freeze or to be accidentally shut off, requirements for the installation of valves in the supply and return mains and the installation of a valve in the top connection from the hot water supply boiler to the storage tank are subjects taken up in this section.

#### Fittings and Appliances

This section is devoted to rules governing the connections for safety valves, for steam heating boilers and water relief valves for water heating boilers, the size of outlet connections for these and all other valves used. In the case of steam boilers, steam gages must be connected to the steam space or to the water column or its steam connection, each hot water boiler should have a pressure or altitude gage connected 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. Hot water boilers must also have a thermometer located and connected so as to be readable when observing the water pressure or altitude gage. The remainder of this section is devoted to temperature combustion regulators, pressure combustion regulators, bottom blow-off connections, water gage glasses, gage cocks, water column pipes and fusible plugs.

### Hydrostatic Test

Hot water boilers, the maximum allowable working pressure of which is not in excess of 30 pounds per square inch and steam heating boilers shall be subjected to a hydrostatic test of 60 pounds per square inch, both at the shop where constructed and in the field when erected and ready for service. Individual shop inspection is not required for boilers under these rules except for those constructed by autogenous welding. Paragraphs are devoted to the standard stamping of boilers coming under these rules.

### Autogenously Welded Boilers

Steel plate boilers for steam heating at pressures not exceeding 15 pounds per square inch or for hot water heating at pressures not exceeding 150 pounds per square inch may be constructed by autogenous welding under these rules. For pressures in excess of 30 pounds per square inch for hot water boilers the factor of safety for autogenously welded steel plate boilers shall not be less than 5, assuming the strength of the welded seams at 50 percent of the full strength of the plate at the welds. The rules specify the manner of design, construction and stamping of these boilers, definition of base metal, the specifications for filling material and for the material used in the plates from which the boilers are fabricated. A ladle analysis must be made of each melt by the manufacturer of the plate to determine the percentage of the important elements, carbon, manganese, phosphorous and sulphur. The chemical composition data thus determined are to be furnished to the purchaser of the plate or his representative and must conform to the requirements given in the Code.

Tensile tests of metal and method of making test specimens, bend tests, finish and the like are given. The methods to be followed in welding are outlined and the arrangement of longitudinal joints specified.

## Cast Iron Boilers

The second section of the Code applies to rules for cast iron boilers where such boilers are for steam service and operate at pressures not exceeding 15 pounds per square inch and for hot water boilers operated at pressures not exceeding 160 pounds per square inch at temperatures not exceeding 250 degrees F. The rules in this section include the determination of allowable working pressure, the arrangement of washout openings, flange connections, threaded openings. Under installation the required connections for safety and water relief valves are given, while the remainder of the Code follows practically the same outline as that in the rules for steel plate boilers with sections devoted to safety valves, water relief valves, steam gages, pressure altitude gages, thermometers, temperature combustion regulators, bottom blow-offs, water gage glasses, gage cocks, water column pipes, fusible plugs, with a final section devoted to hydrostatic tests, shop inspection and stamping of cast iron boilers.

As stated at the beginning, this outline is necessarily incomplete as space does not permit the entire publication of the rules. Those interested in the construction of heating boilers will benefit very greatly by entering the discussion of the subject either by correspondence with the secretary of the Boiler Code Committee or by attendance at the annual meeting of the American Society of Mechanical Engineers, at which time the subject matter of these rules will be openly discussed.

## Copper Boiler Tubes and Fireboxes

The use of copper for locomotive firebox plates and boiler tubes was abandoned in this country many years ago. It is therefore interesting to note that this material will probably be tested again in actual service to determine whether it is more economical than steel under present conditions. The price of copper is now lower than it was before the World War, while the price of steel is more than 50 percent higher. Furthermore, the cost of coal and wage rates are much higher than formerly so that the conclusions which were reached under the circumstances existing 20 years or so ago may not hold good today.

### High Cost of Copper Tubes

One of the factors that caused the railroads to abandon the use of copper was the high cost of this metal. This is not such a serious objection, however, because the scrap value is very little less than the first cost and judging by experience in other countries, the life of the parts should be at least equal to those made of steel. An interesting discussion of the relative merits of copper and steel for locomotive boiler tubes occurred at a recent meeting of the Institution of Mechanical Engineers in Great Britain. One of the speakers at this meeting stated that copper tubes gave a mileage two or three times as great as steel and had only one-thirtieth as many failures. Except in very unusual cases, copper tubes do not corrode or pit and they are, therefore, suitable for use in bad water districts. There is a question, however, whether copper tubes would not set up a galvanic action that would cause corrosion if used with steel firebox plates. In Great Britain the firebox plates as well as the tubes are of copper. The statement is often made that copper tubes save a considerable amount of fuel although little evidence is presented that might be considered conclusive. As has been pointed out before, the limiting factor in heat transmission through boiler tubes is probably the rate at which the heat is transferred from the gas to the tube and, therefore, copper may not give any better results than steel even though it has a heat conductivity eight times as great and does not accumulate as much scale as does steel.

P. C. Dewhurst of the Jamaica Government Railways, who has had experience with both materials, states that he does not see sufficient justification for the use of copper tubes unless it is because of better conductivity. Owing to the high coefficient of expansion of copper, the tube sheets are distorted more between the cold and working temperatures than when steel tubes are used and furthermore, Mr. Dewhurst states, steel tubes do not suffer from eroding at the firebox end, just inside the tube sheet. It is evident that each material has certain important advantages and it will be interesting to note the results of comparative tests which should end the futile theoretical discussion.—*Railway Mechanical Engineer.*

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## Ball-Bearing Casters on Punch Table

(*Continued from page 321*)

able, it is customary to have several men support the outer ends of steel boiler plate sections while rivet holes are being punched. The labor cost for this work can be greatly reduced by means of the table illustrated which enables comparatively large and heavy plates to be handled to the punch by one or not more than two men. As shown, the table is built up of 2½ inch angle iron, braced by 1½ inch iron straps. Ball-bearing casters are firmly fastened in an inverted position on top of the table, their height being arranged so that the top of the casters is at the same elevation as the bottom punch die. This device greatly facilitates the handling of large sheet metal plates to punches and shearing machines.

# The Boiler Maker

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The development of the Ljungström turbine-driven locomotive for the Swedish State Railways marks a great advance in the use of steam for railway motive power. The efficiencies produced in service by this locomotive are due not only to the application of the turbine drive but also to a great extent to the various features of the boiler design and auxiliary equipment.

The advantage of applying a condenser unit to the locomotive from the standpoint of boiler efficiency is apparent for, in addition to utilizing the feed water over and over again, pure feed water will be assured at all times. This results in a reduction of scale and the elimination of a great amount of boiler maintenance work.

For the first time in any locomotive, otherwise waste heat is utilized for pre-heating the air required for combustion. In the apparatus located in the partitioned smokebox the temperature of the combustion gases is reduced from 600 degrees to 300 degrees F. while the air is taken into the fuel bed at this latter temperature. The saving in fuel due to pre-heating is much greater than that required to operate the turbine driven exhaust fan used to create the required draft.

The steam soot blowers controlled from the cab insure clean boiler tubes, superheater tubes and air heater tubes without interference with the draft as the cleaning can be carried out on small sections of the tubes at a time.

Another interesting feature of the boiler auxiliary equipment is the series of three feed water heaters, each supplied with exhaust steam at a different temperature, so that the feed water is raised progressively from about 100 degrees F. to 300 degrees F.

The combination of efficiency promoting features of this locomotive has resulted in a reduction of 50 percent in coal consumption for the horsepower developed. The performance of the locomotive in service will determine the influence which this type of steam locomotive will have on future designs of motive power.

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Too much emphasis cannot be placed on the importance of the two sections of the A. S. M. E. Boiler Code—that on "Construction of Unfired Pressure Vessels" and the revision of the "Heating Boiler" section—which are opened for discussion at this time. Although brief details are included of both sections in this issue of The Boiler Maker all those interested in the design, construction, maintenance or use of heating boilers and pressure vessels coming under the Code should obtain the complete rules from the secretary of the Boiler Code Committee.

As several hearings have already been held on the Pressure Vessel Code no public discussion will be included in the program of the annual meeting of the Society. However discussion on the subject matter of the rules has not been closed and it is still possible for interested individuals to make constructive criticisms of the measures, which will receive consideration before the Code is finally adopted. Such suggestions may be sent to the secretary of the committee.

In the case of the Heating Boiler Code, an open discussion will be held on the provisions at the annual meeting of the society to be held early in December at which time an opportunity will be available for points of difference to be decided on the revisions suggested and additional matters brought up which seem advisable of inclusion in the revised Code.

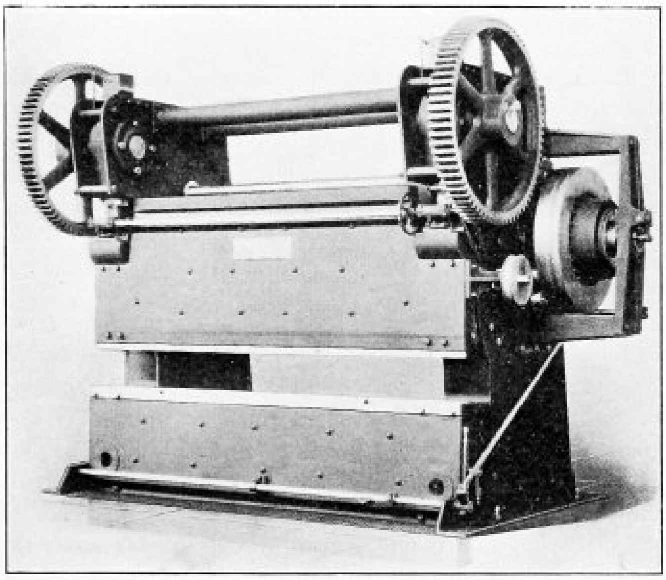
The work of the Boiler Code Committee is rapidly being extended to include a variety of different equipment used in all kinds of pressure service. The only way in which the work of the numerous sub-committees may be made complete, accurate and of greatest assistance to the industries involved is by the active co-operation and support of the members of such industries in their constructive discussions of points occurring in the preparation of the Code, governing the design and construction of such vessels.

# Engineering Specialties for Boiler Making

**New Tools, Machinery, Appliances and Supplies for the Boiler Shop and Improved Fittings for Boilers**

## All-Steel Power Press Brake

A new development in the manufacture of heavy brakes has been made by the Cincinnati Shaper Company, Cincinnati, O., with the introduction of the Cincinnati all-steel press brake. This line of brakes has been designed with an open side in order to facilitate the handling of material. As most bends are made near the edge of the plate, the full



Cincinnati Power Press Brake with Multiple Disc Clutch

length of the die-holding surface can be utilized. Thus, for most classes of work, a machine can be rated with respect to the length of the die-holding surface instead of the distance between housings, which means the use of a narrower, more rigid machine, and a saving in cost and floor space.

The bed and ram are constructed entirely of heavy steel plates and billets, which, together with cross ribs, are welded to each other, thus making what is virtually a heavy solid steel beam of box section with the metal placed to the best advantage. The housings are framed of steel plate, having cast steel members interlocked and welded to the plates. For lubrication the fly wheel, clutch, worm and worm wheel ram adjusting device, and the power drive for this, all run in a bath of oil.

All main drive bearings are of special bronze. A splined trip shaft runs the full length of the machine, on which is mounted an adjustable foot treadle which enables the operator to engage the clutch from the most convenient position. The ram is gibbed endways as well as sideways. This is essential when using the machine as a gang punch. When the machine is to be motor driven, the motor is mounted on a bracket attached to the housing. The drive is through a belt, held in tension by a weighted idler pulley on the slack side.

To meet the demand for increased production these machines have been designed to operate at a greater number of strokes per minute than has been customary in brakes heretofore. The fly wheel is mounted on high duty ball bearings having hardened steel inner and outer races. The clutch is of the multiple disc type, especially designed and developed for this particular tool and operated in oil.

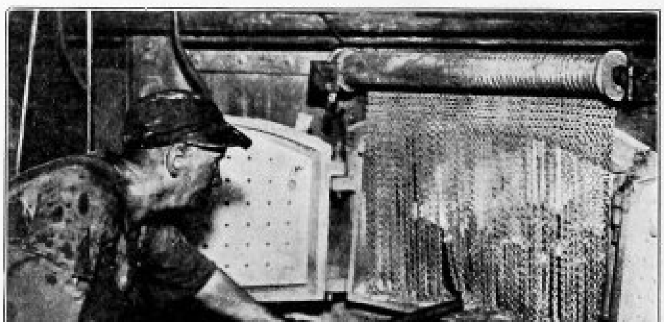
These brakes are built in capacities ranging from 80 to 600 tons for working material from 10 gage to ¾ inch in thickness. The widths between housings are 6 feet 6 inches to 14 feet 6 inches; the weights 18,000 pounds to 120,000 pounds.

## Chain Screen Doors for Boilers and Furnaces

Recent developments in Wiegand chain screen doors, made by the E. J. Codd Company, Baltimore, Md., indicate that this device is of especial value in increasing the efficiency of furnace operation. The principal advantages of the chain furnace door are due to the fact that it is easily penetrable, affording an unhampered view of the interior of the furnace, and assisting materially in keeping heat in and cold air out. The door consists of a curtain of chain which effectively hinders the passage of gases, sparks and air. The loosely hanging strands of light chain are parted with ease and pressed aside by the tools or other objects projecting into the furnace only to fall together again and close the opening when the entrance has been effected. The operator is at the same time protected from the heat and can see what is going on in the furnace. It is said that fine coal and light shavings can be thrown through the chains from a shovel. When the screen is hit by the edge of the oncoming shovel, the chains swing inwards and upwards admitting the fuel.

These chain screen doors are made in different types and with different methods of suspension for use on drop forge furnaces, annealing furnaces, electric furnaces and the furnaces of stationary boilers, etc. Wherever a furnace is kept at a high temperature and it is necessary to have a door for the feeding or manipulation of the contents, these auxiliary chain doors effect fuel economy, avoid damage and delay from chilling drafts to the furnace and contents and tend to provide greater efficiency, comfort and safety to the workmen.

The door shown in the illustration is automatic in action,



Cleaning a Fire Through a Wiegand Chain Screen Door the chains rolling down over the main boiler door opening as soon as the doors are opened.

## Chambersburg Punching and Shearing Machines

Vertical punching and shearing machines on which settings and adjustments of the sliding-head stroke are quickly made by means of a patented electric clutch control have recently been developed by the Chambersburg Engineering Co., Chambersburg, Pa. A double-end machine equipped with the electrical control is illustrated in Fig. 1. This line of equipment is so designed that machines of different capacities may be operated end to end, as well as machines of like capacity. Belt-driven machines may also be provided with a mechanical pedal control, as illustrated in Fig. 3, instead of the electric control. However, this control is recommended to be used only when proper electric current is not available.

The stroke adjustment is made at the head end of the machine when the control head *A*, Fig. 2, is in the adjusting

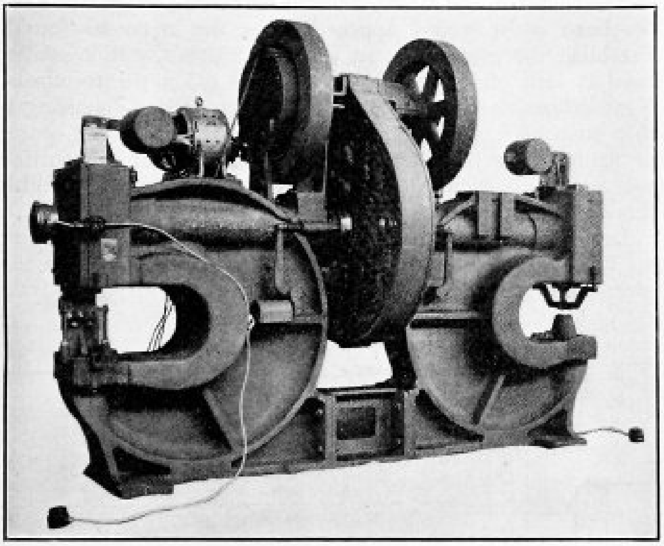


**Fig. 1.—Double End Motor Driven Punching and Shearing Machines Arranged with Electrical Control**

position shown, at which time the electric circuit has been automatically opened, and the clutch disengaged. The stroke adjustment is then made by positioning around cap *B*, a headless set-screw which is exposed. Cap *B* has graduations which indicate the position at which the stroke will be ended when the set-screw has been brought to that graduation. Fig. 2 also shows the control head in the position it occupies when the machine is in operation. A momentary depression of button *C* causes the engagement of the clutch, and this member is automatically disengaged as the sliding head reaches the point indicated by the setting of control head *A*. The machine may also be operated continuously.

A portable push-button switch is provided for operating by either hand or foot. The clutch disengages as a safety measure in case the electric circuit fails. With this automatic control it is unnecessary for an operator to leave the front of the machine while punching or shearing work.

### ARRANGEMENT OF CLUTCH

The clutch is of the solid-jaw renewable-face type. The sliding half is a steel casting and the fixed half is cast integral with the large gear and reinforced by a steel ring shrunk into place. The machine frame is an I-beam type semi-steel casting with a solid jaw. The sliding head is also a semi-steel casting and has a bronze take-up wedge. The

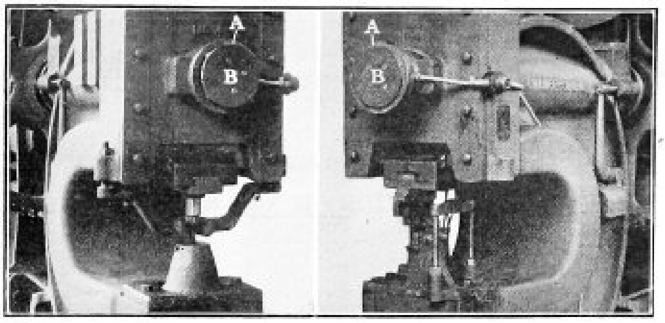



**Fig. 2.—Control Head in Adjusting Position on Punching Machine. (Right) Shearing Machine with Control Head in Operating Position**

eccentric shaft is a one-piece steel forging, accurately finished, which rotates in large bronze bushings. The main bearings and the sliding head are lubricated by sight-feed oil-cups, and oil-grooves provide for the efficient distribution of the oil.

The machine-molded gears are made of semi-steel, the pinion being shrouded. Fractional ratios insure the alternate stressing of the gear teeth. When a machine is motor-driven, a cut steel gear is furnished on the motor shaft. Gear guards may also be supplied. A one-piece safety capstan provides for turning the eccentric shaft by hand, and for camming the capstan bar out of the capstan, should the machine be accidentally started. The driving shaft is turned from machine steel, and runs in babbitted bearings. The tool-blocks are made of cast steel, the upper block being tongued to the sliding head and the lower block bolted to the frame. All tool-blocks are interchangeable on machines of like capacity. A patented floating punch which combines a fixed and a floating punch in one tool facilitates spacing table work. A tool-block can be removed in an instant by a quarter turn of a handle.

This line of machine is made in eight sizes, the smallest of which has a capacity for punching a 5/8-inch hole through mild steel plate 1/2 inch thick; shearing 3- by 9/16-inch flat stock, 1 1/8-inch round stock, and 2- by 2- by 3/16-inch angle-iron; and splitting plate up to 7/16 inch thick. The standard throat dimensions are 6, 12, 18, and 24 inches. The largest size machine has a capacity for punching a 2 1/2-inch hole through mild steel plate 1 inch thick; shearing 8- by 1 1/4-inch flat stock, 2 1/2-inch round stock and 6- by 6- by 11/16-inch angle-iron; and splitting plate up to 1 5/16 inches thick. The standard depths of throat for machines of this size are 15, 24, 36, and 48 inches, which sizes provide for a wide range of work.

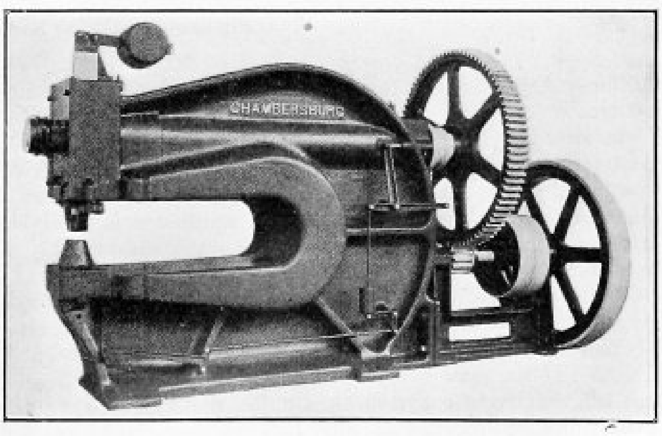



**Fig. 3.—Single End Punching Machine with Mechanical Control and Belt Drive**

# Questions and Answers for Boiler Makers

## Information for Those Who Design, Construct, Erect, Inspect and Repair Boilers—Practical Boiler Shop Problems

**Conducted by C. B. Lindstrom**

*This department is open to subscribers of* THE BOILER MAKER *for the purpose of helping those who desire assistance on practical boiler shop problems. All questions should be definitely stated and clearly written in ink, or typewritten, on one side of the paper, and sketches furnished if necessary. 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 permission to do so.*

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## Locomotive Firebox Repair

Q.—I am a subscriber to THE BOILER MAKER, but am no boiler maker. I wish to ask you a favor which I hope you will grant. Can you tell me how to proceed to replace a complete back end on a boiler. I have to take off a back end of a boiler or firebox. The help I have is not the best so please advise how to proceed after I have taken off the old back end; how I will know how to place so it will be correct. I will thank you for this information.—D. O'B.

A.—It is practically impossible for us to give you definite instructions on the removal and replacement of the back end or backhead of a firebox boiler unless we have a better idea of the construction of this boiler. However, the following general information may be of assistance.

In removing the backhead *a* of a firebox boiler, Fig. 1, first center and drill out the staybolt ends *b* on the outside sheet *a* and then on the inside sheet *c*. If a pneumatic drilling machine is at hand and air power equipment is available use such machines for the operation, otherwise employ a ratchet.

With a side cut, as shown in Fig. 2, remove the rivet heads by striking the head *a* with a sledge. Back out the rivet shanks by using a backing out punch of the form shown in Fig. 3. If the door hole is riveted as shown in Fig. 1 at *d* cut off the rivets *c* and back out the shanks. Remove the door ring and from the opening between the sheets break off the staybolts *f* by using a heavy bar as a pry. Then remove the mudring rivets *g* and the brace rivets *h*. The sheet can then be taken out. If the door sheet and backhead are flanged to form a door hole as shown in Fig. 4 it would then be necessary in order to rivet the sheets together to enter the boiler through the manhole *i*, Fig. 1. This would necessitate the removal of some of the radial stays *j*.

After the head is removed tram it to locate the center line *x-x*, Fig. 5 (a). Above the rivet holes and tangent to them draw the line *y-y* which with *x-x* will form the base lines for getting out the new sheet. The overall dimensions of the head as it would appear in the flat must be found. Establish the center *o* from which the upper section of the head is laid off; this is done by trial using the trammels. Next determine the length of the flange section by using a thin strip of band iron and place it edgewise at the center or neutral line of the plate and bend it to fit the outline *a-b*, *b-c*. This should be done carefully to avoid error. With this data the new sheet can be laid off as shown in Fig 5 (b).

Draw the center lines *x-x* and *y-y* and mark off the center *o*. Take the metal strip and mark off its profile. From the profile find the radius *m* as shown in Fig. 5 (a) and draw

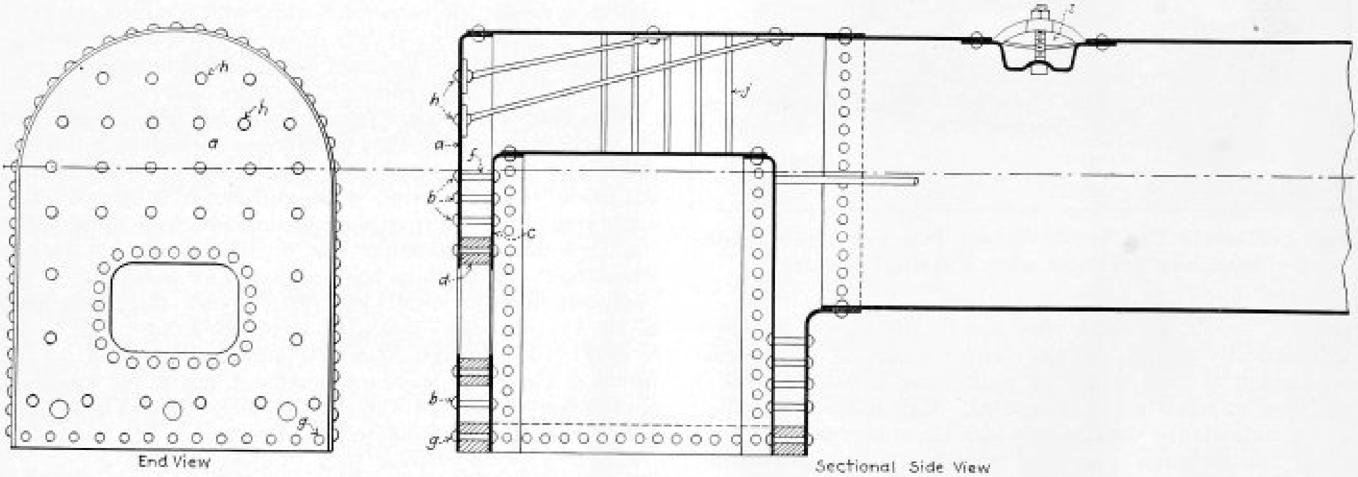



**Fig. 1.—Details of Repair to Firebox Type Boiler**

the lines *m-b* and *m-c*. The arc length *b-c* can then be calculated by multiplying the radius as *m-b* by 3.1416 and dividing the product by 4 to give the length of the quadrant *b-c*.

Measure the distance *c-d* and lay it off on the line *y-y*, then the arc length of *b-c* and the straight length *b-a*. The center line of the flange is along the line *v-v*. Lines from points *a-b* and *c* are now drawn parallel with *x-x* to intersect the line *u-u* which is drawn through the point *o* at right angles to *x-x*. With *o* as a center draw the arcs from the points produced by the intersection of the lines *u-u*, *a-b* and *c*. This gives the required outline of the head. Next locate the centers for the stayholes, braces and rivets; also the outline of the door opening. This may be done by placing the old sheet on the new and centering it with the center lines *x-x* and *y-y;* for marking off the holes use a cylindrical marker with a center teat; then re-center the holes with a center punch.

The flange should then be turned by first heating the plate along the flange section for a length of 10 to 12 inches. Flange a short section of the plate at a time and do not hammer it after the metal has lost its red heat, otherwise cracks or crystallization of the metal may result. Punch or

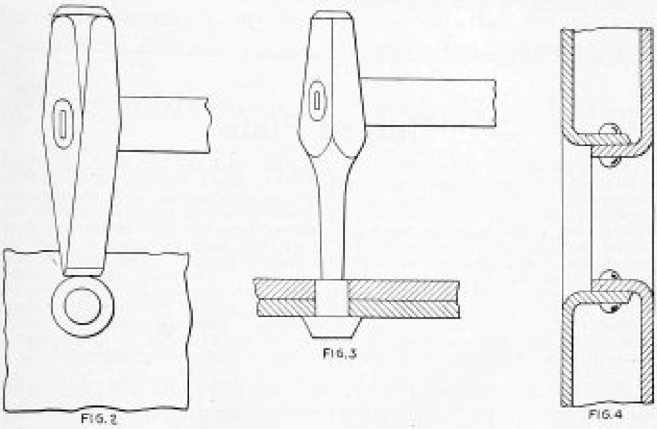



**Fig. 2.—Removing Rivet Heads. Fig. 3.—Backing Out Rivets. Fig. 4.—Flanged Door Hole**

drill the holes for the stays and rivets. Mark off several tack holes on the flange and place the head into the firebox. Bolt the head in place, test it for alinement and lay up the outside sheet against the flange. Drill the rivet holes in place or mark them off from the holes in the firebox sheet and remove the head for placing the holes in the flange. Reset the head and bolt it in place. Tap the stayholes and install the staybolts, or rivet the head in place and then install the stays. The rivets can be held on from the inside of the boiler by using special bars that fit the water space. Wedge shaped bars will be required in order to hold the rivets firmly.

### Testing the Repaired Boiler

Drive the staybolts, brace rivets and mudring rivets. A heavy bar or dolly should be bucked up against these while being headed. Set the door ring and rivet it in place. Fill the boiler with water and with a test pump bring the water pressure up to about one and one-half times the present allowable working pressure. Thus if a steam pressure of 100 pounds is permitted a water pressure of $100 \times 1.5 = 150$ pounds can be used for testing. Note all leaks and loose connections, calk all leaks after the pressure is removed.

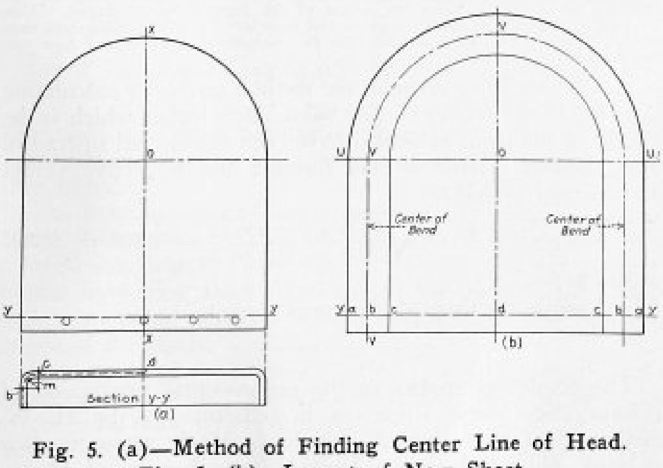



**Fig. 5. (a)—Method of Finding Center Line of Head. Fig. 5. (b)—Layout of New Sheet**

# Raising the Temperature of Pulp

Q.—I should be greatly indebted to C. B. Lindstrom, or any of your correspondents, for information which would help to solve the following problem: It is desired to raise the temperature of 100 pounds of pulp from 40 degrees F. to 300 degrees F., the operation being carried out in a vessel semi-circular in shape and jacketed on the bottom and sides. It is proposed to use steam for the heating medium, the condensate being led to a steam trap.

(1) What would be the steam consumption at 80 pounds gage pressure per hour—saturated steam?

(2) At 120 pounds gage pressure—saturated steam?

(3) At 80 pounds gage pressure—superheated to 400 degrees F? The 100 pounds of pulp would be required to attain its maximum temperature of 300 degrees F. in 20 minutes. Also, what would be the respective heating surfaces for each system of heating. (Pan heating surface.)—C. H. W.

A.—In order to handle this problem it is essential to know the *specific heat* of the substance. Specific heat is the ratio of heat required to raise a substance 1 degree F. as compared with the heat required to raise an equal weight of water 1 degree. To determine the number of heat units (*British thermal units*) required to raise the temperature of a substance to a higher temperature measured in degrees F., multiply the specific heat of the substance by its weight in pounds and by the number of degrees. The specific heat of water is 1, of iron 0.2026, of mercury 0.0333. Thus only 0.2026 British thermal units (B. t. u.) is required to raise 1 pound of iron 1 degree F. and 0.0333 B. t. u. to raise 1 pound of mercury 1 degree F. Engineers' handbooks give a table of the specific heat of the common substances.

In this example the specific heat of the pulp is not known, so we will consider it the same as water which is 1. Then to raise 1 pound of the substance from 40 degrees to 300 degrees F. requires $300 - 40 = 260$ B. t. u. For 100 pounds it requires $100 \times 260 = 26{,}000$ B. t. u.

Since this quantity of heat is obtained from the latent heat of the steam at 80 pounds gage pressure, find the number of B. t. u. in the latent heat and also the steam temperature at this pressure from a steam table giving the properties of saturated steam. The steam table gives the readings above vacuum and the steam gage gives the pressure above the atmospheric pressure; that is, when the steam gage registers 0 it indicates atmospheric pressure of 14.7 pounds per square inch. Therefore the atmospheric pressure 14.7 must be added to the reading of the gage to obtain the reading above vacuum. At 80 pounds pressure, the pressure above vacuum equals $80 + 14.7 = 94.7$ pounds. At 120 pounds pressure, the pressure above vacuum equals $120 + 14.7 = 134.7$ pounds. The latent heat in B. t. u. at these pressures from the steam table are given as follows:

| | |
|---|---|
| For 80 pounds gage | 1180.52 B. t. u. |
| For 120 pounds gage | 1188.7 B. t. u. |

The temperature of steam at 80 pounds gage equals 323.2 degrees and the temperature at 120 pounds gage equals 350 degrees.

One pound of steam at 80 pounds gage gives up in condensing 1180.52 B. t. u. and in addition gives up its temperature in falling from 323.2 degrees to 300 degrees F., consequently each pound of steam gives up $1180.52 + (323.2 - 300) = 1180.52 + 23.52 = 1204.04$ B. t. u. Therefore, it will require $26000 \div 1204.04 = 21.6$ pounds of steam at 80 pounds pressure. The amount of steam required under a working pressure of 120 pounds per square inch would be figured in a similar way.

Superheated steam would not be suitable since it would first be required to raise the temperature of the steam and again reduce it to saturated steam to obtain its latent heat for heating purposes.

The pan heating surface cannot be determined definitely without experimenting, and I would therefore suggest that you present this problem to concerns dealing with heaters and cookers.

Possibly some of our readers can supply further information and we would be pleased to hear from any one interested in the problem.

# Efficiency of Ligaments for Equal and Unequal Tube Spacing in a Water-tube Boiler Drum

Q.—Will you please give the solution for finding the distance *x* Fig. 1, to give an efficiency of 45.3 percent?—P. H. E.

A.—1. The respective efficiencies of the ligaments between the larger tubes in the upper row and between the smaller tubes in the lower row are determined as follows in accordance with Paragraph 192 of the A. S. M. E. Boiler Code.

When a shell or drum is drilled for tubes in a line parallel to the axis of the shell or drum the efficiency of

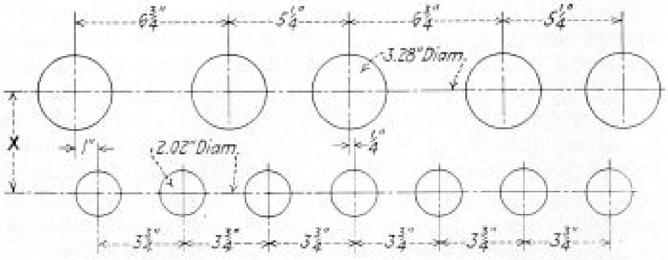



**Fig. 1—Problem in Tube Spacing**

the ligament between the tube holes shall be determined as follows, when the pitch is equal as in the small tube row.

$$\frac{p - d}{p} = \textit{efficiency of ligament}$$

where; $p$ = pitch of tube holes, inches.
$d$ = diameter of tube holes, inches.

Using the values given for the tube dimension and pitch, the efficiency for the smaller tube ligaments equals:

$$\frac{3.75 - 2.02}{3.75} = .461 \text{ or } 46.1 \text{ percent.}$$

2. For the larger tube spacing and when the pitch of tube holes in any one row is unequal the following formula is used:

$$\frac{p - nd}{p} = \textit{efficiency of the tube ligament}$$

in which; $p$ = unit length of ligament, inches.
$n$ = number of tube holes in length, $p$.
$d$ = diameter of tube holes, inches.

The unit length of ligament in the example equals 6¾ + 5¼ = 12 inches, and number of tubes equals 2. Using these values in the formula,

$$\frac{12 - 2 \times 3.28}{12} = 0.453 \text{ efficiency of ligament.}$$

3. The A. S. M. E. Code specified with regard to the strength of the ligaments between the tube holes which are subjected to a longitudinal stress that this strength shall be at least one-half the required strength of those ligaments which come between the tube holes which are subjected to a circumferential stress.

4. In this case the question is to make the efficiency equal to 0.453 or 45.3 percent. From the dimensions of the tubes $\frac{3.28 + 2.02}{2} = 2.65$, as the section of metal which is considered as removed between the tubes in the longitudinal rows. The efficiency of the solid plate section equals 100 percent and the efficiency of the tube section removed equals 100 — 45.3 = 54.7 percent. Then from the proportion 100 : 54.7 :: 2.65 : x, we have

$$\frac{100 \times 2.65}{54.7} = 4.844 \text{ inches, the required distance between parallel rows of tubes.}$$

5. Basing the calculations on paragraph 3, this distance may be reduced to a length that gives a strength equal at least to one-half the strength of the ligaments subjected to a circumferential stress.

# Bulged Plate

Q.—In the case of a return tubular boiler in which the first course has been overheated and mudburned, I would like to know whether it would be permissible to straighten back the bulged plate, dispense with a stay now used and allow the boiler the original pressure which was 120 pounds per square inch. The bulge is down 2½ inches from the true cylindrical form of the shell and the stay, mentioned above, has been extended through the top of the shell and down through the bulged portion. The pressure was reduced from 120 pounds to 110 pounds gage. The plate on the bulged area has been reduced in thickness from ½-inch to ⅜-inch. The complete details of the boiler are: Length, 17 feet, 10 inches; diameter, 70 inches; thickness of shell, ½-inch; thickness of bulged area, ⅜-inch; longitudinal joint, triple riveted butt type, ⅞-inch rivets on a double strap of zigzag riveting with 3½-inch pitch on the inner and 7⅛-inch on the outer.—A. H.

A.—On account of the reduced thickness of the plate and in view of the fact that a permanent set was forced into the plate in the burned section, it would not be safe to place the original pressure of 120 pounds on the shell when straightened. If the maximum allowable working pressure was 120 pounds per square inch on ½-inch plate, the pressure would necessarily have to be cut down on account of the reduced plate thickness of the bulged plate. This pressure may be determined as follows:

$$\frac{120 \times 0.375}{0.5} = 90 \text{ pounds per square inch.}$$

in which; 120 = original allowable working pressure, pounds per square inch.
0.375 = reduced plate thickness, inches.
0.5 = original plate thickness, inches.

If the original allowable working pressure is needed to supply the required power, then it is advisable to have the boiler inspector to explain the repairs necessary. A patch can be applied, but if the section is wasted too much the old patch should be removed and a quarter or half sheet section applied.

# Correction of a Segment Calculation

Q.—In reading the August issue of THE BOILER MAKER (page 239) I find the formula for "Allowable Pressure on Flat Heads" worked out. In writing out the formula as given by the A. S. M. E. Code the Editor has used H as the height of the segment and not as the height from the tubes to the shell. The height of the segment has already been found by subtracting the 3½ inches + 2 inches from 20¾ inches. I do not see any reason for deducting the 5½ inches again as was done in working out the formula, as it only reduces the height of the segment to be stayed. Also, in working out the formula as given the area will be considerably less than given. I would like to know whether the formula is correct and how you get the answer you have? R. J. R.

A.—There is an error in the method given for calculating the area of the segment. The value 20¾ inches which is the height of the segment should have been substituted instead of 15¼ inches. Hence in the formula the respective values should read as follows:

$$\frac{4(20\tfrac{3}{4} - 3\tfrac{1}{2} - 2)^2}{3} \times \sqrt{\frac{2(35\tfrac{1}{4} - 3\tfrac{1}{2})}{(20\tfrac{3}{4} - 3\tfrac{1}{2} - 2)} - 0.608} = 582.95$$

square inches.

The formula for this calculation is correct.

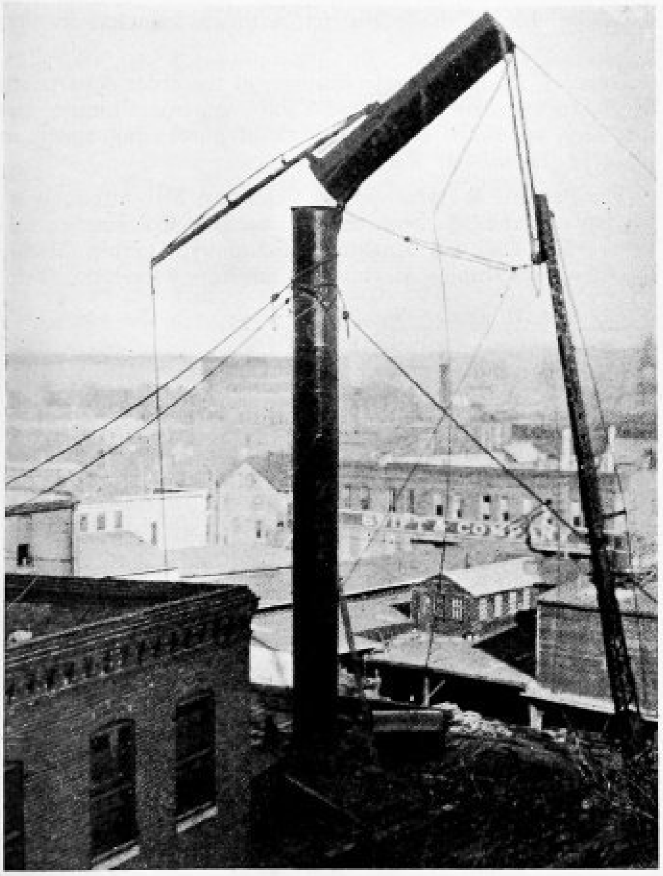
The results of studies in the experimental production of certain alloy steels are given in bulletin 199, by H. W. Gillett, chief alloy chemist, and E. L. Mack, assistant alloy chemist, published by the United States Bureau of Mines.

# Letters from Practical Boiler Makers

**This Department Is Open to All Readers of the Magazine —All Letters Published Are Paid for at Regular Rates**

## Modern Methods of Staying Steel Stacks

In the October number of THE BOILER MAKER there appeared an article entitled "Considerations in Designing Steel Stacks," in which we find the following: "The guys are attached to the stack by means of an iron ring," and in another place, "Little can be done to prevent corrosion on



*(Keystone View Co.)*

**Seven Ton Stack Erected with 70 Foot Traveling Crane**

the inside of a stack but the outside should be protected by a good stack paint and a new coat should be applied from time to time."

The firm by whom I am employed has erected a great many steel stacks in this territory and has therefore had considerable practical experience in this line. Erecting companies have long since discontinued the use of guy bands and use instead eyebolts with a reinforcing plate on the inside of the stack.

The guy band is the most prolific source of external corrosion on steel stacks, the stacks invariably breaking off right at the band long before the stack really needs to be taken down. This leaves a large, heavy section of stack to fall and do heavy damage, often pulling the band to one side. Thus the remaining portion of the stack is very poorly guyed and absolutely uncontrollable when it comes to taking it down, unless a scaffold is built to the top.

Such scaffolding is an obsolete method of razing stacks, the low scaffold with chain block being the most practical and economical method for taking down old stacks and erecting new ones, up to 6 and 6½ feet in diameter and 125 to 150 feet high.

### EYEBOLTS USED FOR GUYING STACKS

Stacks with eyebolts give longer service because there is no outside corrosion, the eyebolts seldom or never pulling out, even when the stack has several holes eaten in it, and the top is practically nothing but rust and scale. This is a proven fact and not theory.

Another point I have noticed on stack specifications, and I have helped build and erect many, is that the top is always the thinnest on large stacks, where, if anything, it should be the heaviest, because on a stack built of the same thickness throughout the bottom portion can often be used for two top sections, the top always *wearing out* first.

On some stacks with oval bases, or breechings connecting two horizontal boilers, the base or breeching often lasts for three stacks, when built of the same thickness as the stack.

There is not so much weight as to require the bottom to be built of any heavier steel than the top, even on a 200 foot stack.

Stacks higher than 200 feet of course have to have special considerations and they are not guyed stacks.

DuBois, Pa. G. A. HALLSTROM.

## Layout of a Taper Sheet

If it is desired to lay out a conical course, the following method should give full satisfaction. The difference between both the diameters of the large and small end should be small, for instance, the thickness of the plate, or a little greater.

The conical course to be laid out in this instance is shown in Fig. 1. For developing the sheet first find the circumferences of the large and small ends as usual by multiplying

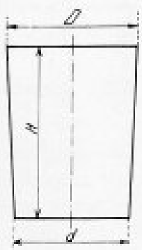



**Fig. 1**

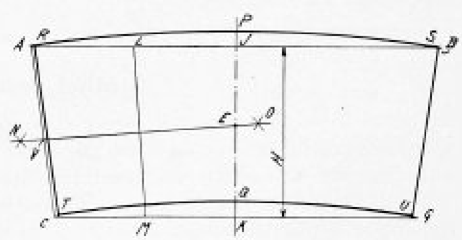



**Fig. 2**

the diameters by 3.1416. Draw a line and mark the point *J* on it, as shown in Fig. 2. From *J* strike off on each side of the line one-half of the circumference of the large end. Erect *A-B* perpendicular to the line through *J* and strike off the height *H* of the cone finding the point *K*. Through *K* draw a line parallel to line *A-B* and strike off on each side from *K* half the circumference of the smaller end of the cone and find the points C and G.

Now draw the line $A$ to $C$. Bisect the distances $A$-$J$ and $C$-$K$ resulting in the points $L$ and $M$. Draw the line $L$ to $M$ and bisect it in the usual manner by striking cords with centers at $L$ and $M$ with any radius and intersecting them at $N$ and $O$. The line $N$-$O$ is to be drawn and the intersecting points are found first with line $A$-$C$ at $V$ and second with line $J$-$K$ at $E$. From $E$ strike off the distance $A$-$V$ along $E$-$J$ finding point $P$ and from $E$ the distance $V$-$C$ finding point $Q$.

Through the points $A$, $P$, $B$ and $C$, $Q$, $G$ are laid cords. From $P$ to $R$ and $S$ step off half the circumference of the large end of the conical course and from $Q$ to $T$ and $U$ step off on the cord one-half of the circumference of the small end.

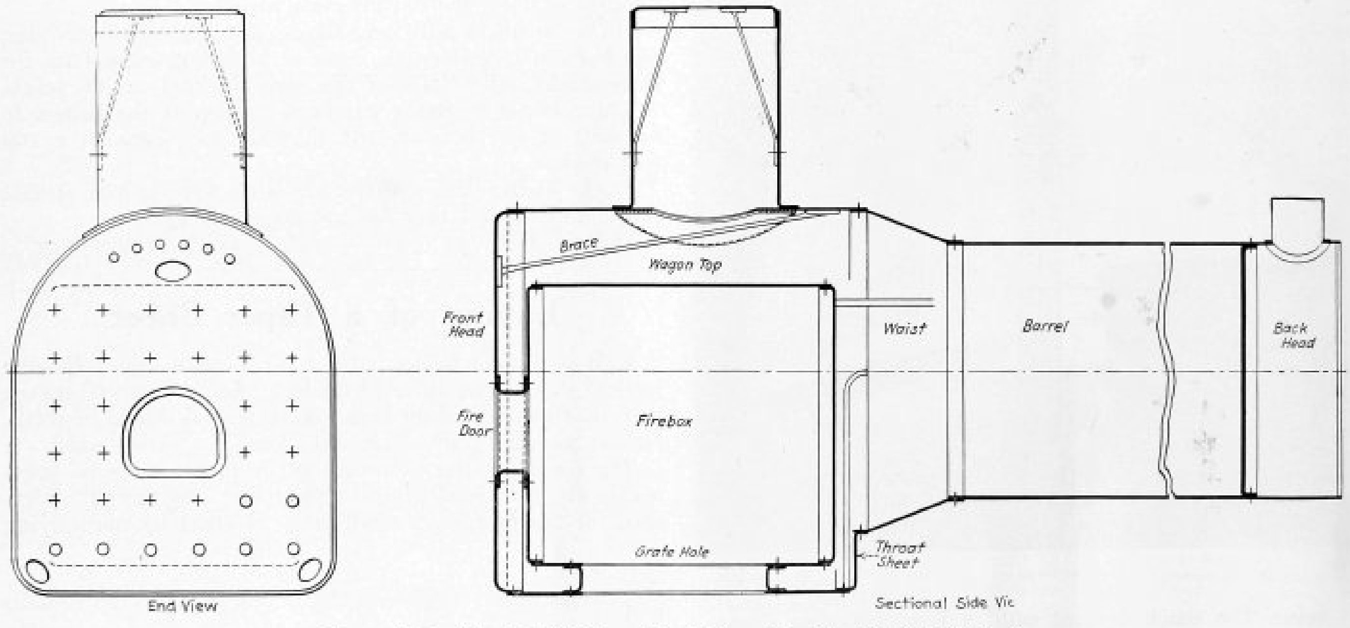
By drawing the lines $R$ to $T$ and $S$ to $U$ the layout is completed.

Graz, Austria. JOHN JASCHKE.

## Boilers Given Hard Service in the Oil Fields

The accompanying illustrations show the front and side elevation and sectional view of the Tifft boiler. This type was developed back in the old days by the G. W. Tifft & Sons Machine Works, Buffalo, N. Y. A gentleman by the name of Thomas Howard was foreman at the time and he had a lot to do with getting it out, I believe.

I do not think there ever was a type of boiler made that has stood up under so much abuse as this boiler. I have seen every rivet seam and even the solid plate sweating the salt from the water that was used and the boiler all atremble with the pressure that was on. The safety valve lever was generally loaded down so no one could ever tell how much steam was on it. There was never time to clean out the boiler.




General Details of Tifft Portable Boiler Used in Oil Field Service

As will be seen in the sketches there is a 4-inch space on the sides, front, bottom and throat sheet. By the time two oil holes were sunk the sediment would be packed to near the top of the firebox. I have repaired some of these boilers and had to use chisel bars to dig out the sediment. The outside and firebox side sheets would be bulged out between staybolts like a cushion but the bolts did not give. The sketch shows that there are hand holes on each corner and one above the crown sheet and one on the back head, but of course no one had time to take the plates out and scrape any of the mud out.

Springfield, Ill. JOHN COOK.

## BUSINESS NOTES

J. W. Floto has been appointed sales manager of the Globe Steel Tubes Company with headquarters at Chicago, Ill.

E. deH. Caldwell has joined the staff of the Franklin Railway Supply Company, New York, as special engineer in its service department.

R. S. Dean has been appointed district sales manager of the machinery and crane departments of Manning, Maxwell & Moore, Inc., Chicago district, with headquarters in that city.

Harry J. Reefe, formerly manager of the order department of the Independent Pneumatic Tool Company, Chicago, has just been appointed to the position of purchasing agent, in place of Thomas J. Keegan, resigned.

The Pawling & Harnischfeger Company, Milwaukee, Wis., has appointed new agents for its machine tool line as follows: The Cadillac Machinery Company, Detroit, Mich.; the Cleveland Duplex Machinery Company, Cleveland, Ohio, and the Seifreat-Woodruff Company with offices at Dayton and Cincinnati, Ohio.

Charles E. Fisher, assistant engineer, test department, New York, New Haven & Hartford, has been appointed service engineer of the Franklin Railway Supply Company, New York, in charge of New England territory, with headquarters at Boston, Mass.

Work has been started by Dwight P. Robinson & Co., New York, on the design and construction of an extension to the plant of the American Rolling Mill Company at Ashland, Kentucky. The extension will include a jobbing and sheet mill, and a galvanizing plant.

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Vice-Chairman—D. S. Jacobus, New York.
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Joseph Flynn, International Secretary-Treasurer, suite 504, Brotherhood Block, Kansas City, Kansas.

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Treasurer—W. H. Laughridge, G. F. B. M., Hocking Valley Railroad, 537 Linwood Ave., Columbus, Ohio.

Executive Board—L. M. Stewart, G. B. I., Atlantic Coast Lines, Waycross, Ga., Chairman.

## TRADE PUBLICATIONS

Welding Repairs.—Methods of utilizing welding in repair work in England are outlined in a bulletin recently sent out by Barimar, Ltd., Oxford street, London, England.

Refractory Products.—The October bulletin of Laclede-Christy, St. Louis, Mo., contains articles on the value of clay products in the United States. The use of firebrick in glass plants, electric furnaces, metallurgical furnaces and the like.

Anti-Slip Tile.—A catalogue describing in detail a new non-slip tile for walking surfaces which is manufactured by the Carborundum Company, Niagara Falls, N. Y., is being sent out by the sales representatives, The American Abrasive Metals Company, New York.

"The Valve World."—The October issue of the Crane Company, Chicago, bulletin contains several excellent business and economic editorials and a special feature article of the City of Pittsburgh, its industries and buildings, with special reference to Crane service in this district.

Line Shafting.—A condensed catalogue of equipment produced by the Medart Company, St. Louis, Mo., is being distributed stating facts about the most generally used types of line shafting. The object of this book has been to state dimensions, details of construction and list prices in a way to enable engineers, designers, mechanics and power users to plan installations of and purchase the equipment described.

Boiler Settings and Chimneys.—A bulletin outlining the service of Ballard, Sprague and Company, Inc., New York, in the construction of boiler settings, chimneys, steel stacks, and the like, has been issued for the benefit of those interested in boiler plant and industrial power plant construction and repair. Details of interesting stack construction jobs with numerous photographs, as well as boiler settings, acid towers and other types of construction are features in the book.

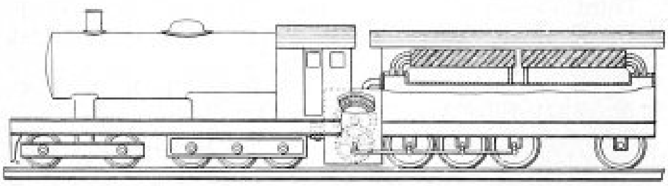
# SELECTED BOILER PATENTS

Compiled by
GEORGE A. HUTCHINSON, Patent Attorney,
Washington Loan and Trust Building
Washington, D. C.

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

1,429,356. LOCOMOTIVE AND THE LIKE PROVIDED WITH AIR COOLER FOR CONDENSING PURPOSES. FREDRIK LJUNGSTROM, OF BREVIK, LIDINGON, SWEDEN, ASSIGNOR TO AKTIEBOLAGET LJUNGSTROMS ANGTURBIN, OF STOCKHOLM, SWEDEN.

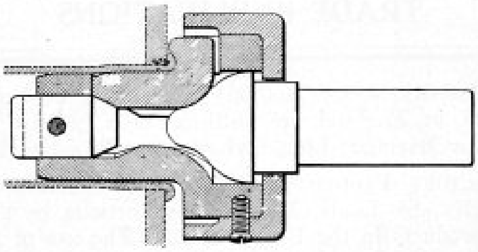
*Claim* 1.—In a locomotive or the like having a steam generating boiler



placed on a separate car and an air cooler for condensing purposes on another car, a driving steam motor for the locomotive placed solely on the cooler car at the end of the cooler facing the boiler.

1,423,545. COMBINED TUBE EXPANDER AND BEADING TOOL. JOHN JAMES SMITH, OF WINNIPEG, MANITOBA, CANADA.

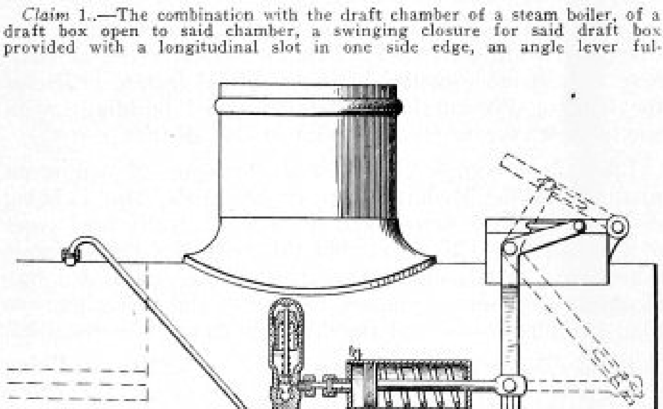
*Claim* 1.—In a combined tube expanding and beading tool, a cup-shaped body having an axial opening, a cage including a tubular shank insertable into the tube end to be worked, the said cage having a plurality of radially extended chambers that open from the bore of the shank through the peripheral face thereof, a combined expanding and beading element mounted, one in each of



the said chambers in the cage, an expanding mandrel that extends through the axial opening in the cup-shaped body and engages the combined tube expanding and beading elements and adapted, as it is being forced lengthwise into the body portion and the cage to hold the several expanding and beading elements in working engagement with the tool, and means mounted upon and cooperative with the cage for regulating the set of said expanding and beading elements to suit the diameter of the tube being worked. Six claims.

1,426,840. DRAFT CONTROLLER FOR LOCOMOTIVES. HENRY M. RICE, OF KNOXVILLE, TENNESSEE.

*Claim* 1.—The combination with the draft chamber of a steam boiler, of a draft box open to said chamber, a swinging closure for said draft box provided with a longitudinal slot in one side edge, an angle lever ful-



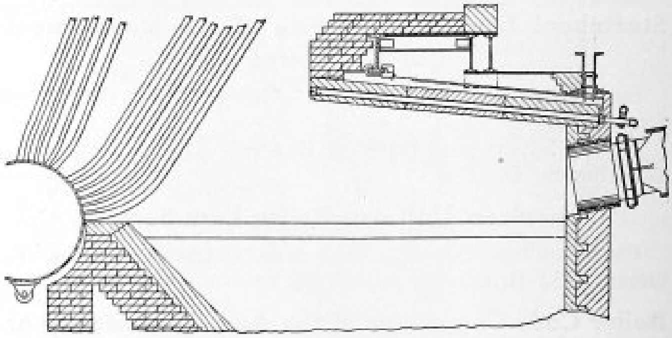
crumed upon the draft box and provided at one end with a pin playing in the slot in the said closure and provided at its opposite end with a longitudinal slot, a rod carrying a pin playing in the slot of the angle lever, and pressure-controlled means acting on said rod whereby to oscillate the lever.

1,416,925. BOILER-FUR PREVENTATIVE. OFFER LAURITZ KJÆR ANDERSEN, OF STRUER, DENMARK.

*Claim* 1.—A solution for preventing boiler scale consisting approximately of 25 parts, by weight, of sodium hydroxide, 10 parts, by weight, of mangrove bark, 10 parts, by weight, of gambier, 30 parts, by weight, of catechu and 25 parts, by weight, of potato water.

1,424,948. ARCH FOR THE FIREBOXES OF BOILERS. WILLIAM J. STOOP, OF WHEELING, WEST VIRGINIA.

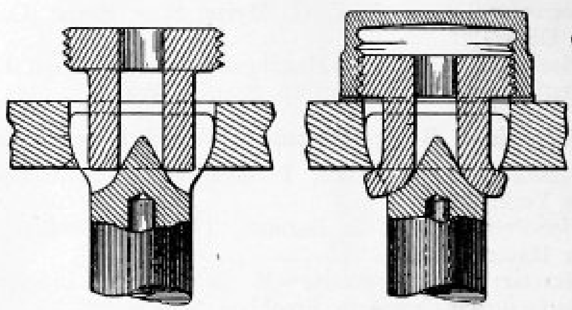
*Claim* 1.—An arch for the fireboxes of boilers, comprising an arch facing composed of a plurality of parallel courses of longitudinally alined blocks of a suitable refractory material, each course having the blocks thereof provided



with parallel longitudinally extending bores, a water pipe of substantially U-shape extending throughout said courses and having the opposite legs thereof received in said bores, said pipes having their outer ends coupled together in series to provide for circulation of water successively through the various courses, and means supporting said courses. Three claims.

1,428,536. STAYBOLT STRUCTURE FOR BOILERS. ETHAN I. DODDS, OF PITTSBURGH, PENNSYLVANIA, ASSIGNOR TO FLANNERY BOLT COMPANY, OF PITTSBURGH, PENNSYLVANIA.

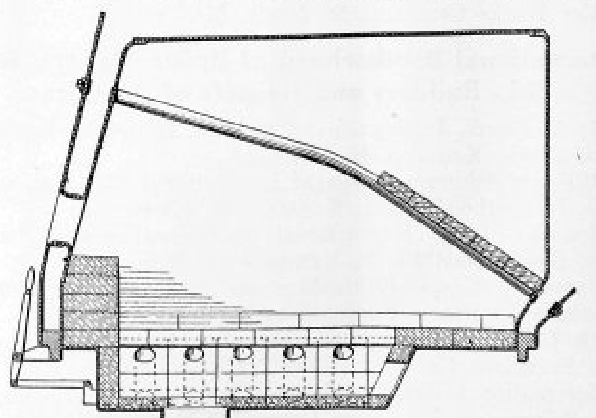
*Claim* 1.—In a staybolt structure, the combination with a boiler sheet having a bolt opening, of a clincher member having a part passing through



the boiler sheet adjacent to said bolt opening and engaging the inner portion of the boiler sheet, said clincher member provided with means forming a closure over the bolt head. Five claims.

1,402,198. LOCOMOTIVE FIREBOX. ALFRED H. WILLETT, OF WEST NEW YORK, NEW JERSEY, ASSIGNOR TO AMERICAN ARCH COMPANY, OF NEW YORK, N. Y., A CORPORATION OF DELAWARE.

*Claim* 1.—A brick having along one face thereof a groove and an aperture communicating with said groove at an end thereof and opening into the



opposite face of the brick whereby the brick when associated with an adjacent member constitutes a duct, said duct terminating short of an edge of the brick. Five claims.

# The Boiler Maker

DECEMBER, 1922

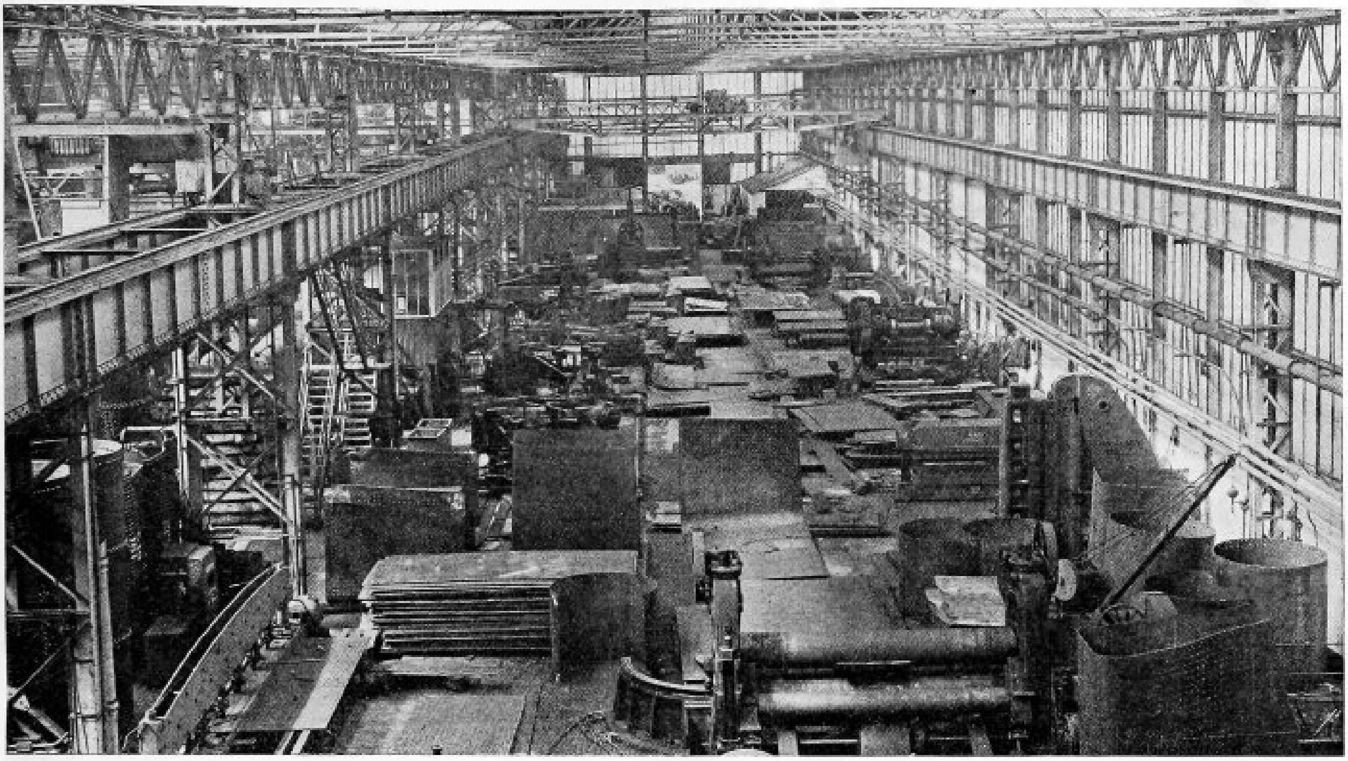



Fig. 1—View of North Bay of Elswick Works Boiler Shop of Sir W. G. Armstrong, Whitworth and Company, Ltd.

# Locomotive Boiler Work in a Modern English Shop

**Equipment and Methods Employed at the Elswick Works of Sir W. G. Armstrong, Whitworth and Company, Ltd.**

ONE of the best equipped locomotive boiler shops in England, and one which has accomplished a high production of locomotives for export, is that of the Elswick Works of Sir W. G. Armstrong, Whitworth and Company, Ltd., Newcastle-on-Tyne, England. The boiler department of the locomotive works, with which the following description is particularly interested, is situated at the east end of the Elswick Works, close to the old shipyard and parallel with the river Tyne.

As the illustrations indicate, the buildings are modern steel and glass structures having all the advantages of natural daylight that are possible from this system of construction. In addition, flood lights are provided so that when artificial lighting is needed proper illumination at all times is assured.

Complete and adequate heating, ventilating and sanitary systems have been installed throughout the shops, so that a maximum of comfort and convenience is provided for the men.

### Details of the Shops

In general the main boiler shop is located under one roof but is divided into three bays each devoted to special processes in the scheme of production. Besides the main shop there are numerous subsidiary shops engaged in producing items of equipment, castings, tools and the like that are required in the boiler assembly. The main shop and the subsidiaries combined cover a floor space of something over 16,000 square yards.

A good idea of the layout of machinery and the capacity of the various departments may be gained from the accompanying illustrations which show the three bays of the shop. The plan and organization have been built up to a point of efficiency where fifty main line locomotive boilers are averaged each month with a working staff at present of about 1,000 men.

### Shop Equipment

The arrangement of the shop is such that raw material enters at the west end of the north bay, Fig. 1, and follows a horseshoe course through the departments in the regular order of fabrication. Throughout the various operations the material follows a steady course through the shops and passes the machines in order, never zigzagging or returning on its path until it finally arrives at the testing pits in the form of finished boilers. An equipment of twenty overhead electric

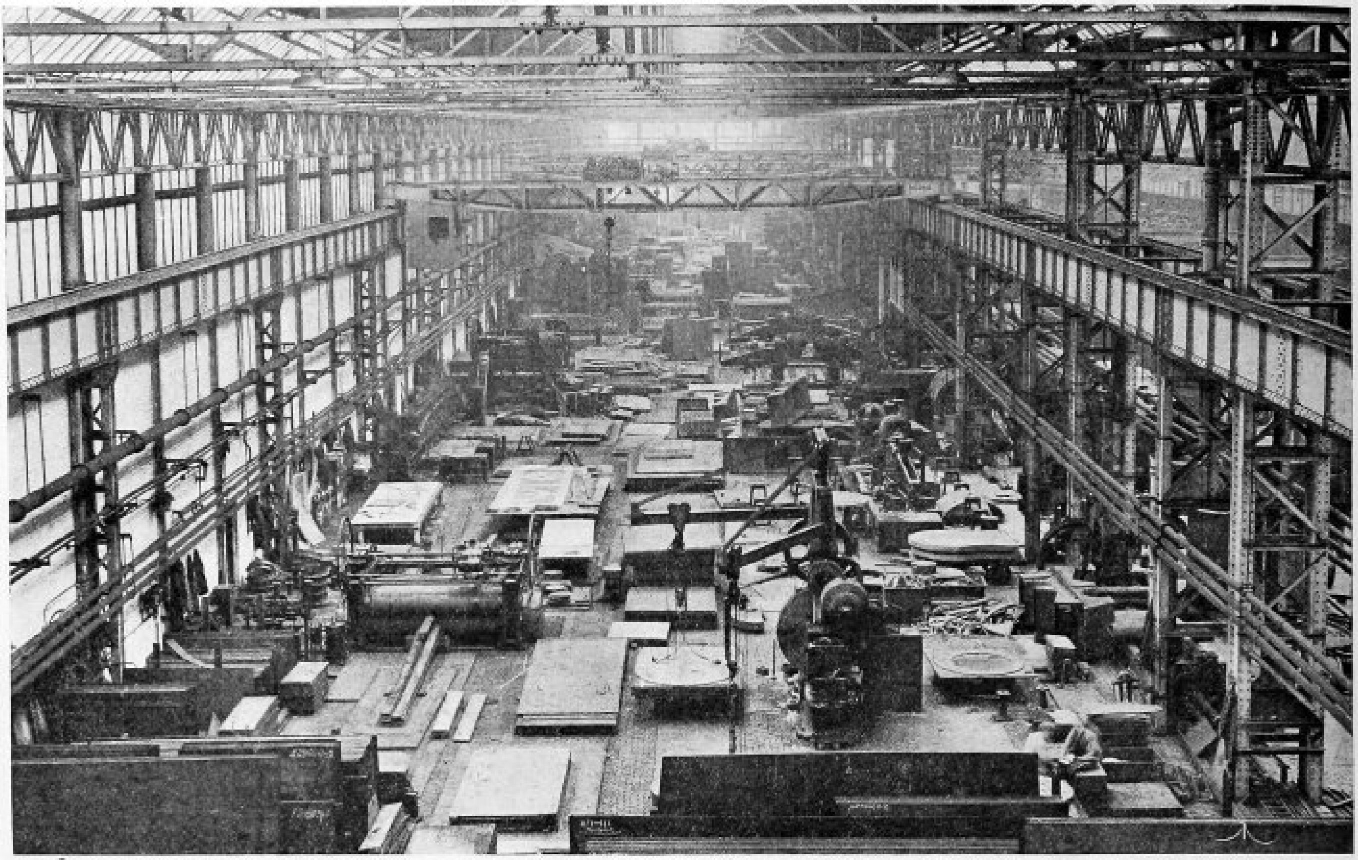


Fig 2—Eastern Section of North Bay Where Plates Are Laid Out, Drilled, Flanged and the Like

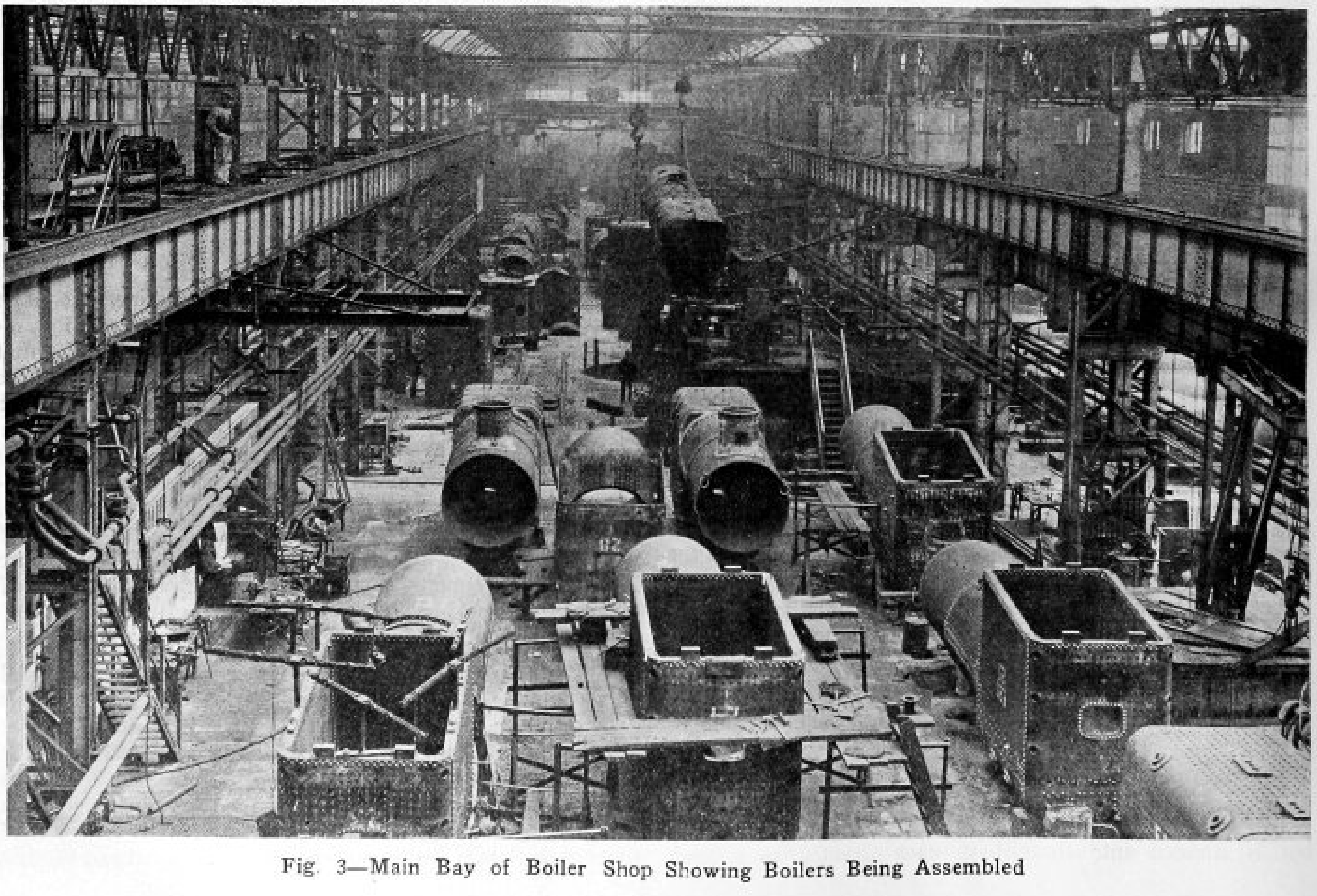


Fig. 3—Main Bay of Boiler Shop Showing Boilers Being Assembled

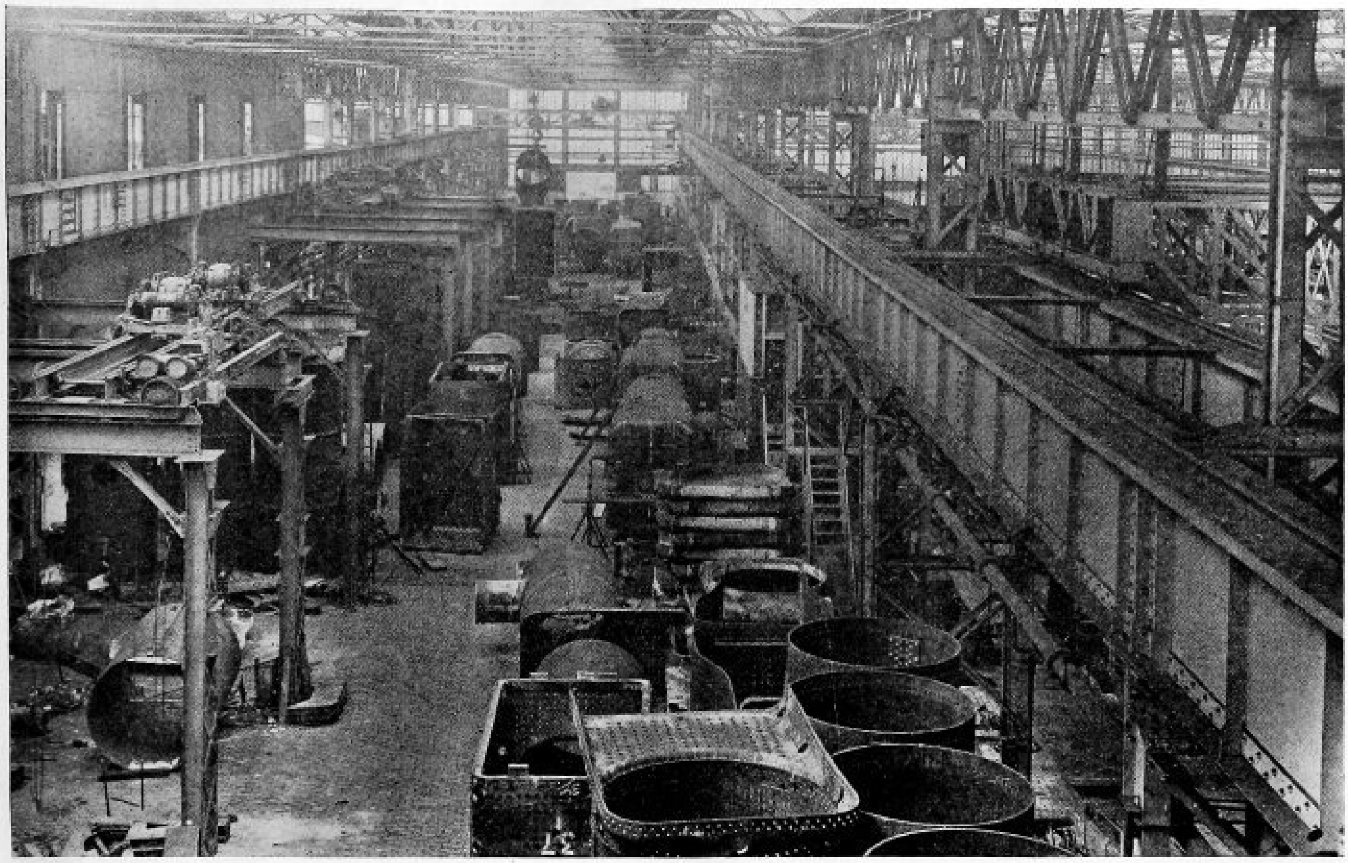


Fig. 4—Center Bay Looking West, with Battery of Hydraulic Riveters in Action

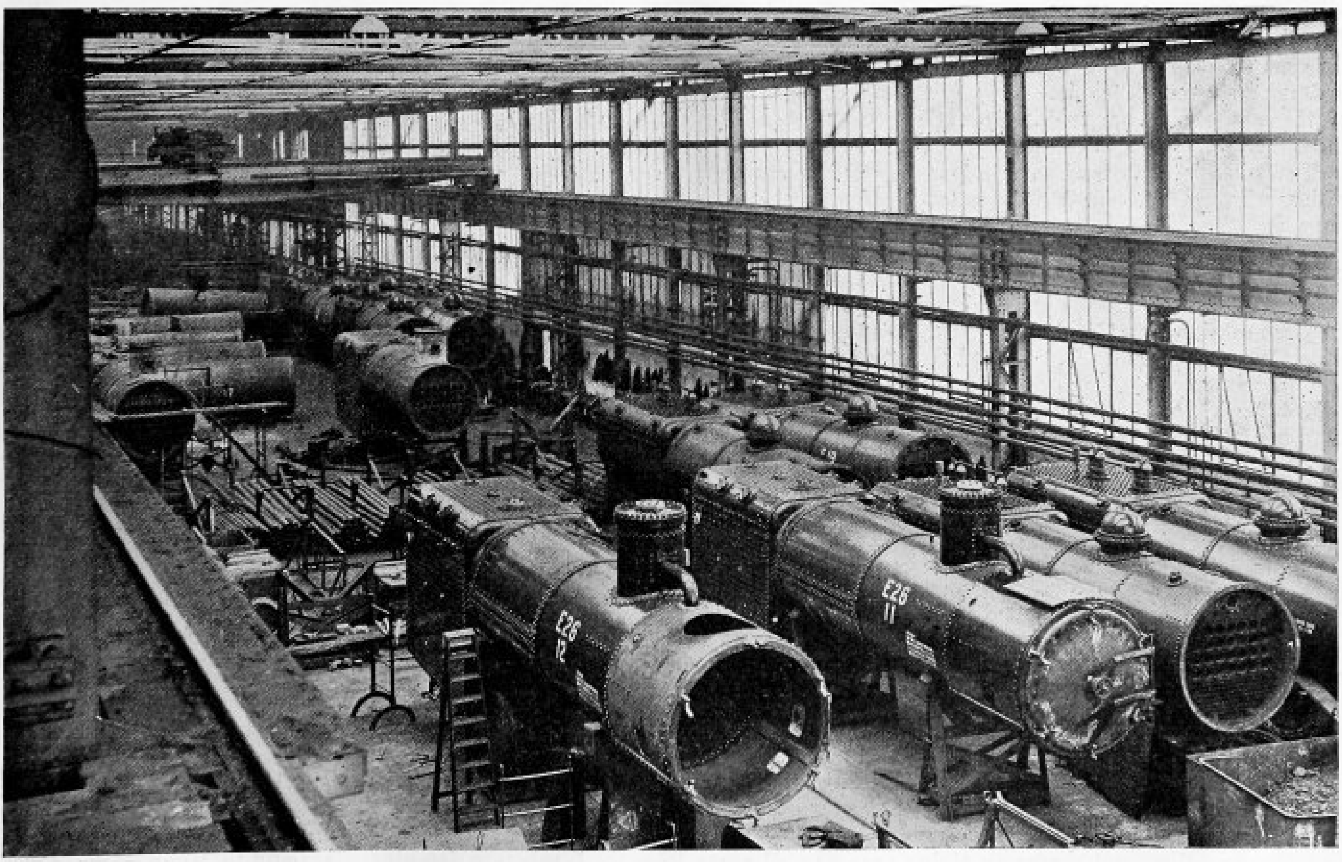


Fig. 5—Boilers on the Testing Stand in the South Bay, Being Made Ready for Foreign Shipment

cranes facilitates quick handling and transportation of the plates and other details. The machine tools number over 200, all of the latest types employed in locomotive boiler manufacture. The battery of boiler shell drilling machines and the hydraulic flanging presses were made by the machine tool department of Messrs. Armstrong, at the company's Openshaw works. The flanging presses work in conjunction with incandescent furnaces and electric charging machines, the equipment being sufficiently powerful to enable the very largest Belpaire throat plates to be flanged in a single heat. There are also four large hydraulic riveting machines, for shell work, one of these machines having a gap of 27 feet. In the smithy section another powerful press is installed for the welding of firebox foundation rings and similar work.

### Facilities for Air Tool Operation

Compressed air lines are located everywhere throughout the shops and utilized for riveting, calking, drilling, tapping and chipping. All the pneumatic tools employed are of Messrs. Sir W. G. Armstrong, Whitworth and Company's design and manufacture, and special devices are used for supporting the tools conveniently when at work. Gages, jigs and templates are used to the fullest possible extent in boiler fabrication to ensure accurate and interchangeable work, so that all unnecessary adjustment of pipes, and the like, is done away with when the boiler has been placed in the engine framing.

### Production Methods

From Fig. 2 an excellent idea may be gained of the eastern section of the north bay where the operations of laying out the sheets take place. In this department also the plates are drilled and punched and put through the various processes of shearing, planing and bending until they are in the proper shape for assembly. From the north bay the plates work into the center bay where they are assembled and riveted up. In a general view of the main bay, given in Fig. 3, the boilers are shown being tapped and stayed. In the center of the shop as well may be seen two shells in the hydraulic riveting machine. As previously mentioned, four of these machines are included in the equipment of this shop, the largest of the type having a gap of 27 feet.

A subsidiary section of the shop is completely equipped with machinery of recent design for the production of copper stays, and the like.

In the western end of the south bay boilers are put through the final process of fabrication and brought to a finished state ready for test. In the assembly of parts in this section the jigs and gages previously mentioned for insuring accurate alinement and position of pipes and fixtures are used to the best advantage.

Finally in Fig. 5 at the eastern end of the south bay a number of boilers which have passed the required hydrostatic and steam tests are shown in the process of being stripped of their mountings and made ready for foreign shipment.

### Testing the Boilers

The testing pits are located at the west end of the south bay and provide for the testing of four boilers simultaneously. Underground flues carry away the smoke and products of combustion to a stack outside the shop, so that the air within is not fouled. The testing pits are within a couple of hundred yards of a deep-water pier where the largest ocean-going steamers can be berthed. The dock is equipped with a hydraulic crane capable of handling loads up to 150 tons, so that the boiler department is excellently situated as regards convenience for overseas shipment. Its transport facilities in other respects are also particularly good, as there are rail connections and roadways giving access to all parts of the works.

# Labor Saving Kink for the Layer-out

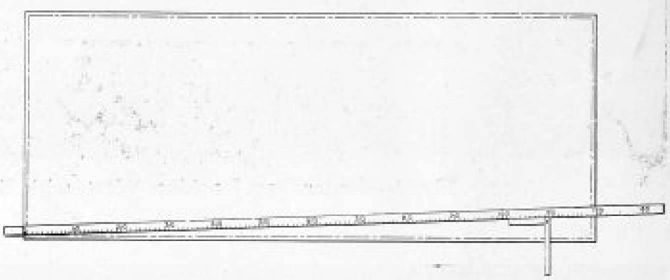
**By John S. Watts**

The spacing of the rivet holes in a circumferential seam is a very tedious operation, involving as it does the dividing up of the circumference into a large number of small parts, by stepping off with dividers, the final result only being obtained after at least three or four trial attempts.

The method shown in the accompanying sketch eliminates all the trial efforts, as it gives the exact spacing at the first attempt, and requires no extra skill in its use; in fact, less skill is needed.

The only equipment needed is a wooden straight-edge, with its edges marked with equal spaces, up to the extreme length likely to be needed, and an adjustable bevel, which latter instrument is usually to be found in any boiler shop, or if not, can be readily made or purchased. Referring to the sketch, we will assume that the plate is to be rolled for a 76-inch shell and the rivets are to be arranged with a two-inch pitch. The circumference of the 76-inch shell being 238.8 inches, the number of rivets in the circumferential seam will be 119.

The mode of procedure is as follows: Lay the straight-edge with its zero mark on one end of the line to be divided, and incline it until the 119 division on the straight-edge is



Method of Spacing Out Holes on Plate

on the center line through the other end of the line, as shown in the figure. Now clamp the straight-edge to the plate.

Next set the leg of the bevel parallel with the latter center line and then slide the bevel along the straight-edge and transfer each division from the straight-edge to the center line on the plate. This line will then be divided up exactly.

It is not necessary that the straight-edge should be set with the 119 division line on the center line of the longitudinal seam, if not convenient to do so, as the result will be just as accurate, so long as the bevel is set with its edges on this division, and the blade intersecting the end of the line to be divided. It is usually, however, as easy to set the straight-edge as shown and then there is little possibility of taking the wrong division when setting the bevel.

Whether the center lines of the longitudinal seams are at right angles to the circumferential seam, or at some other angle, as when the shell is to be tapered, makes no difference in the accuracy of the result.

It need hardly be emphasized that this equipment will convert what is now a most tedious and time consuming operation into an easy and quick one, and at the same time practically eliminate any possibility of spoiled plates through a miscount in stepping off the right number of holes.

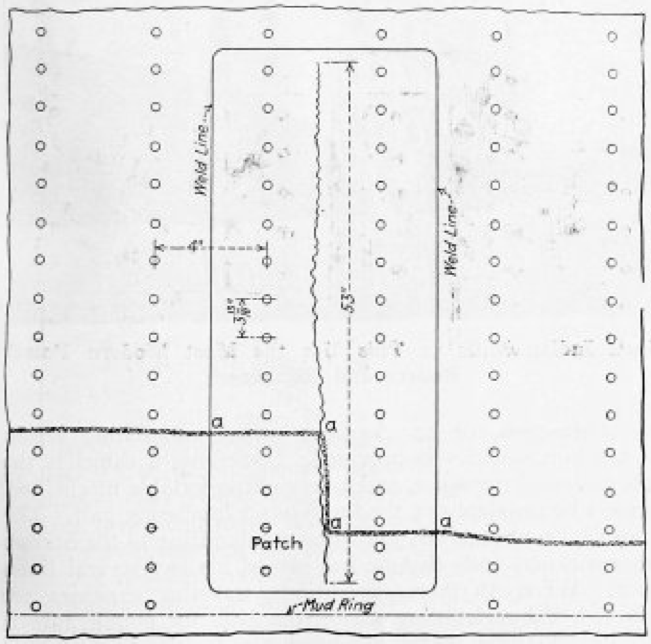
The straight-edge will prove most convenient if all four sides are marked with divisions of different lengths. For average work make these divisions 1½ inches, 2 inches, 2½ inches and 3 inches, respectively, so that it will be always possible to have a side that will give a convenient setting for the bevel gage for all the spacing that will occur. For wider spacing we can easily skip every other division.

# Comments on Autogenous Boiler Welding

### By C. W. Carter, Jr.

MANY boilermakers do not have much faith in autogenous welding but experience has shown that welds, properly made under the correct conditions prove satisfactory and effect great savings in the construction and repair of pressure vessels. It is essential in getting good results to have welders who thoroughly understand the limitations of autogenous welding and are extremely careful to see that the materials properly fuse together. Welders must also see that the sheets are clean; that the proper distance between plates is allowed; and that the material is of the best quality in order to secure satisfactory results.

Numerous boiler patches that have come under my observation gave good results, but I have also seen patches which should have been condemned. The New York state code and rules of the A. S. M. E. Boiler Code Committee specifically state that any surface welded on boilers must be supported, or in case the boiler is repaired by patching, stays must project through a patch before it can be welded. The satisfactory welding of patches may be obtained by cutting out the patched portion, beveling the edge to 45 degrees and also the edge of the new patch to be applied. The patch is put in place, its size being such that a distance of 5/32 inch is provided between the sheet and the patch. Also, the rows of staybolts adjoining the patch are cut out to aid in expansion and to prevent leaky bolts which would occur after the patch was welded in place. Unless this precaution is taken, new cracks are almost sure to develop owing to the lack of provision for expansion and contraction.




**Method of Repairing Boiler with Long Vertical Crack Due to Freezing**

A locomotive was recently sent to a repair shop for light running repairs, and after standing outside the shop for four days was finally brought in for repairs. It was then discovered that the water had not been drained from the boiler but had frozen. The gang foreman ordered steam turned into the boiler after the dome cap and hand hole plates were removed as far as possible. As the boiler maker who was cutting flues at the time heard a loud snap he investigated and found the right side sheet had developed a crack 53 inches long. This crack extended vertically from a place just above the mud ring upwards nearly to the crown sheet flange as shown in the drawing. The stays were ⅞ inch and 1 inch in diameter and had a pitch of 3 13/16 inches. Repairs were made by cutting out the cracked portion including two rows of bolts and a section of an old weld as illustrated. The edges of the sheets were beveled to form an angle of 45 degrees and the new patch fitted, its edges also being beveled to 45 degrees. All joints were electric welded and up to the present time the patch has proved entirely satisfactory.

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# Work of 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, Mr. C. W. Obert, 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.

Below are given the interpretations of the Committee in Cases Nos. 395, 397, 406 and 407, as formulated at the meeting of September 20, 1922, and approved by the Council. In accordance with the Committee's practice, the names of inquirers have been omitted.

Case No. 395. (Annulled.)

Case No. 397. (Reopened.) *Inquiry:* Was it the intent, in paragraph 199, to permit a value of 175 for *C* where copper washers were used as described in the definition for *C*?

*Reply:* It is the opinion of the Committee that the washers should be of steel to permit the use of 175 for *C*. Copper washers may be used provided the value of *C* is taken the same as if no washer were used.

Case No. 406. *Inquiry:* Will a form of forged steel boiler nozzle with flange pressed hot over the end neck of the nozzle which is compressed or forged into a recess or groove in the flange conform to the requirements of the Code?

*Reply:* It is the opinion of the Committee that this method of forming a steam outlet connection meets the requirements of the Rules in the Boiler Code.

Case No. 407. *Inquiry:* Is it permissible under the Rules of the Code for Boilers of locomotives to mark a safety valve A.S.M.E. Std., when it is not fitted with a lifting device, whereas paragraph 282 of the Power Boiler section of the Code requires such a lifting device?

*Reply:* Inasmuch as paragraph 282 of the Power Boiler section of the Code requires a lifting device and there is no similar requirement in the section of the Code for Boilers of Locomotives, it is the opinion of the Committee that safety valves for use in stationary service under the Power Boiler Rules must be fitted with a lifting device and those intended for use on boilers of locomotives need not have such a lifting device, and that it is proper in each case to mark the safety valve A.S.M.E. Std.

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Models of the Connelly watertube boiler, manufactured by the D. Connelly Boiler Company, Cleveland, O., were exhibited at the Power Exposition held at the Grand Central Palace, New York, December 7 to 14, showing the positive circulation obtained in this type of boiler.

# Inspecting Boilers in British India

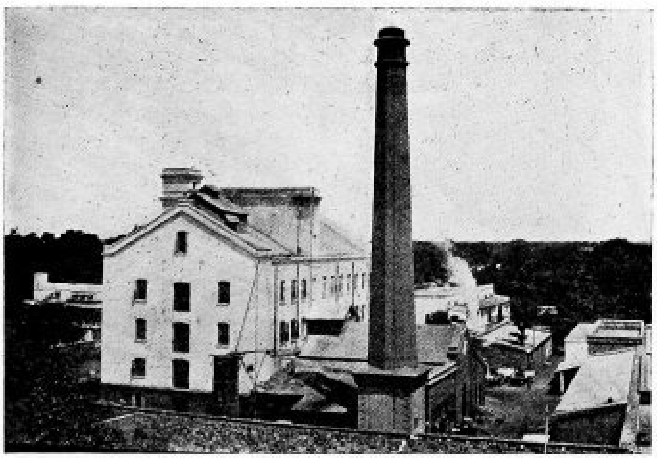
## Power Boilers in Jute, Sugar, Flour and Other Mills Demand Inspector's Constant Attention

**By George Cecil**

ALTHOUGH the Indian boiler inspector is not highly paid, the appointment is much sought after, for the billet is a government one and carries with it a small pension. Having attained his fifty-fourth birthday, the boiler inspector is fixed to retire into private life and to pass the remainder of his days on the savings of some thirty years—plus the trifling pension. If the pensioner is a European, he rents a tiny bungalow in the Himalayas, leading an uneventful existence and breathing the fresh mountain air year in and year out. Should the ex-inspector have become Indianized, the heat of the "plains" means nothing to him. He is well content to "stew in his own juice," as the Anglo-Indians inelegantly put it. In neither case is life in his native country, England, possible for the expatriated one. 'Tis so many years since he has been "Home" (the exile always speaks of England as "Home") that life west of Port Said would not appeal to him. Besides, living is far cheaper in India, and ways and means have to be considered.

### A Much-Traveled Individual

Meanwhile, the retired boiler inspector is happy in the remembrance of past glories. He has been in government service, and users of boilers have trembled at his frown and sunned themselves in the light of a good report. For at least three decades he has wielded power—if on a comparatively small scale. He is a man of note.

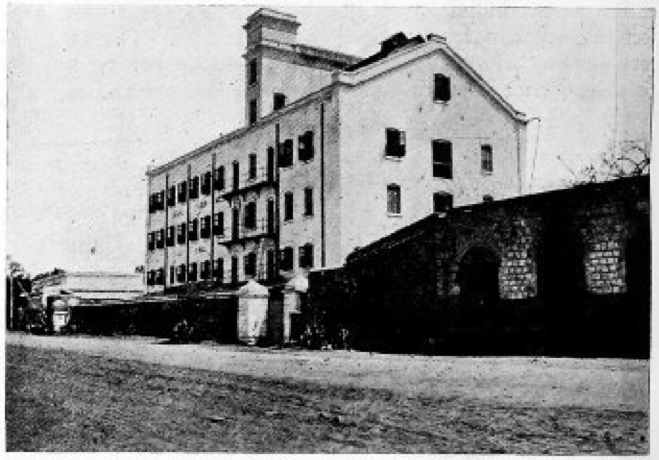


**General View of a Calcutta Flour Mill, Which Is One of the Best Equipped in India**

The boiler inspector's duties take him all over India—a vast country. The jute mills of Bengal and the cotton mills of Bombay have his attention, and there are paper mills east and west. Sugar mills have been erected at various points many hundred miles apart; and the inland river steamer companies and railway companies are of abounding activity. Calcutta, Bombay, Kutachee and Madras have their engineering works, while smaller concerns flourish in unexpected places. The indigo factories employ steam power on a modest scale, while the flour mills at Delhi, Calcutta and Bombay are equipped with the latest machinery.

The boiler inspector visits each in turn. He may suddenly be called from Calcutta to Bombay, a three days' railway journey, to replace a defunct colleague, for in India cholera annually thins the ranks of boiler inspectors, while dysentery, that scourge of the East, removes many a white man. And in the regular course of duty three or four nights are spent in the train, should several boilers require attention in one week. Altogether a wearing life—and an ill-recompensed calling.

Upon arriving at the railway or river steamer terminus, a second journey may have to be undertaken. If the distance is not great, the boiler inspector hires a pony and rides to his destination, or an elephant—whose undulating action makes him seasick—is provided. Sometimes a camel is the sole means of transport, and a very uncomfortable means, too, since, like the elephant, the brute has a lumbering gait. The man who cannot do his job without submitting to the horrors of seasickness feels that he has earned his pay several times over. When on these expeditions, traveling expenses are allowed, the scale being a generous one, for double fare is drawn. Nothing, however, compensates for the discomfort of the after-journey.



**Such Indian Mills as This Use the Most Modern Power Boilers and Equipment**

There also is the ekka, a sort of sedan chair on wheels drawn by a pair of bullocks. It is used where the roads are too bad for a pony cart, its construction being such that nothing will break the springless and inexpressibly uncomfortable vehicle. On descending from his perch, the poor, stiff boiler inspector is a wreck.

### The Easy-Going Half-Caste

The half-caste inspector does not mind the above-mentioned inconveniences. Indeed, these strange people, when applying for the post lay special stress on the fact that hardships mean nothing to them. But if the Eurasian performs any sort of journey without turning a hair, he is not always deaf to bribery . . . "the boiler's existence," he argues, "should be equal to my tenure of office. Not till I retire will I condemn it. If I refuse to pass these ancient boilers my fees will diminish. Better far to pass, and repass them, and, if the manager offers me a trifle for being so obliging, why should I not accept it? Rupees do not grow upon banana trees . . ." So the complaisant semi-native acts as his conscience dictates—and puts by money. As his living expenses are about half those of the white boiler inspector, he saves considerable.

Every now and then the *Kerani* (man of mixed race) is caught out and dismissed the service with ignominy, forfeiting a pension and losing a much-prized social position. Such instances, however, are rare, for the man of color is assisted by an inherent cunning which enables him to keep on the right side of his superiors. He knows how far it is safe to go—none better.

Some of these antiquated boilers have left very many years' service behind them. Near Calcutta there is one, which, together with the curious old beam engine which it feeds, has been in action longer than the oldest inhabitant can remember. Twenty years ago even the most hardened Eurasian inspector jibed at certifying its plates for fear of giving himself away. At the time of writing the ancient boiler still is in use, having been patched up amazingly firm. Decidedly, the work is a triumph, even if the result will eventually be an explosion.

Bombay also runs to a very old boiler, said to have been in use for close upon a hundred years. A considerable number of boiler inspectors must have made its acquaintance.

# Methods of Training Railway Shop Foremen*

## A Discussion of the Need for Foreman and Group Leader Training; Outline of a Typical Training Course

**By Hugo Diemer**

HOW can the latent capacities of the railway shop foreman be most effectively developed so as to make him realize and exert to the fullest his part in bringing about greater efficiency?

In my experience as a shop superintendent and industrial engineer, I have had occasion to observe the type of mechanic and foreman who has come into other industries from the railway shop. The outstanding characteristics of the railway shop man when he comes into a manufacturing shop are:

1. A very praiseworthy quality of resourcefulness. He has been accustomed to get results with poor equipment and poor tools. He has been schooled in the importance of getting work done the best way possible with poor facilities. The outstanding fact, however, is that he does manage to get the work done somehow. If he happens to get into the maintenance and repair department this quality is a very desirable one.

2. This willingness to be satisfied with makeshifts is, however, quite harmful in work where interchangeability and economy of production are essential. Neither railway mechanics nor railway shop foremen taken as a whole, have been given systematic training in either modern mechanical methods or modern methods of organizing production work. Is not this really the reason why many railroad shops find it cheaper to farm out a great deal of their work to shops where modern methods have become thoroughly established? I have had occasion as head of engineering and shop work in two large educational institutions to be located very near to, and to be closely associated with the shop work of a prominent western railroad for three years, and with the shop work of a prominent eastern railroad for eleven years. In the case of the western railroad shop I have seen the installation of improved stores methods, better equipment and a more satisfactory wage system which, while it constituted a great step forward, did not by any means put the railway shop on a basis of real equality with a modern commercial industrial shop. In the case of the eastern railroad which about ten years later adopted these methods, I saw the same improvement. It was, however, a slow process of conversion of even the engineering and higher executive staff that brought about these changes. This staff was by reason of the fine reputation of the road as a whole, inclined to discount the idea that they could learn anything from other industries. Having now made the improvements in the way of centralizing stores, better equipment and more scientific piece rates they are still inclined to be skeptical as to the applicability of the organization and training methods of the modern industrial shop to the railroad field.

In the railroad shop as in the industrial shop the foreman is the connecting link between the management and the worker—the key man, the top sergeant who reports the policies and orders from the front office and passes them on to workers under his direction. It is his job to convert plans into product. To do this he must know how to handle men; he must understand company policies; he must be able to pass them on to his workers in a manner that they will understand; in other words, he must be a leader, an executive. Nobody can attain leadership without paying the price for it, which means he must be willing to study. The present day foreman cannot employ the old "driving" tactics and hope for much success in his efforts.

Too often the foreman promoted from the ranks has become overbearing and arrogant in his treatment of those now under him. If the foreman is cheerful, loyal and efficient, the men under him naturally tend to become that way also; while the foreman who is unfair, a tyrant, or a toady, will do more damage to an organization in a day than his influence on production can undo in a year.

The foreman of today is a human engineer and must be able to gain confidence and good will. As such he must prepare himself for industry's big job, the education of the worker. Education must therefore begin with the foreman, for from him it will naturally reach the worker.

The outstanding need in industry today is for foremen who not only know what is to be done and how to do it, but who also know how to convey that knowledge quickly and surely to the workers directly responsible for doing a job. Training departments, no matter how well developed, can never take the training entirely out of the hands of the foreman on the job. Getting successful results in training employees involves not only methods of quickly acquiring manipulative skill but also standardizing intelligent leadership.

### Development of Foremanship Training

Foremanship training is a term which has come to be applied to those agencies which attempt to prepare individuals for discharging effectively the responsibilities of the foreman's job. It further is used to familiarize others whose work draws them in contact with foremen and foremanship problems with the underlying principles and practices of foremanship.

*Reprinted from the *Railway Mechanical Engineer*.

As the idea of foremanship training has grown, it has come to be generally recognized that a survey of the people who can profitably make a study of foremanship includes a wider range than just practicing foremen. It is desirable to include in this training men filling minor executive positions such as gang leaders, sub-foremen, assistant foremen; also others such as storekeepers, tool department heads, cost clerks, inspectors, who come in contact with foremanship problems.

Few foremen have ever carefully analyzed their own methods of handling men and work. The foreman is not to be blamed for this failure to analyze his situation, for it is but the results of the schooling which industry has given him ever since he began as a workman. There is something about the atmosphere of the average shop with its commands and orders, its "do as I tell you" and "ask no questions" which dulls the finer sensibilities of both foreman and worker. It is only natural that a foreman should acquire a dual personality; on the one hand a personality of good fellowship, which reveals itself to his family and relatives, and on the other hand the petty tyrant of the shop. The foreman does not want to assume a mask in the shop, but he does it because he thinks that is the way the management wants him to act. Under the pressure of his position he acts hastily, tactlessly and at times blunderingly.

Much of the apparent loyalty of the foreman to the management is only assumed and is part of the occupational mask mentioned before. In foremanship classes, where some representative of the management sits in with the foremen, it has been found that in answer to the question, or in the point of view taken in the discussion, the foremen talk only as they think the management would like to hear them talk. Only too often the management gets from the foreman that which the foreman thinks the management would like to have.

In reality, loyalty is measured in the way the foreman feels at heart toward the management. If America has been able to succeed so well industrially in the last few years with discontent and disloyalty so prevalent, what could she not do if the foreman and the workers had their hearts in their jobs? After all, the biggest result to be gotten out of any plan of foremanship training is this co-operative spirit founded on a clear understanding of the real basic facts connected with the foreman's job.

### Four Common Methods of Training Foremen

The methods of foremanship training and the content matter of training courses are so intimately interwoven that it is best to consider them together. There are four prevalent methods of such training:

In the first, or disconnected lecture method, it is customary to get department heads to give prepared talks to foremen on such subjects as Purchasing, Storekeeping, Cost Accounting, Maintenance Problems, Planning, Scheduling, Employment, etc. In this method we can expect increased general intelligence with regard to the problems of the organization as a whole. If some lectures of an inspirational type are introduced they may produce an inspirational effect provided the men are able to follow the lecturer and thoroughly grasp the points set forth.

The second plan, namely of co-ordinated lectures, is usually the outgrowth of a year's experimenting with the first plan. The department heads' talks are edited and put into educational form and all the talks are arranged in some kind of rational sequence. In this method we also often have a specific objective. For example, better co-operation between foremen and their superiors, or the improvement of the foreman's attitude in dealing with his men. This method may be expected to promote general improvements in the field covered by the lectures, if the lecturers know how to create and maintain interest and have an aptitude for imparting information clearly.

In the third, or conference method, the responsibility for results is centered in the group leader. He has a sequential program as in the second plan but instead of having the foremen listen to a talk they get only a few remarks by the leader accompanied by perhaps a chart or two. He asks questions which have been carefully prepared with a view to tying up the work of the man who is asked the question with the subject under consideration. The object is to stimulate the members of the group to think and form opinions and judgments of their own.

The members of the group are active, not passive or merely listeners. The conference leader in this plan must establish personal relations with members of the group and vary his method according to the particular make-up of different group members. The conference plan can be used to give training by means of the case method under it. Pooling of experiences is made possible. The number of individuals competent to conduct conferences without special training is of course limited.

The problems and questions must be prepared in advance. In order that the foreman can solve these problems we must first of all develop in him what we may call an industrial intelligence. The development of industrial intelligence involves a discussion under the leadership of men familiar with the actual conditions under which the foreman operates. The program of discussion should be built around men, materials, equipment and systems as they exist in the particular work of each member.

In the fourth plan the conferences are supplemented by systematic home study. There is a consensus of opinion among the best authorities that a definite co-ordinated content matter in the way of reading and problems to be studied at home by each group member, greatly strengthens the conference plan. Best results are obtained when this content matter is brought home to the foreman in such a way as to develop his thinking and initiative in applying the ideas to his own work and problems.

At present there is a wealth of material available to form a basis for the content matter of a course in foremanship training. Standardized courses in detail have been prepared with the co-operation of the best educational, industrial and editorial talent in the country. The adaptation of this standardized material to the peculiar needs and conditions of any business is far more easily accomplished and much more economical than to attempt to prepare special home-made courses.

In the conference plan with home study, it is particularly important that the man who conducts the conferences have the unqualified co-operation of a chairman of the group. This chairman is preferably a man whose position outranks that of the other members. In order to get the best work from the group the chairman must conscientiously do all the required home study and work out the problems himself. It is his example and leadership that will result in 100 percent work by the other members.

### Outline of Typical Training Course

As a typical example of the content matter of a foremanship training course the following outline of a course which I have helped to create will be representative. The arrangement and sequence in this course have been given careful thought and co-operation by an advisory counsel composed of industrial managers, production managers, personnel managers, educators and foremen.

Fundamentally the instructional material is based on the application of the methods of job analysis to the foreman and his job in the plant. In making this job analysis questions were handed to over 5,000 foremen in various industrial plants so as to get the foreman's own expressions and ideas as to what a foreman has to do and what kind of a man he ought to be. With this idea of job analysis as a basis one running all through the course, the material is divided into four groups.

The first group deals with the human element in industry and the foreman's responsibility for molding all sorts and conditions of men into a unified working force. The competent foreman must grasp his opportunity to build the team spirit. Before he can do this he must learn the qualities, characteristics, intimate desires and motives of men, how men think and feel and act; the foreman must know how to use this knowledge of human qualities to attain to leadership himself. He must learn how to develop the essential personal qualities for team leadership. This first group also deals with the subject of training a working force, discussing fundamental principles and methods of teaching and training in the shop.

The second group deals with job analysis with illustrations by cases and problems. The flow of work through a plant, the principles behind all planning and production methods, the effect of shop conditions in getting out the work, and the qualities of a good production man are discussed in this group.

The third group deals with the foreman as a business man. It discusses his participation and co-operation in stock keeping activities in keeping down production costs and material wastes. It presents the purposes and typical records of central stores and efficient practice in stock handling, not only in the stockroom but everywhere in the shop. The fundamentals of cost keeping are taken up, the stress being on practice rather than systems. The topics discussed are not of an accounting nature but include such matters as productive and non-productive labor, material and expense, depreciation, predetermined costs and cost control.

The fourth group discusses foremanship in its relation to economic and social matters. The economic facts and factors on which production and industry are based, the knowledge which it is necessary for any men to possess who would think straight on industrial questions and shop problems. Certain aspects of the law are taken up, with which the foreman should be familiar. Those activities of industrial service which are usually carried on by the personnel department when there is such a department, but in which the foreman must be a participating factor, are taken up in this group.

### Group Leaders Must Be Trained

The recognition of the benefits to be obtained from the group training of foremen has resulted in the development of courses of instruction for men desiring to become group leaders. We have recent bulletins of the Federal Board for Vocational Education and of the various state departments devoted to the subject of instructor training in foremanship work. Personally conducted classes for the training of instructors and group leaders in foremanship have been organized and carried on as resident courses by state and private educational institutions and as extension work of various state institutions.

Examples of what is contained in these teacher training or group leader training courses are as follows:

Unit 1—The analysis and classification of what is to be taught.

Unit 2—Thinking it over; what instruction is; how to get the best results out of discussion; developing broader intelligence.

Unit 3—Lesson planning; tying up auxiliary information with a standard lesson.

Unit 4—Difficulties in learning; getting local production problems into an effective instruction sequence.

Unit 5—Handling a group for effective instruction. Interest and interest factors; instructional conditions as affected by surroundings and materials.

The above is the merest abstract of what is the general content of intensive teacher or group training courses. But it will serve to show how generally we are coming to recognize the important position of the group leader in foremanship training. We must recognize also that in this field as in the teaching field in general a person may have the sincerest desire to be a good group leader, and may take the best of training and still fail. The earnest hard worker who lacks personality and vitality will not fill the bill. Neither will the smart fellow with lots of assurance and effrontery but without a background of real hard work. The most successful group leader is apt to be a man who has had actual industrial experience either by necessity or by choice and who has advanced to a higher position. A man of good physique with pronounced personality and who has sufficient humility to study hard the fundamentals applicable to all foremanship training as well as the peculiar problems of his own situation comes nearest to filling the requirements.

According to the last published census of manufacturers, 98 percent of all American industrial plants employ less than 250 people; there are 3,000 plants employing 250 to 500 people; 1,400 plants employ from 500 to 1,000; and only 648 plants employ over 1,000 people. The big industries in general have come to recognize pretty well the advantages of foremanship training.

### Foreman Training Important as Scientific Management

It is the realizations of the tremendous field of possibilities in the smaller industries that justifies the growth of the movement for foremanship training. We are only at the threshold of this movement. Those who are active in the movement and who have had an opportunity to observe and measure its results feel confident that ultimately it will prove as important as scientific management in bringing about greater industrial efficiency and in maintaining America's industrial supremacy.

# Two Boiler Shop Devices

**By C. E. Lester**

A COMBINATION beading tool and finished bead gage that may be dimensioned in accordance with the standard practice on each individual road is shown in Fig. 1. This gage is valuable for use in the manufacture of beading tools, setting flues to the proper length and testing the finished contour of the beads.

It is more or less impractical to attempt the design of one standard beading tool that will fulfill all the requirements in various localities and under varying conditions as well as to satisfy the pronounced ideas that many boiler makers have on the subject. However, there are but three prime factors in the construction of a beading tool that will form a perfect bead. These are: first, a predetermined fixed length of flue

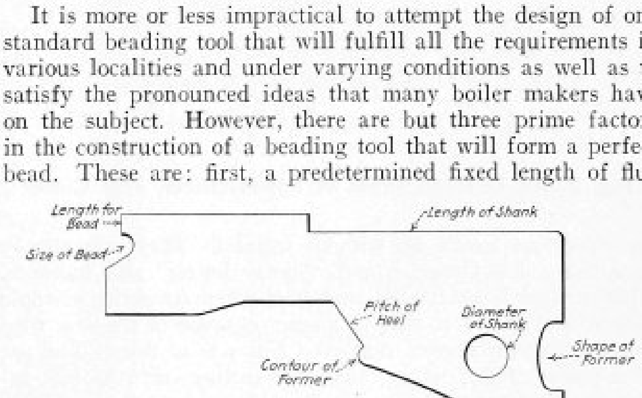



**Fig. 1—Combination Gage for Beading Tools and Beads**

outside the sheet to form a bead; second, a standard gage thickness of flue that runs true to gage; third, a forming recess in the beading tool that is of the exact size to form a perfect bead, taking into account the amount that the flue will upset in working.

Auxiliary to these prime factors, there are needed in the making of a correctly designed beading tool (a) a forming recess in the tool parallel to the axis of the tool; (b) a former narrow enough to conform its movement to the small diameter of the flue without marking or cutting the bead; (c) a former with two convex surfaces for the same reasons.

### Narrow Working Surface Needed

In the rotary movement of the air hammer necessary to turn the bead without making a burr inside the flue, it will be found that the working surface of the former, as illustrated, must be very narrow, otherwise the tool is handled with difficulty and puts rough ridges in the beads. The curve of the thumb is purely a matter of personal preference. For those who desire the flue beaded straight down without flaring, a comparatively straight thumb will suffice. For those who first flare the flue, the thumb may vary from nearly straight to one curved to strike the inner surface of the flue on the opposite side. This latter type prevents "curling" the air hammer so much that the heel of the tool cuts the sheet. This particular feature has some merit in it with an unskilled man handling the tool; otherwise none.

Due to the severe service that beading tools receive, they rapidly become worn and over sized, requiring repairs, or rather frequent dressing if flue work is kept standard. It is believed that a gage of the general description of the one illustrated in Fig. 1 should be in the hands of the tool room foreman, boiler shop foreman and boiler inspector. The tools should be frequently checked and kept to gage. Workmen should be required to draw beading tools on tool checks and return them at the end of every job that each tool be checked by the gage before reissuing.

### Removing Old Flues

The old style of ripping and closing in flues preparatory to removal is a practice so well known that a discussion of

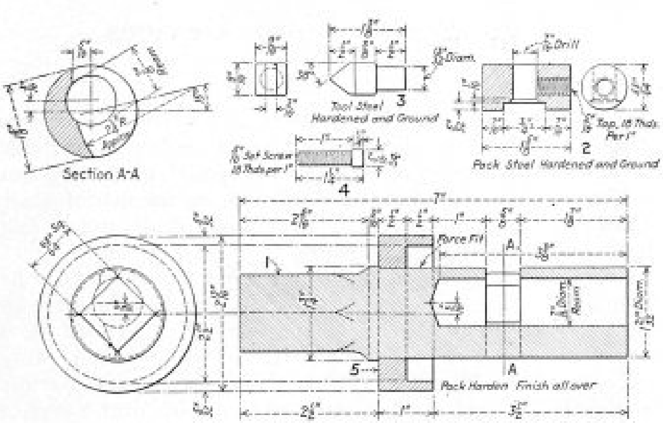



**Fig. 2—An Effective Form of Power-Driven Flue Cutter**

the operation would be without interest. The tools simply comprise a flat chisel, ripper, "oyster knife," and hammer. This method is practically universal when removing a single defective flue and is still in vogue on some of the less progressive railroads when removing full sets of flues. The use of a power-driven rotary cutter for cutting off flues just inside the front sheet is by far the best and most economical method of removal. In fact, the use of this type of cutter is rapidly superseding all other methods. The cutter, illustrated in Fig. 2, is but one of several of the same general type. It gives good results and has merit in its simplicity of construction and operation.

Referring to the illustration, 1 is squared shank of a round piece of steel provided with a 7/8-inch eccentric hole carrying tool holder 2 and hardened tool steel cutting point 3. The cutting point is held in place by a set screw 4. The steel ring 5, recessed to extend over a flue bead, is a force fit on the body of the tool and provides for cutting flues at the proper point. From Section A-A it is evident that revolution of the spindle clockwise will cut a flue and counter-clockwise will release the cutting point allowing the tool to be removed from the flue.

# A Cooperative Effort to Secure Welding Information

THE history of the word "welding" is associated with the idea of the word "boiling," and in the early days meant the beating of heated iron.

Welding is now recognized as one of the greatest aids in the construction and repair of metal structures and parts. The matter of fastening two pieces of metal together is one of the fundamental problems of mechanical engineering, since all machines and metal structures are made up of many pieces of metal fastened together. As a general proposition a riveted or bolted joint has a tensile strength considerably less than the original piece, whereas the welded joint may be made as strong as the original section. Further, a welded joint is oil and water tight up to its breaking point, while riveted or calked joints leak badly at as low as twenty-five percent of their ultimate strength.

Time, labor, and material may also be economized in correctly designed welded structures. In the past the wearing of a fraction of a cubic inch of metal from one of the surfaces of a steel part made it necessary to scrap the part with a consequent loss of the labor investment. But with the introduction of autogenous welding processes it became possible to stop this economic waste. The repair of broken members of a machine has been another important engineering achievement made possible by the electric, gas, and thermit processes of welding.

While these processes have been in use for some time, there has been no definite agreement as to the best methods of procedure. The problems are complex from the metallurgical as well as from the mechanical standpoint.

Now it is time to tell of an interesting piece of organization work.

The American Welding Society was organized on March 28, 1919, its purpose being to extend the knowledge of the art of welding and its field of industrial application. But something more than this society was needed. To bring about the desired coordination of effort in learning basic facts about welding there was organized by the Society and the Division of Engineering of the National Research Council an Advisory Committee on Welding Research and Standardization known as the American Bureau of Welding. This Bureau consists of twelve representatives appointed by the American Welding Society, two each from each local section of that Society, and one each from some twenty other interested scientific, engineering and classification societies, and government bureaus.

In addition, certain members at large are appointed because of special fitness. Eleven research committees were created, and as a first step critical summaries of existing knowledge on the most important phases of the work were prepared. It would be foolish to start with a research where we do not have available results of a large amount of work which has been done by individual investigators and by various companies. To learn just how much we know and then go after what we do not know, in a cooperative way that will avoid duplication of effort and bring the best minds to the immediate problems—such is the plan.

Already there have been prepared for publication—

(1) Specifications for standard tests for welds,
(2) Specifications for welding wire,
(3) Specifications for electric welding of storage tanks,
(4) Standards for arc welding apparatus.

A study of welding rail joints is in progress; also investigations in electric, gas, and thermit welding. In co-operation with the mechanical engineers, the refrigerating engineers, and others, research in welding and unfired pressure vessels is being planned.

# Rules for Use of Welding in Unfired Pressure Vessels

## Section of Preliminary A. S. M. E. Report on Unfired Pressure Vessel Construction Devoted to Acceptable Welding Practice

IN the November issue of THE BOILER MAKER a brief outline was given of the preliminary report of the "Unfired Pressure Vessel" Code prepared by a special sub-committee of the A. S. M. E. Boiler Code Committee. As noted, this outline was intended to suggest the subject matter discussed in the Code so that those interested in the matter might obtain complete copies of the Code from the secretary of the Boiler Code Committee, C. W. Obert, 29 West 39th street, New York.

The fact was brought out in the introduction to the outline in the last issue of the magazine that this preliminary draft of the Code will not be given a further public hearing, as it has already been discussed in open meetings on several occasions. However, all who wish to make constructive criticisms of the measures or suggest improvements in the subjects covered should take up the matter with the Boiler Code Committee through the secretary.

One section of the Code is especially important—that outlining the rules for welding, and the paragraphs devoted to the subject are given below.

Reference is made to the classes of vessels to which the rules on welding apply so that this classification is given herewith. The three classes are contained in Section VI.

### CLASSIFICATION

U-1. The vessels to which these rules apply are divided into three classes:

*Class A:* Vessels for containing liquids at temperatures above their boiling points at atmospheric pressure, inflammable substances, or any gas, over 6 inches in diameter, more than 1.5 cubic feet in volume and carrying over 15 pounds pressure per square inch, except pressure vessels used in domestic water supply and those provided for in Class C.

*Class B:* Vessels for containing liquids, the temperatures of which are under control so as to be below their boiling points at atmospheric pressure, over 9 inches in diameter, more than 4 cubic feet in volume and carrying over 30 pounds pressure per square inch but not to exceed 125 pounds pressure per square inch. For pressures over 125 pounds per square inch, the rules in Class A vessels apply.

*Class C:* Vessels for carrying on cooking or similar heating processes of food, medicinal or other chemical preparations, having surfaces coated with glass or similar enamel; and limited to a maximum allowable working pressure of 150 pounds per square inch.

### VESSELS CONSTRUCTED WITH WELDED OR BRAZED JOINTS

U-87. All Class B vessels may be fabricated by means of autogenous or forge welding, or brazing provided the rules governing the method adopted and as given in Paragraphs U-92 to U-151 of the Code are followed:

U-88. The following Class A vessels may be fabricated by means of autogenous welding with the exception of longitudinal seams when the rules given in Paragraphs U-92 to U-110 are followed:

*a* Air tanks in which the pressure does not exceed 150 pounds per square inch.

*b* Tanks for containing other than noxious or explosive gases other than ammonia, when the pressure does not exceed 150 pounds per square inch.

*c* Tanks for containing liquids other than those which are noxious or explosive, when the pressure does not exceed 150 pounds per square inch.

*d* Tanks for containing ammonia shall be built for a maximum allowable working pressure of 250 pounds per square inch and installed in connection with safety valves to prevent this pressure being exceeded.

U-89. Class A vessels for any uses or pressures may be fabricated by means of forge welding when the rules given in Paragraphs U-111 to U-135 are followed.

U-90.—Class A vessels for any pressures and for any temperatures not exceeding 450 degrees F., may be fabricated by means of the brazing process when the rules given in Paragraphs U-136 to U-151 are followed.

U-91. The design and construction of all vessels with welded or brazed joints shall conform to and be based upon the formulas, specifications and data which are given in this Code.

### RULES FOR THE AUTOGENOUS PROCESS OF WELDING

U-92. *Processes.* The autogenous process, so-called, shall consist of welding by means of either the oxy-acetylene process or the electric-arc process, using a metallic electrode, either bare, coated or covered.

U-93. When properly welded by the autogenous process, the strength of a joint may be taken as a maximum of 28,000 pounds per square inch of net section of plate.

U-94. *Terms.* The term *base metal* as used herein shall mean the metal or metals of which the vessel is constructed and which are joined together by the welded seam.

U-95. *Filling Material.* The term "filling material" as used herein shall mean the weld-rod, filling rod, electrode or other metal which is used to join together two sections of the base metal, or metals. The following material has been shown to give acceptable results and may be used:

FOR OXY-ACETYLENE WELDING

| | |
|---|---|
| Carbon | not over 0.06 percent |
| Silicon | not over 0.08 percent |
| Manganese | not over 0.15 percent |
| Phosphorus | not over 0.04 percent |
| Sulphur | not over 0.04 percent |
| or | |
| Carbon | 0.18 to 0.22 percent |
| Manganese | 0.40 to 0.50 percent |
| Phosphorus | not over 0.04 percent |
| Sulphur | not over 0.04 percent |
| Nickel | 3.0 to 3.5 percent |

FOR ELECTRIC-ARC WELDING

| | |
|---|---|
| Carbon | not over 0.06 percent |
| Silicon | not over 0.08 percent |
| Manganese | not over 0.15 percent |
| Phosphorus | not over 0.04 percent |
| Sulphur | not over 0.04 percent |
| or | |
| Carbon | 0.12 to 0.18 percent |
| Silicon | not over 0.06 percent |
| Manganese | not over 0.40 to 0.60 percent |
| Phosphorus | not over 0.04 percent |
| Sulphur | not over 0.04 percent |

U-96. *Weld Metal.* The term *weld metal* as used in this Code shall mean the metal of which the welded seam is composed after welding is completed, and which is described as being the metal deposited between the edges and for the purpose of joining the sections of the base metal. This metal may be, and usually is, a combination of base metal and filling metal, modified in the process of fusing.

U-97. *Material for Base Metal.* The base metal shall not exceed ⅝ inch thickness and shall be made by the open-hearth process, of soft and good weldable quality, and shall conform to the following requirements:

### Chemical Properties and Tests

U-98. *Chemical Composition:*

| | |
|---|---|
| Carbon ............................ | not over 0.15 percent |
| Manganese ........................ | not over 0.60 percent |
| Phosphorus ....................... | not over 0.04 percent |
| Sulphur ........................... | not over 0.05 percent |

The silicon, nickel, or chromium content shall not be of such amount as will affect adversely the welding qualities of the plate, and in any event shall not exceed 0.05 percent.

U-99. *Ladle Analysis.* An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus, and sulphur. This analysis shall be made from a test ingot taken during the pour of the melt. The chemical composition thus determined shall be reported to the purchaser, or his representative, and shall conform to the requirements specified in U-98.

### Physical Properties and Tests

U-100. *Tension Tests.* *a* The base metal shall conform to the following requirements:

| | |
|---|---|
| Tensile strength, maximum, pounds per square inch.. | 55,000 |
| Yield point, minimum, pounds per square inch ...... | 24,000 |
| Elongation in 8 inches, minimum, percent.......... | 1,500,000 |
| | Ten. Str. |

*b* The yield point shall be determined by the drop of the beam of the testing machine at a speed not exceeding ½ inch per minute.

U-101. *Test Specimens, Bend Tests, Finish, Etc.* The test specimens, bend tests, homogeneity tests, number of tests,

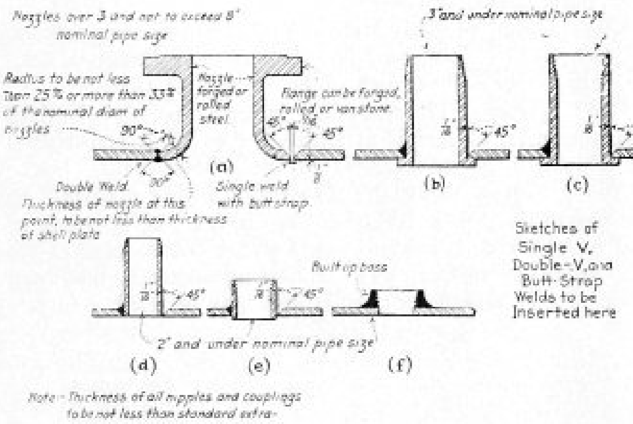



**Fig. U-3—Methods of Autogenously Welding Nozzles**

permissible variation in gage, finish, marking, inspection, rejection, shall conform with the requirements of the Specifications for Boiler Plate Steel.

U-102. *Method of Welding.* Seams, or joints may be welded on both sides by the double-V method, so-called, or on one side only with a single-V, using the butt-strap method in which the butt strap is tacked clear of the sheet at least 1/16 inch, or by such other method as will best assure the joint being filled with sound metal thoroughly fused, and to a thickness in excess of the maximum thickness of the plate, not less than 10 percent, nor more than 15 percent, see Fig. U-3 (*a*).

There shall be no valley either at the edge or in the center of the joint and the weld shall be so built up that the welded metal will present a gradual increase in thickness from the surface of the sheet to the center of the weld. At no point shall the sheet on one side of the joint be offset with the sheet on the other side of the joint in excess of one-quarter of the minimum thickness of the sheets, or plates.

U-103. *Longitudinal Joints.* Where vessels are made up of two or more cylinders, the welded longitudinal joints of adjacent sections shall be 180 degrees apart.

U-104. *Distortion.* The cylinder, or barrel of a vessel shall be substantially circular at any section, and to meet this requirement shall be reheated, rerolled and reformed.

U-105. *Dished Heads.* Dished heads convex to the pressure shall have a skirt not less than 3 inches long and shall be inserted into the shell with a driving fit in excess of the full length of the skirt, welded to the shell with a V'ed weld, heated to the annealing point, the shell to be constricted on the end to a diameter not less than 1 inch smaller than the original diameter.

Dished heads concave to the pressure shall have a skirt not less than one-tenth the diameter of the shell but not less than 3 inches long, and shall be attached to the cylinder by a butt weld.

U-106. *Hemi-Spherical Heads.* Hemi-spherical heads concave to the pressure shall have a skirt not less than 1 inch long, and shall be attached to the cylinder by a butt weld.

U-107. *Nozzles.* Nozzles in heads or shells over 3 inches and not to exceed 8 inches nominal size, shall be of forged or rolled steel with a flared skirt. These nozzles shall have a forged, rolled or Van Stone flange for pipe connections. The method of welding shall be as shown at (*a*), Fig. U-3.

U-108. *Nipples.* Nipples or couplings over 2 inches and not to exceed 3 inches nominal pipe size, shall be inserted from the inside through the sheet or plate, shell or head to a flange or shoulder and welded thoroughly from the bottom of the V'ed shell plate and with a fillet, as shown at (*b*) and (*c*) in Fig. U-3. The thickness of the nipple or coupling wall and shoulder shall be not less than extra heavy pipe-size standard. Nipples of this type smaller than 3 inches may conform to this same construction.

Threaded nipples 3 inches nominal pipe size and under, may be made of extra heavy steel pipe or steel tubing with corresponding thickness of wall, inserted in a hole with V'ed edges in the shell or head, and welded full with a fillet as specified before in this paragraph and as shown at (*d*) and (*e*) in Fig. U-3. Threaded connections for pipes 3 inches and under may be made by using an extra heavy pipe-size coupling inserted in a hole with V'ed edges in the shell or head and welded full with a fillet as before specified for nipples of like size and shown at (*e*) in Fig. U-3. Threaded connections for pipes 3 inches and under may also be made by building up a boss of filling metal thoroughly fused to the plate or sheet, and then drilling and tapping through both boss and sheet; the outside diameter of the boss shall be not less than the outside diameter of the boss of an extra heavy cast fitting of like pipe size, all as shown at (*f*) in Fig. U-3. The height of the boss and tapping shall be such that when a nipple is screwed into place, the inner end of the nipple, which shall have the full number of threads, shall be at least flush with the inner surface of the plate or sheet.

U-109. *Hydrostatic Tests.* While subject to the hydrostatic pressure herein before specified, a thorough hammer or impact test shall be given. This impact test shall consist of striking the sheet on both sides of the welded seam a sharp vibratory blow with a 2- to 6-pound hammer with a handle similar to a blacksmith's striking hammer, the blows to be struck 2 to 3 inches apart and within 2 to 3 inches of, and on each side of, the seam—the blows to be as rapid as a man can conveniently strike a sharp, swinging blow, and as hard as can be struck without indenting or distorting the metal of the sheet. During this test the shell shall be completely filled with water.

U-110. *Defective Welds.* Welded seams, or joints, which do not pass this test without leaks, distortion or other signs of distress shall not be accepted until the defects are remedied and a further test applied which shall be successfully passed. Defective sections of a welded seam may be cut out and rewelded provided the value of the sheets has not been definitely lowered, and where this shall be brought into question a coupon shall be cut out across the weld at this point or points in question and subjected to microscopic or other examinations.

### RULES FOR FORGE WELDING

U-111. The plate for any part of a forge-welded vessel, on which welding is done, shall be of forge welding quality in accordance with the following specifications:

U-112. *Process.* The steel shall be made by the open-hearth process.

U-113. *Chemical Composition.* (*a*) The steel shall conform to the following chemical requirements:

| | | |
|---|---|---|
| Carbon | for plates ¾ in. or under in thickness .......... | not over 0.18 percent |
| | for plates over ¾ in. in thickness .............. | not over 0.20 percent |
| Manganese ........................ | | 0.40–0.60 percent |
| Phosphorus ........................ | | not over 0.04 percent |
| Sulphur ........................ | | not over 0.05 percent |

(*b*) The composition of steel for forge welding plates should preferably be free from silicon, nickel or chromium. Where these elements are present the maximum quantity of any one shall not exceed 0.05 percent.

U-114. *Ladle Analysis.* An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus and sulphur. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in U-113.

U-115. *Check Analysis.* An analysis may be made by the purchaser from a broken tension test specimen representing each melt. The chemical composition thus determined shall conform to the requirements specified in U-113.

U-116. *Tension Tests.* (*a*) The material shall conform to the following requirements as to tensile properties:

| | |
|---|---|
| Tensile strength, maximum, pounds, per square inch .. | 55,000 |
| Yield point, minimum, pounds, per square inch ..... | 24,000 |
| Elongation in 8 inches, percent .................... | 1,500,000 |
| | Tens. Str. |

(*b*) The yield point shall be determined by the drop of the beam of the testing machine, at a speed not exceeding ½ inch per minute.

U-117. *Modifications in Elongation.* (*a*) For material over ¾ inch in thickness, a deduction from percentage of elongation specified in U-116 (*a*) of 0.25 percent shall be made for each increase of 1/32 inch of the specified thickness above ¾ inch, to a minimum of 20 percent.

(*b*) For material under 5/16 inch in thickness, a deduction from the percentage of elongation in 8 inches specified in U-116 (*a*) of 1.25 percent shall be made for each decrease of 1/32 inch of the specified thickness below 5/16 inch.

U-118. *Bend Tests.* The test specimen shall bend cold through 180 degrees flat on itself without cracking on the outside of the bent portion.

U-119. *Test Specimens.* (*a*) Test specimens shall be prepared for testing from the material in its rolled condition.

(*b*) Test specimens shall be taken longitudinally and except as specified in Par. (*c*) shall be of the full thickness of material as rolled. They may be machined to the form and dimensions shown in Fig. U-4, or with both edges parallel. (See Fig. 1, page 13, of Part I, Section 1, of the A. S. M. E. Boiler Code.)

(*c*) Test specimens for plates over 1½ inches in thickness may be machined to a thickness or diameter of at least ¾ inch for a length of at least 9 inches.

(*d*) The machined sides of rectangular bend test specimens may have the corners rounded to a radius not over 1/16 inch.

U-120. *Number of Tests.* (*a*) One tension and one bend test shall be made from each melt; except that if material from one melt differs ⅜ inch or more in thickness, one tension and one bend test shall be made from both the thickest and the thinnest material rolled.

(*b*) If any test specimen shows defective machining or develops flaws it may be discarded and another specimen substituted.

(*c*) If the percentage of elongation of any tension test specimen is less than that specified in U-116 (*a*) and any part of the fracture is outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

U-121. *Finish.* The finished material shall be free from injurious defects and shall have a workmanlike finish.

U-122. *Marking.* The name or brand of the manufacturer and the melt number shall be legibly rolled or stamped on all finished material. The melt number shall be legibly marked, by stamping if practicable, on each test specimen.

U-123. *Inspection.* The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's work which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests (except check analysis) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

U-124. *Rejection.* (*a*) Unless otherwise specified, any rejection based on tests made in accordance with U-115 shall be reported within five working days from the receipt of samples.

(*b*) Material which shows injurious defects subsequent to

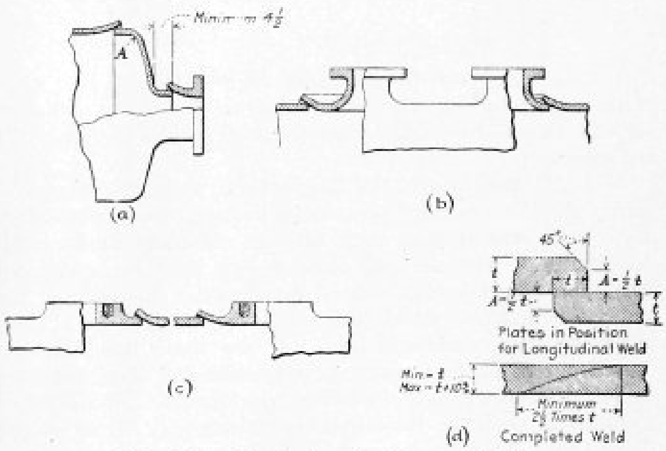



**Fig. U-5—Methods of Forge Welding**

its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

U-125. *Rehearing.* Samples tested in accordance with U-115, which represent rejected material, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for rehearing within that time.

U-126. The minimum thickness of any plate shall be ¼ inch, but in no case shall the thickness of shell plate be less than the diameter of the vessel divided by 200.

U-127. The efficiency of the joint when properly welded by the forge welding process may be taken as 85 percent of the minimum ultimate strength of the plate for Class A vessels and as 95 percent of Class B vessels.

U-128. *Corner Radius of Dished Heads.* The corner radius of a dished head measured on the concave side of the head, shall be not less than 6 percent of the inside diameter of the head [see *A* at (*a*), Fig. U-5].

U-129. *Depth of Flange.* The depth of flange on the flanged and dished head measured from a point tangent to the corner radius of the head to the end of the flange, shall be not less than 5 inches.

U-130. *Heating.* The heating agent shall be suitably prepared water gas or other heating medium by which equivalent or superior results will be obtained, and shall be applied to both sides of the section and adjacent surfaces, and precaution shall be taken to see that the flame is of a type that will minimize the possibility of burning or oxidizing the metal and that it be free from all impurities which would tend to introduce foreign elements into the steel. The temperature of the flame for heating the surfaces shall be under constant and close control.

U-131. *Welding.* The edges that are to be welded together shall be lapped a distance at least equal to the thickness of the plate to be welded. All plates 1 inch thick and under shall be welded without scarfing; plates more than 1 inch thick, if desired by the manufacturer, may be scarfed, the scarf to start at least one-half the thickness of the plate from the side next to the weld [see *A* at (*d*), Fig. U-5]. After the material has been brought up to the proper welding temperature, it shall be placed between an anvil and a hammer, or between rolls, or mandrel and roll, or between mandrels, and the plates welded together by a pressure, applied by the hammer or rolls, or mandrels, which will actually displace the material while the welding action is occurring. The metal in and adjacent to the weld shall not be worked at what is termed the critical blue heat temperature of the steel, that is, between about 400 and 800 degrees F.

The thickness of the weld for all longitudinal and circumferential seams or special welds [see (*d*), Fig. U-5] shall be as follows:

$$\text{Minimum} = t$$
$$\text{Maximum} = t \text{ plus 10 percent}$$

The contact line of completed forge weld shall be equal to at least two and one-half times the thickness of the plate ($t$) as shown at (*d*), Fig. U-5.

U-132. *Annealing.* All longitudinal and circumferential welds shall be annealed by heating to the proper temperature to relieve strains and then allowed to cool slowly. All longitudinal welds on cylindrical vessels shall be heated not less than 8 inches each side of the center of the weld or the entire shell, after which they shall be rerolled to a commercially true cylindrical form. If any vessel has been distorted out of shape it must be reformed and then annealed or reformed at a proper annealing temperature. In a finished cylindrical shell the variations in diameters shall not exceed 1 percent of the mean outside diameter when measured at any section. When a straight edge two diameters long is laid longitudinally on the outside of a shell, it shall be possible to so set the straight edges that no part of the edge will come farther than 1 percent of the mean outside diameter from the outer surfaces of the shell.

U-133. *Inlet and Outlet Connections.* All connections less than 5-inch standard pipe size may be attached by autogenous welding as specified in the Code for autogenous welding. Nozzles 5 inches and over shall be attached by forge welding or by riveting.

If nozzles are attached by forge welding, they shall be of forge or rolled steel material, seamless tubing, or forge-welded pipe, attached to shell by forge welding, by either of the two methods shown at (*b*), Fig. U-5 or attached to a bead by forge-welding as shown at (*a*), Fig. U-5. Either the nozzle or shell may be flared for this purpose.

Saddle flanges may be used if made of forged steel and may be attached by forge welding or riveting by either of the two methods shown at (*c*), Fig. U-5.

All dished heads may be attached to shell by forge welding as shown at (*a*), Fig. U-5, or by riveting. (Note corner radius *A* referred to in Paragraph U-128.)

U-134. *Hydrostatic Tests.* Vessels with seams or joints made by the forge welded process shall be subjected to the test specified in Paragraph U-109.

U-135. Every vessel with forge welded joints shall be inspected during its entire construction at the shop where manufactured. In the case of Class A vessels, the inspection and stamping shall be as provided in Paragraphs U-53-54.

## Boiler Explosion Wrecks Saw Mill

OUT through country districts in all parts of the United States great numbers of small power boilers are installed in mills of various kinds. Frequently notices appear in the press of disastrous explosions caused by the failures of boilers of this type which have not been properly inspected or maintained. An account of one of these explosions is given in a recent issue of *The Locomotive.*

The boiler in question was located, before the explosion, in a saw mill two and a half stories high situated on the outskirts of a small Ohio town. It was of the horizontal tubular type about thirty years old and operated at 80 pounds (?) pressure. Up to two years ago the boiler was operated at 100 pounds pressure, but at the time of the investigation following the accident, the operator stated that two years ago he decided that he had better cut the pressure down, so he "went up on the top of the boiler and screwed the pop *down* (which would of course raise instead of lower the blowing pressure), and was pretty sure that it blew at 80 pounds." The safety valve could not be found after the explosion. The boiler had not been inspected within the two years previous to the explosion, nor had the steam gage been tested within that time.

Upon examining the internal surface of what was left of the boiler it was found that the shell plate and tubes were very badly pitted and grooved. The break on the plate edges was abrupt with no knife edge anywhere. The shell plates tore completely away from the head and tubes, at a point about three inches from the joint and no rivets were sheared. The owner had just finished sawing a log and was loading the carriage preparatory to sawing another log, when the boiler let go, the building collapsed and a beam fell across either the engine or the saw carriage in such a way as to form a pocket and protect him from the falling beams.

## Welding Tubes

Boiler plate, unless it is of the very best material, is often the cause of many troubles in the welding of the tubes into the sheet. The very method of making the plate tends to poor and non-uniform structure unless strict instructions are given as to the cropping, and are followed out. The impurities that go to the central part of the ingot will form flaws that will ultimately find their way into the weld and in time result in leaks and fractures.

In determining the best method of welding the tubes into the tube sheet, consideration is given to three things: (1) the effect of the welding on the metal of both the tube and the tube sheet; (2) the effect of the final outline of the tube end, the tube sheet and the deposited metal, upon the hot gases entering the tube; (3) the amount of work required to perform the entire operation from start to finish.—*Power.*

# Repairing Cracks in Copper Tube Sheets

## Methods Employed in British Shops in Making Temporary and Permanent Locomotive Boiler Repairs

**By A. Wrench**

THE firebox tube sheets of locomotive boilers frequently develop cracks between the tube holes and the question of repairing these cracks is a matter of interest to boiler makers. Frequently the work of repairing tube plates falls to the locomotive running department staff as at the time the cracks develop the locomotive may not have run the necessary miles to warrant a stopping for general repairs. Often it is found advisable when a locomotive is sent into the shop to repair a cracked tube plate rather than renew it.

The method of repair depends upon whether or not the boiler is empty of tubes. If only a few tubes in the vicinity of the cracks are removed a good repair can be made by threading the tube holes which have their bridges cracked and inserting tapered brass plugs. Heads are formed on the plugs which meet one another and entirely cover the cracks. The centers of the plugs are then drilled to receive the tubes, the tubes in this case being smaller than the original to allow of a substantial thickness of metal in the bushing. This method makes a fairly good repair as the tubes have an unbroken contact surface and the cracks are covered and protected by the heads of the plugs.

### Substantial Repairs Possible

Another method often employed is to insert plugs as in the previous case and then bore a tube hole into every alternating plug leaving the remainder solid and plugging up the corresponding holes in the smokebox tube plate. The tube plate is thereby strengthened in the parts which are cracked, but the heating surface is reduced and additional stress thrown on stays and tubes in the vicinity.

If the boiler is empty of tubes, a standard flange bush can be used which has a head or flange formed before insertion. This avoids the danger of disturbing the cracks by hammering to form a head. These bushes are received from the brass foundry as shown in Fig. 1 and have an hexagonal hole in the center to enable them to be inserted with the bush driver shown in Fig. 2. The tube holes after having been made round with a rosebit are threaded with a suitable tap the first, third, fifth, etc., from the firebox side and the second, fourth, sixth, etc., from the boiler side. The holes are threaded to the size of the trial plug, Fig. 3.

The tube plate is faced and grooved to receive the flange and tongue of the bush. The bushes are inserted from each side of the tube plate, their flanges covering the cracked tube plate bridges on both sides. The tube holes are then bored for the tubes first by means of a drill and then by a cutting tool.

It is necessary that the operation of rosebitting and tapping the holes be correctly done or the flanges of the bushes will not fit into the grooves properly. To enable this to be done a guide bracket as shown in Fig. 8 is used which enables the operator to prepare the tube holes accurately by inserting the tool shanks in the bush on the end of the bracket. The end of the bracket can be removed by taking out two set screws. The washer and eccentric bolt heads allow the bracket to be bolted up to a tube plate from which only a few tubes have been removed. In a case of this kind the bushes can only be inserted from the firebox side. This method of bushing makes a good repair if properly done and does not give trouble from leaking. The writer has known loco-

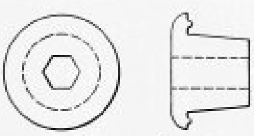


FIG. 1—Cast Bush before being screwed

FIG. 2—Bush Driver

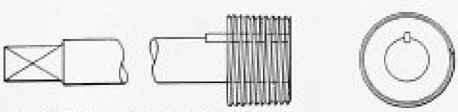


FIG. 3—Trial Plug and Spindle

FIG. 4—Spindle and Facing Cutter

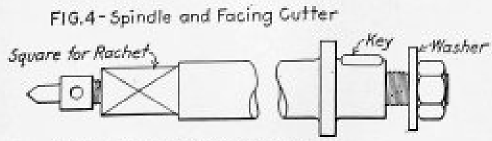



FIG. 5—Superheat Rosebit Spindle

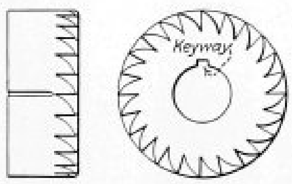



FIG. 6—Superheat Tubehole Rosebit

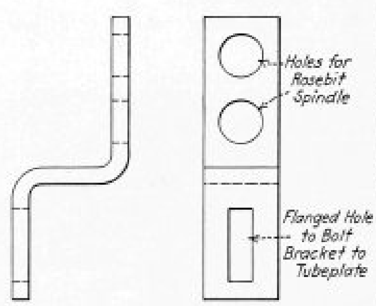



FIG. 7—Guide Bracket for Superheat Tubehole Spindle and Rosebit

FIG. 4a—Grooving Cutter

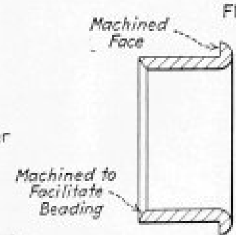



FIG. 9—Copper Liner for Superheat Tubehole

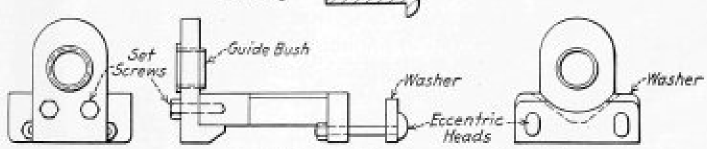



FIG. 8—Guide Bracket for the Spindles of Bushing Tools

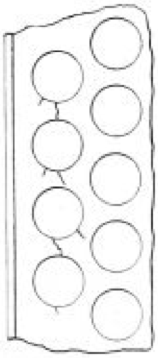
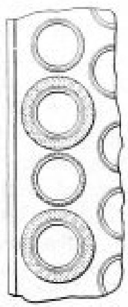


FIG. 10—Portion of Cracked Tubeplate



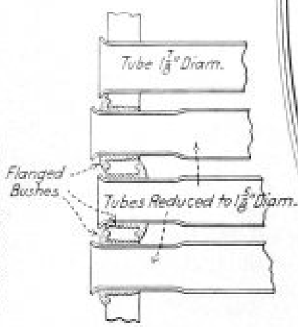



FIG. 11 FIG. 12
Tubeplate Repaired with Flanged Bushes

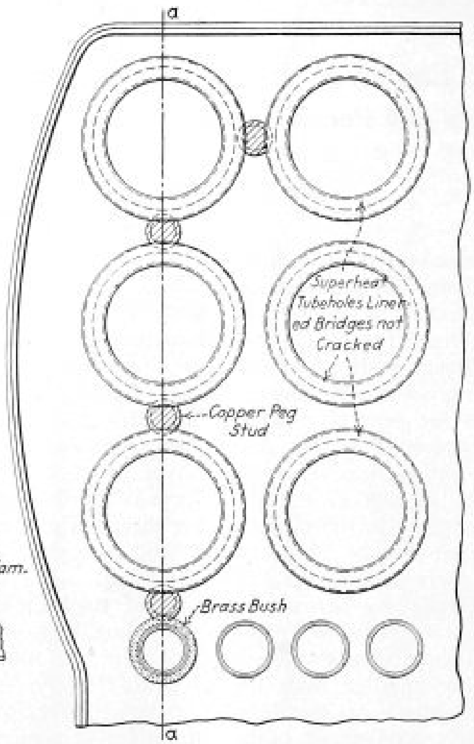



FIG. 13—Tubeplate Repaired with Peg Studs and Copper Liners

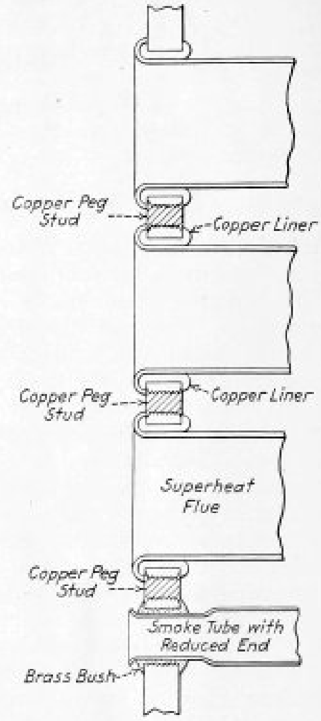



FIG. 14—Section a-a

motive boilers so repaired to run 40,000 miles without giving trouble from leakage.

### Examples of Repairs

Fig. 10 shows cracks in a tube plate before repair; while Figs. 11 and 12 show elevation and sectional views of a portion of tube plate repaired by flanged bushes.

Repairing a cracked tube plate by patching is not to be recommended as the width of the tube hole bridges only allows small rivets or studs to be used and these are too widely spaced apart.

The foregoing remarks refer only to cracks between small tube holes.

When the superheater was adopted for locomotive purposes the large tube holes for the smoke flues carrying the superheater elements greatly reduced the net section of plate across the tube plate and the compression per square inch on the material was thus increased. As a result cracks developed in the tube hole bridges. Where direct crown plate staying was adopted the tube plate was not in compression but the cracking of the tube hole bridges was not eliminated. The heavy expanding required to make these tubes tight and also the re-expanding during the period of service greatly enlarges the tube holes and reduces the area of metal in the bridges, which accounts for most of the cracks which are found between superheater tube holes.

### Trouble With Superheater Tubes

The original size of superheater tubes is usually 4 inches at the firebox end. After these have been expanded several times they reach a much larger size and become deformed, which necessitates their being made round with suitable rosebits. Usually when the tube holes are large one can expect cracks in the rows close to the sides of the plate as these tubes give most trouble from leakage.

When a tube plate is found to be cracked the repair depends on the condition of the rest of the firebox and locomotive generally. If it is decided not to renew the defective plate, the tubes in the neighborhood of the cracks are removed and the full extent of the cracks observed. When it is found that the cracks do not pass through the full thickness of the plate the hole may be trued with a rosebit, liners fitted, and the tubes replaced. This reduces the tube to its original size and the tube plate bridges are strengthened by the beaded liner. The crack is calked before the liner is inserted. This repair may last some time until the crack extends through the plate when it will be necessary to make a further repair. This can be done by peg studding and inserting liners, the method adopted being as follows:

The tube holes are made round with rosebits, after which a hole is drilled and threaded between the tube holes which are cracked. This hole is usually about ½ inch diameter and takes away most of the crack. It is countersunk on both sides if possible which takes out a portion of the crack above and below the peg stud hole and allows the stud to be riveted over flush with the plate. All the crack is thereby drilled away or filled with the head of the stud.

A copper liner is then inserted from the boiler side, expanded and beaded over on the firebox side to cover part of the countersunk head of the peg stud. The tube is then inserted and beaded over the liner beading.

Frequently tube plates are found to be cracked between the top row of small tubes and the bottom row of superheater tubes. The small tube hole in this case is threaded and a brass plug inserted. Prior to this plug being riveted over, the peg stud is fitted and riveted, after which the head of the brass plug is formed to cover part of the peg stud.

A copper liner is then inserted in the superheater tube hole with its beading resting on the upper portion of the stud. The brass plug is then bored to receive a tube with a reduced end which allows a good thickness of bush. The tubes are then fitted and beaded. Sometimes owing to the thickness of the bridge being much reduced the small tube is dispensed with and a solid plug inserted. The peg stud in this case is inserted after the plug has been riveted and fitted partially into the plug and partly into the plate. The head is riveted into the crack and into a recess formed in the head of the solid plug.

Where a crack does not extend from tube hole to tube hole, the effect of fitting a peg stud prevents further development of the crack.

METHODS OF REPAIR FOUND SATISFACTORY

These methods of repairing tube plates give satisfaction in practice and delay renewals until perhaps other portions need renewing or a new firebox is required. It is necessary that the work be carefully done.

The liners which follow the rosebit sizes must always be a good fit. After the liners are expanded the tubes are made to the size obtained by calipers. This size should be accurate and the tubes made a good fit, or the peg studs will be disturbed during the process of fitting the tubes.

EXPANDING THE TUBES

The principal trouble with this method of tube plate repair is that expanding the tube often undoes much careful work. Good results have been secured by first of all expanding the tubes in the vicinity of the crack and then inserting the peg stud without removing the tube. To do this it is necessary to cut away a portion of the beading of the tubes in order to countersink the stud hole and allow the stud head to be properly riveted into the crack. This should not be done if the tubes require renewing.

Figs. 5 and 6 show the spindle and rosebit used for making the superheater tube holes true. A number of these rosebits are stocked, the sizes ranging from 4-1/32 inches to 5 inches in 1/32 inch increases. All fit on the standard spindle.

The liners are made of copper turned to size with one end flanged as shown in Fig. 9. They are about ¼ inch thick and are used instead of a screwed bush as the threading of large tube holes in a confined space is not practicable. When beaded over on both sides of the tube plate they substantially stiffen and support the bridges.

Figs. 13 and 14 show a portion of a tube plate repaired by the peg stud and beaded liner method.

# Firebox Repaired by Oxy-Acetylene Welding*

## Fifty Feet of Welds Used In Replacing Crown and Side Sheets and in Patching Door Collar

AT a large copper mining plant in the Southwest some interesting locomotive firebox welding was recently done under the direct supervision of a service engineer of an oxy-acetylene apparatus company, this service having been requested by the master mechanic after several unsuccessful efforts to effect the needed repairs by various other means.

"When the master mechanic wired," writes the service engineer, "a patch which had been riveted on less than a week previously had failed to hold, and the mining company was confronted with the necessity of installing a new firebox at a cost of approximately $2,500 and with a probable delay of several months if it were found impracticable to make the repair by welding."

The story is graphically told in the illustrations. Figs. 1 and 2 show the work done on the locomotive boiler. The first shows a firebox patch 18 feet long by 22 inches wide, consisting of two side sheet sections and one crown sheet section. The crown sheet section of the patch was butt-welded to the old flange of the flue sheet, the old rivet holes being first filled in. The side sheet sections were butt-welded somewhat closer to the flue sheet knuckle, the flange having been cut off back of the old rivet holes.

The crown sheet section was welded to the crown sheet by starting in the center and welding out to each side (side

* Reprinted from the October issue of *Oxy-Acetylene Tips*.

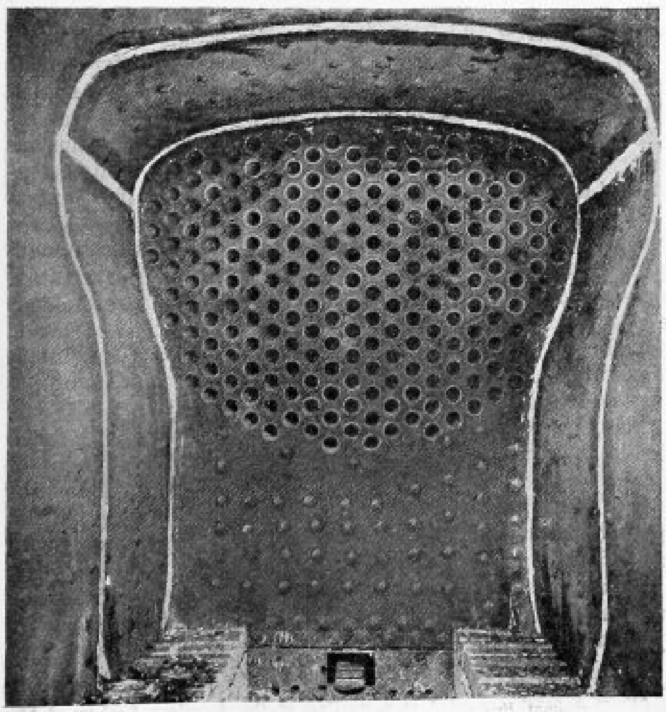


Fig. 1.—Firebox Patch on Locomotive Boiler

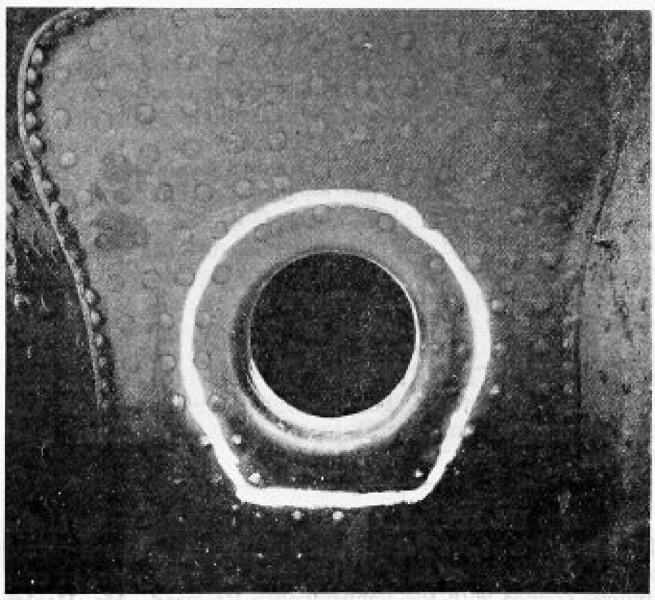


Fig. 2.—Door Collar Patch Welded on Boiler

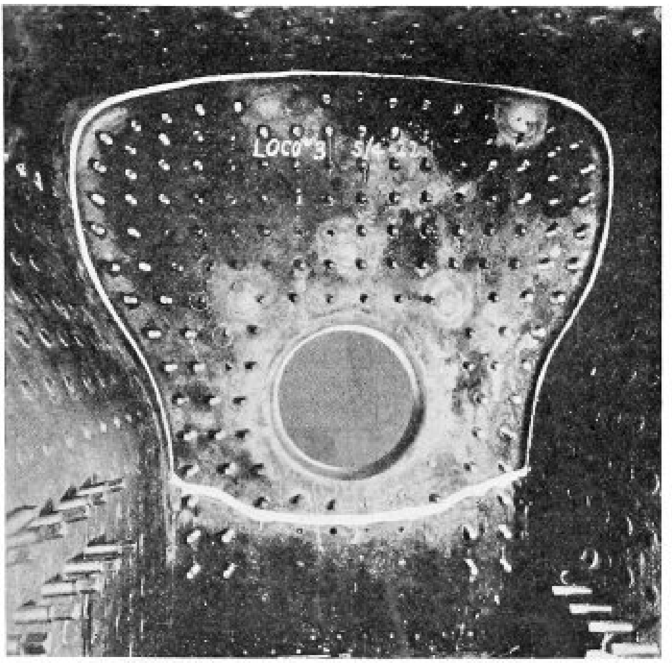


Fig. 3.—Door Sheet Welded Into Superheater Type Locomotive Boiler

of the firebox, end of the seam). It was then joined to the flue sheet flange with a welded seam starting 10 inches from one of the sides and extending to a point 10 inches from the opposite side. The crown sheet section was then smoothed over and reinforced from the water side.

The welds on the side sheet sections were started below the center or at the top of the flat section of the firebox and welded down to the mud ring at the bottom, after which the upper portion of the welded seam was made. The sections were then welded to the flue sheet up to a point within about 20 inches from the top. The horizontal welds were made by finishing at the end nearest the flue sheet and the welding was completed by finishing the remaining 30 inches at the knuckle of the flue sheet on each side.

### Details of Door Collar Patch

In the second picture is shown the door collar patch in the same engine. There was a total of about 15 linear feet of welding on this patch. The total welding on the firebox exceeded 50 linear feet.

Complete data covering the cost of this job are not available, but the locomotive was out of service only ten days, and the time saved alone was a very important consideration.

The third picture shows a ¾-inch door sheet welded into a superheater type locomotive at the same plant.

This mining company has about 20 cutting and welding units, a 200-pound duplex and a 100-pound portable acetylene generator, and supplementary shop equipment. The process is used for general work on mining and mill machinery such as pumps, rolls, flywheels, gears, ore cars and, until recently, on manganese grates for ball mills. The company now purchases these grates already welded from an eastern manufacturer, thereby releasing ten welders from the force ordinarily employed. The present force of welders and cutters engaged on general repair work varies from eight to ten.

---

Patrick Healey, of Altoona, Pa., a boiler tester at the Juniata shops of the Pennsylvania Railroad, has been placed on the roll of honor as a retired man after 46 years of continuous service with the Pennsylvania Railroad. Mr. Healey was born in County Cork, Ireland, on March 3, 1855.

# Strength of Welded Pressure Containers*

**By R. J. Roark†**

The following conclusions were reached as the result of an investigation of pressure tests on electric welded, gas welded and riveted pressure containers, similar to air reservoirs used in railroad service, furnished by the Vilter Manufacturing Company, Milwaukee, Wis. Tension and shear tests on specially prepared specimens of welded metals, also were made, demonstrating the strength and uniformity of construction secured by electric welding. In all nine containers were tested, using pressures from 200 to 2,100 pounds per square inch. The containers were 15¼ inches in internal diameter and 10 feet long with inserted dished ends held in place by electric welding.

Some of the more important points brought out by the tests are enumerated and discussed below.

### Weak Points in the Containers

None of the welded containers of standard design failed primarily at the welded head joint. The nature of the fracture shows that the weak points in the containers were, first, the lap weld in the pipe forming the shell, where failure occurred due to circumferential tension, and, second, the body of the shell at its junction with the head flange, where failure occurred due to the combination of longitudinal tension and bending.

### Strength of Electric Welds

From the tests on four specially prepared specimens, the average tensile strength of electrically welded joints was found to be 28,500 pounds per square inch. From tests on five specimens cut from containers, the average shearing strength of electrically welded joints was found to be 25,500 pounds per square inch. The mean variation from the average tensile strength per linear inch of weld was found to be 2 percent, and the maximum variation 4.5 percent. The mean variation from the average shearing strength per linear inch of joint was found to be 5.2 percent and the maximum variation 7.8 percent. The results of eccentric tension tests on specimens cut from containers showed that no one of the specimens was markedly weaker than the average for the lot. It is believed that the uniformity of strength thus indicated is of especial interest and importance.

In connection with the values given above for tensile strength, two points should be noted. First, at the section through the weld, where failure took place, the load was eccentric, because of the fact that the specimen is unsymmetrically thickened at that point by the joint. This eccentricity undoubtedly made the average stress on the joint at failure less than it would otherwise have been, and so the values obtained were less than the actual tensile strength of the metal. The effective eccentricity was not as great as one-half of the excess thickness of the joint, because the ends of the specimen were restrained. No attempt has been made to allow for the effect of this eccentric loading, because it represents a condition inherent in any so-called single-V weld which has an excess thickness.

Second, each of the four specimens had, within its tested length, several transverse welded joints. The strength of each specimen, therefore, represents the strength of the weakest of these seven joints, and so the value given, 28,500 pounds per square inch, is less than the average strength for all joints.

The tension tests indicated that the resistance to tension applied with a large eccentricity is greater for the riveted joint than for the welded joint. The shear test indicated

(*Continued on page* 362)

*From a paper presented at a meeting of the American Society of Mechanical Engineers.
†Assistant Professor at the University of Wisconsin.

# The Boiler Maker

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## CONTENTS



The annual index of THE BOILER MAKER will be published separately from the magazine at the end of the year. As the annual index will be useful only to those subscribers who have kept a complete file of the magazine for the year, only a sufficient number of copies will be printed to fill the orders received for it at this office on or before January 1. A copy of the index will be mailed without cost to each subscriber whose order for it is received on or before that date.

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In a modern boiler shop no one can assume the responsibilities or discharge the duties of foreman without study. The day has passed when the competency of a man for such a position can be judged chiefly by his length of service or his standing with the management, although such factors, of course, may have an important bearing upon the selection of a man for the place. What is required in a foreman, as is pointed out elsewhere in this issue, is that he must know not only what is to be done and how to do it but also how to convey that knowledge quickly and surely to the workers directly responsible for doing the work. So today, in order to meet the requirements, there has developed a movement for foremanship training and this applies not merely to the general foreman but also to those men filling minor executive positions such as assistant foremen, sub-foremen, gang leaders, inspectors and others who come in contact with foremanship problems. The need for foremanship training in the boiler making industry is a real one and some form of training should be encouraged. Until experience has shown the best methods of accomplishing this in the boiler shop, a careful study should be made of the results obtained in other industries.

---

While American locomotive boiler practice differs in some respects from British practice the difference is not so noticeable in the layout and equipment of the shops for building the boilers in the two countries. This fact is apparent from the illustrated description of the locomotive boiler shop at the Elswick Works of Sir W. G. Armstrong, Whitworth and Company, Ltd., Newcastle-on-Tyne, England, published elsewhere in this issue. The Elswick boiler shop, while only a part of an immense industrial plant, is one of the most up-to-date establishments of the kind in Great Britain. In accordance with the best practice the world over the buildings are of steel and glass construction giving a maximum of daylight in the shop, which is supplemented by a carefully worked out system of artificial illumination. Heating, ventilating and sanitary arrangements are adequately provided and the facilities for the mechanical handling of materials are unusually complete. Based on the principle of a steady flow of the material through the shop from the laying out department to the final assembling and testing of the finished product without any retracing of its path or undue delay in its progress, the layout of the machinery and fabricating equipment in this plant plays an important part in making it possible for a working force of 1,000 men to turn out an average of 50 main line locomotive boilers per month. In this connection it is interesting to note that much of the machinery and fabricating equipment in the shop, including the boiler shell drilling machines, hydraulic flanging presses and all of the pneumatic tools, is designed and built by the company itself. Another point of interest is the extensive use of gages, jigs and templates in the fabrication of boilers, insuring accurate and interchangeable work, so that all unnecessary adjustment and fitting of parts is eliminated when the boiler is erected on the engine framing. While not many locomotive boiler builders have the facilities for supplying a large part of their own machinery and tools in accordance with their own designs, as in this case, nevertheless all meet on common ground when it comes to the layout and arrangement of the shop with a view to economical production and for this reason the arrangement and methods employed at this modern, efficient plant deserve careful study.

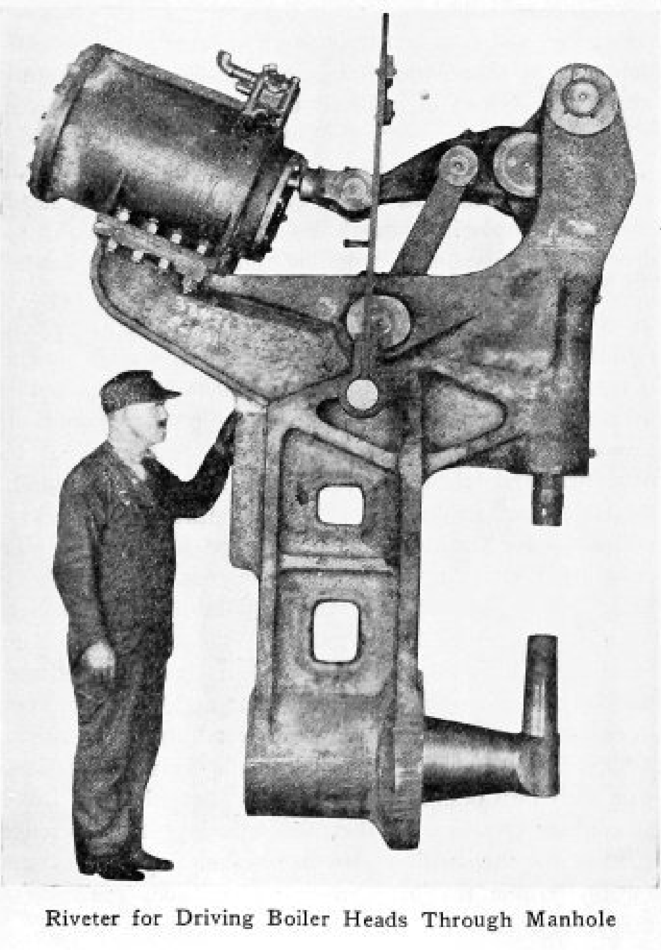
# Engineering Specialties for Boiler Making

**New Tools, Machinery, Appliances and Supplies for the Boiler Shop and Improved Fittings for Boilers**

## Last Head in Boiler Riveter

The Hanna Engineering Works, Chicago, Ill., has recently completed a large riveting machine for use in connection with driving up the last heads in boilers through the manhole. The reach of the unit is 14 inches to 18 inches, the gap 35 inches, cylinder diameter 18 inches, capacity 100 tons. The die stroke is 5¾ inches and the weight 9,900 pounds.

Machine is arranged for portable use in two positions. Suspension is made with dies vertical as shown in the accompanying illustration. The machine swivels about a point close to the center of gravity, allowing the stationary die to be swung on and off the manufactured head of the rivet in a direction very nearly that of the line of die travel. For this reason the mass or weight of the riveter is not lifted or lowered in riveting. The stake is of forged alloy steel. The distance from the center of the beam stake to the end face of the die standing thereon is 30 inches, which accommodates a 60 inch shell. The length of this die can be varied in conjunction with the opposite die to take care of shells as small as 42 inches in diameter. The distance from the axis of the dies to the long face of the throat is 16 inches. This



Riveter for Driving Boiler Heads Through Manhole

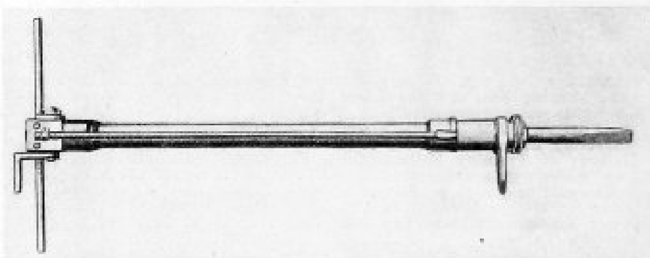
machine is used on high pressure containers, in which rivets are 1¼ inches diameter and plates 1½ inches thick.

This riveter may be arranged with either a straight push hydraulic actuating mechanism or with the patented Hanna pneumatic mechanism.

## New Type Rivet Cutter

On the principle that when cutting rivets, a number of comparatively light, rapid blows cause more vibration and therefore more distortion of steel plates than a few intermittent, heavy blows, the Chicago Pneumatic Tool Company, New York, has designed and manufactured a new type of rivet cutter known as the "Boyer Superior."

Its construction is described as consisting of a dead handle, a throttle handle of the crank design, a throttle valve of the taper type, a back head screwed onto the cylinder and secured by a locking device, a cushion chamber in the rear end



Improved Rivet Cutter

of the cylinder, a cylinder of seamless steel tubing, a bypass from back to front head, a non-removable electrically welded front head, square coiled spring buffer, adjustable chisel lock, hand hold of the spade handle type and chisel.

To operate, the throttle handle is moved in a line parallel with the cylinder. Each forward and return stroke of the piston is hand controlled. About four blows, requiring approximately 10 to 15 seconds, are said to be required to cut off the head of a ¾-inch rivet. Two men are required to operate the machine. It can be used wherever rivets are to be cut.

## Double End Staybolt Threading Machine

The machine, illustrated in Fig. 1, is made by the Cleveland Automatic Machine Company, Cleveland, Ohio, and designed to thread reduced center forged or rolled locomotive boiler staybolt blanks, on both ends at the same time. By this method there is no loss of time passing the die over the center part, the amount of time required to complete any length of staybolt being only that necessary to thread the longest end.

Also, on account of the hopper magazine the operation of the machine is continuous, not being subject to delay as in the case of machines where the staybolts are chucked by hand. By means of a small independent vertical conveyor each staybolt is carried from the main magazine down in line with the threading dies to be gripped and this continues until the magazine *M* is empty.

Because of threading from both ends the staybolt must be gripped in the center. For this reason the gripping jaws are floating so that the two ends of the staybolt may be presented to the dies in accurate alinement regardless of the center part, which is always somewhat out of true with the ends. This means that the threaded ends in the rough can be over 1/16 inch out of line and still the dies thread both ends in line with one another—a great saving in forging.

The gripping jaws are composed of an upper half *N* (Fig. 2) and a lower half pivoted on stud *O* and opened or closed by toggle mechanism *P* operated by levers *Q* and suitable cams.

In setting up a job a master staybolt or long thread gage is inserted in the die heads, one of which is closed upon the gage, and then by a fine adjustment provided, the other die head is brought to a position where it may also be closed upon the gage which sets the die heads so that continuous lead will be produced. The lead screw which is mounted back of the die spindles is driven by gears at *E* (Fig. 1) direct from the die spindle at the left.

The two die slides *F* and *G* (Fig. 1) are controlled by the lead screw during the cutting stroke and when the desired length of thread has been cut, the die heads are opened. When the return stroke is nearly completed and the die heads just clear of the work, the jaws open and move backward, ejecting the finished staybolt which drops into the pan and another is lowered from the magazine *M*.

Referring to the machine (Fig. 1) the pulley at the left drives a shaft extending through the inside of bed to the right-hand end and from this main driving shaft the die spindles are driven by gears at *A* and *B*, the feed shaft *C* by spiral gears, and from shaft *C* the cam shaft in the rear is driven by change gears at *D*.

Part of the backward movement of toggle mechanism opens the jaws, and the balance ejects the finished staybolt and withdraws the slide upon which the jaws are mounted, allowing another staybolt to be lowered from the magazine to a position in line with the die heads.

The forward movement of toggle mechanism advances the slide with the open jaws until they are in position to close on the staybolt, at the same time seating the staybolt into *V* blocks at each end just in front of the die heads, aligning the staybolt with the dies. The jaws then close, gripping the staybolt securely. A heavy spring cushion at the top of toggle lever allows for slight variations in diameter of bolts where the jaws grip.

The machine is equipped with a safety pin which will shear off in case of trouble from staybolts which are too much

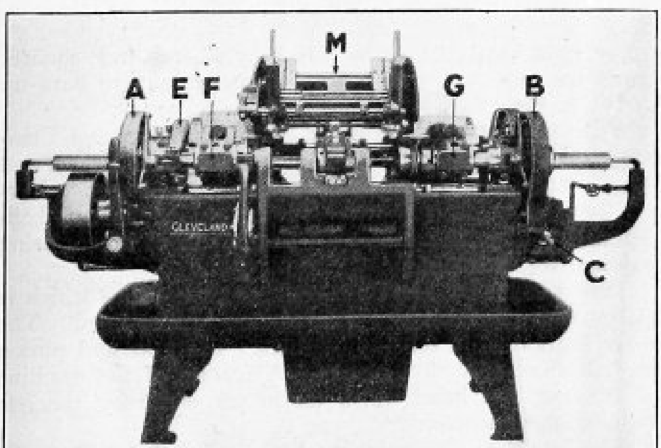



Fig. 1.—General View of Cleveland Double End Staybolt Machine

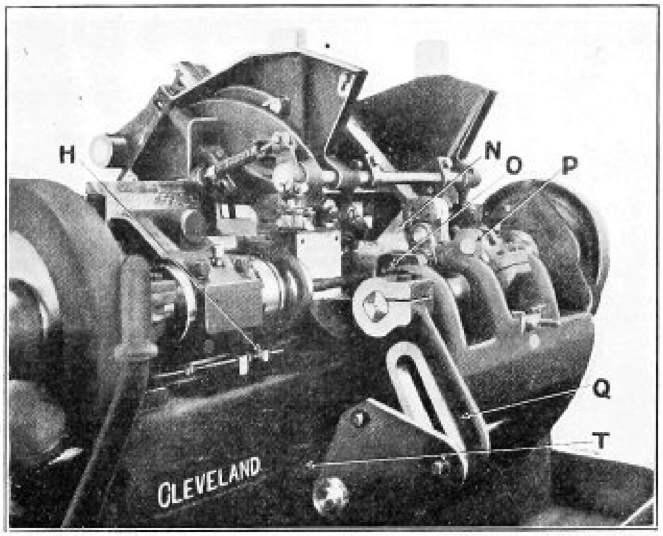



Fig. 2.—Close-Up View Showing Chuck Details

out of shape to be used. Cutting oil is pumped through both die heads, providing a heavy stream washing away chips, cooling and lubricating the chasers. Change gears regulate the cam shaft to suit different lengths of threads to be cut.

A lever at the left-hand end controls the starting and stopping of the machine through a friction clutch.

The machine is entirely automatic and threads staybolts up to 1 5/16 inch in diameter from 7 inches to 18 inches long.

The production time is 35 to 60 seconds per staybolt, depending upon the diameter and length of thread. The magazine only requires filling every 50 to 55 minutes, depending upon the size of the staybolts.

Adjusting the machine when changing from one length or size of bolt to another is a simple operation, as the two adjustable die head spindles can be moved longitudinally and located in a few minutes' time. The magazine is also adjustable for the different lengths to accommodate the location of the die heads.

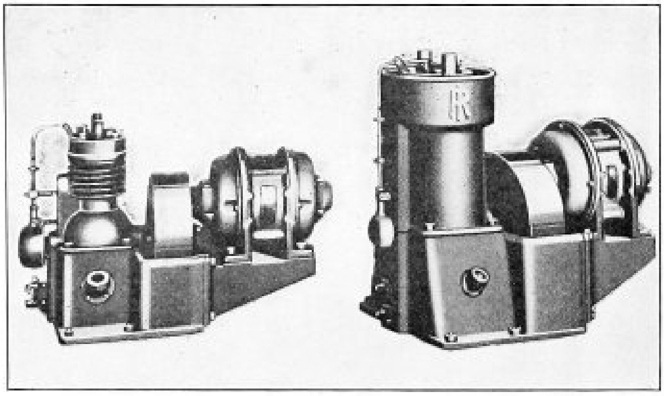
## Small Vertical-Type Air Compressors

The Ingersoll-Rand Company, New York, announces a new line of small vertical air compressors known as "Type Fifteen." In addition to plain belt drive, each of the four sizes is built as a self-contained electric motor outfit, driven through a pinion and internal gears, or by employing a short belt drive arrangement. The compressing end and electric motor of both gear and short belt-drive units are furnished mounted on a common sub-base, so that they are in no way dependent upon the foundation for correct alinement.

Several noteworthy features of construction have been incorporated, of which the constant-level lubrication system is the most important. Others include the constant speed unloader for plain belt-drive machines; the centrifugal unloader for start and stop control machines; and the increased size of the water reservoir cooling pot.

The constant speed unloader controls the unloading of the compressor by automatically opening the inlet valve when the receiver pressure rises above that at which the unloader is set to operate.

The centrifugal unloader allows the compressor to start under "no load" such as is essential when automatic start and stop control is used, and permits the electric driving motor to come up to full speed before the load is thrown on automatically. This unloader accomplishes its purpose by holding the inlet valve open until the motor has reached full speed.



3-inch by 3-inch Air-Cooled and 4½-inch by 5-inch Water-Cooled Ingersoll-Rand Air Compressors

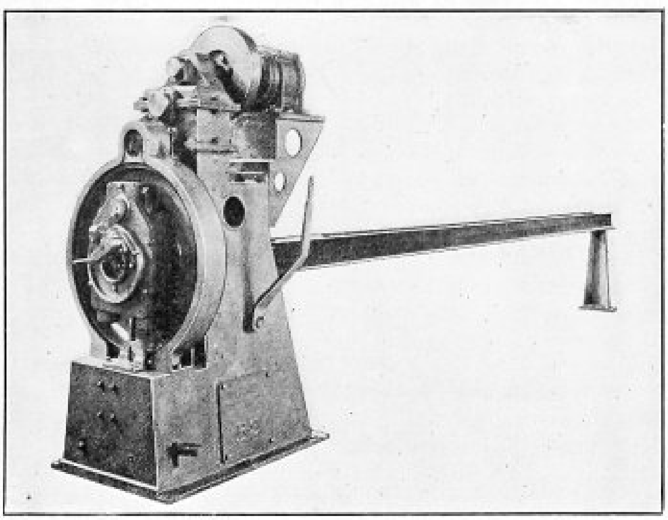
The smallest size is built with either ribbed cylinder for air cooling, where the service is intermittent, or a water-jacketed cylinder of the reservoir type for constant service. All other sizes are built with the water jacket of the reservoir type. The belt and electrically-driven machines include the 3 inch by 3 inch air-cooled, the 3 inch by 3 inch, the 3½ inch by 4 inch and the 4½ inch by 5 inch water reservoir cooled machines.

## Power-Driven Tube-Shearing Machine

With the object of providing a machine for shearing pipes and tubes rapidly, without loss of material, with a square cut free of fins and without revolving the pipe or tube, the Laughlin-Barney Machinery Company, Pittsburgh, Pa., has developed the tube-shearing machine illustrated.

In general design this machine is compact, rugged and simple thus meeting the fundamental requirements of machine tools used in railroad shops. All gears are fully covered for the protection of the operator. The shearing principle employed is quite novel and consists of an internal arbor and two shear knives in the form of two hardened steel rings which are placed close together, and through which the pipe or tube passes (these shear knives do not revolve). One knife is held concentric and the other carried in the shear head which follows an eccentric path, thus causing the pipe or tube to be sheared off in one revolution of the machine.

This method of shearing is said to have little wearing effect on the cutting edges of the knives and owing to their simple design they can be quickly removed and easily sharpened by grinding the sides of the knives.



Laughlin-Barney Tube-Shearing Machine

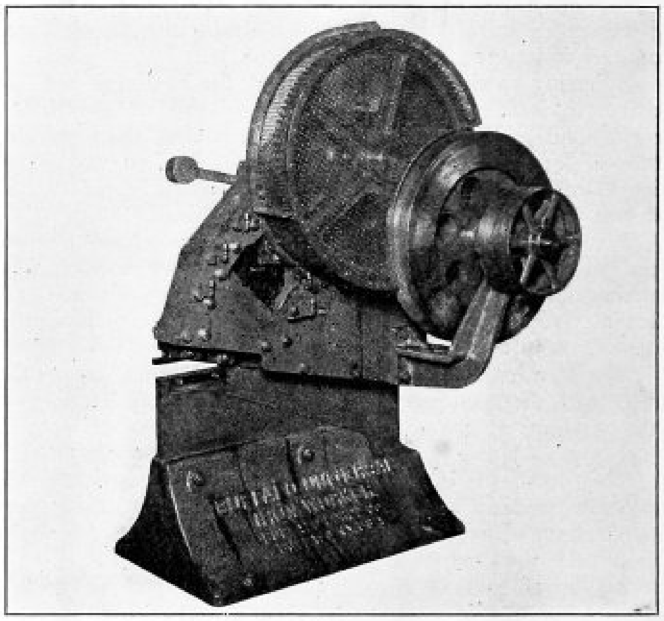
The machine is under entire control by the operator at all times, this being accomplished through a positive clutch operated by a foot treadle which permits either intermittent or continuous operation as desired. These machines can be furnished either belt or motor driven and for shearing practically any size or kind of tubing.

The tube shearing machine, illustrated, is motor driven by a motor mounted on a bracket attached to the upper machine frame work. The two shear knives are driven through reduction gearing, all of which is carefully guarded. The machine is operated by means of the levers, conveniently placed. A support for long tubing is provided as shown at the right.

## Universal Slitting Shear and Bar Cutter

The Buffalo Forge Company, Buffalo, N. Y., has just placed on the market a universal slitting shear and bar cutter. The shear is equipped with 10-inch knives which will cut plates ½ inch thick, of any length and width, or 6 inches by ⅝-inch flats. The knives may be operated at the rate of 30 strokes per minute.

The bar cutter has standard five-piece knives which will cut the following: 4 inch by 4 inch by ⅜-inch angles, square; 3 inch by 3 inch by ¼-inch angles 45 degrees mitre, left or right hand; 3 inch by 3 inch by ⅜-inch tees, square; round bars up to 1⅝ inches in diameter; square bars up to 1½ inches.



Buffalo Universal Sitting Shear and Bar Cutter

With special knives, furnished by the Buffalo Forge Company, the bar cutter will take 5-inch, 9.75-pound beams and 5-inch, 9.00-pound channels, or any other rolled section having the same weight and area. One set of blades shears both channels and beams of the same size, a pair of knives being required for each size.

This machine has the Buffalo armor plate frame which is guaranteed unbreakable. Bearings are bronze lined. The drive shaft runs in oil-ring bearings. The gear and pinion are cut from semi-steel blanks. A feature of the machine is its cast iron base, which makes an expensive concrete foundation unnecessary.

The length of the entire machine is 5 feet 4 inches, the width 2 feet 8 inches and the height 6 feet 4 inches. The total weight is 4,500 pounds. Approximately 3 horsepower is required to operate the machine at capacity.

# Questions and Answers for Boiler Makers

## Information for Those Who Design, Construct, Erect, Inspect and Repair Boilers—Practical Boiler Shop Problems

**Conducted by C. B. Lindstrom**

*This department is open to subscribers of* THE BOILER MAKER *for the purpose of helping those who desire assistance on practical boiler shop problems. All questions should be definitely stated and clearly written in ink, or typewritten, on one side of the paper, and sketches furnished if necessary. 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 permission to do so.*

## Lining Up a Locomotive Boiler With the Cylinders and Frame

Q.—Will you please outline the rule used in locomotive design to determine the center line of the boiler. Also, how is the boiler lined up and connected to the engine frame?—"Personal."

A.—There are two methods of assembling and lining up a locomotive boiler with respect to the cylinders and frames. In one case the boiler is rigged up on blocking and the cylinders and frames assembled and lined up around the boiler, and the other consists of assembling the cylinders and frames first; the boiler is then placed in position.

Fig. 1 shows the method employed when the boiler is blocked up, so as not to interfere with the erecting of the saddle *b* and cylinders *c*. When the boiler is placed the saddle and cylinders are lined up to bring them in line with the center line of the boiler. To secure proper alinement a plumb line *d-d* is placed over the boiler shell and the plumb line *e-e* is arranged over the firebox, as shown in the illustration.

The center of each cylinder is then established as shown at *f* and a plumb line *f-f* is extended through the center of each cylinder, fixing the ends of lines to a strip *g* and *h*. Lines *f-f* should be parallel and an equal distance apart throughout their entire length, as shown at *i*. The distance *j* on each side of the boiler between the plumb lines *d-d* and *f-f* should be equal, and the horizontal distance *k* between lines *e-e* and *f-f* should also be equal on both sides of the firebox.

The center line of the dome *l* should come directly in line with center line of the bottom of the firebox, and the sides of the shell should be an equal distance from the vertical center line. However, if there is a slight mis-alinement, the boiler may be shifted to average the discrepancy. For illustration, if the dome is plumb with the center line of the firebox and the shell is off center a trifle, the boiler may be shifted to bring the sides of the shell equally distant from the center line of the firebox.

The frame installation is shown conventionally in Fig. 2, in which the frames *a* are bolted to the cylinders *c* at the front

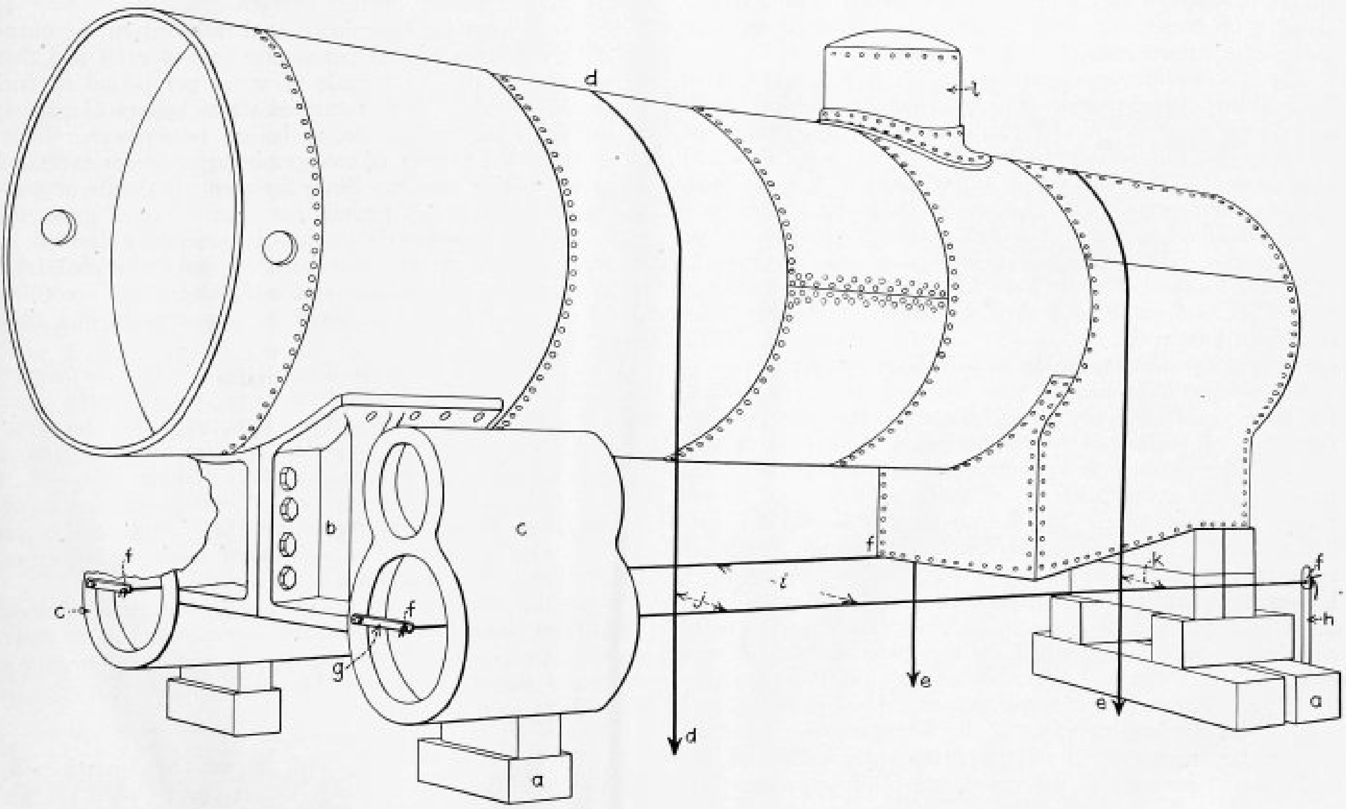



Fig. 1.—Determining the Center Line of the Boiler, Cylinders and the Like

end and at the firebox end they are bolted to the foot plate *d*. The foot plate acts as a distance plate, spacing the frames at the required distance apart. Both frames are set under the firebox, forming the necessary support. A shell brace *e* is also used in fixing the shell to the frame.

This question as I understand it is not within the scope of boiler making; the explanation given covers in a general way only some of the requirements in lining up and assembling the boiler on its chassis.

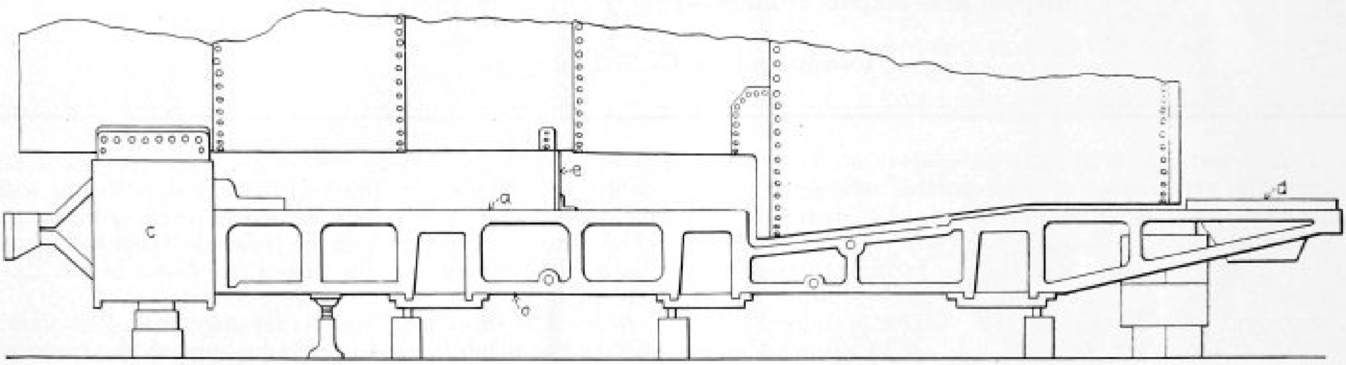



Fig. 2.—Lining up the Locomotive Boiler and Frames

## Nominal Horsepower

Q.—Please print in THE BOILER MAKER at your earliest convenience the formula for finding the nominal horsepower of a locomotive type boiler. —"Stationary."

A.—*Boiler Horsepower*. The expression *nominal horsepower* used in the earlier period of boiler making meant that a boiler having certain stated horsepower would furnish steam to develop that required power in a given steam engine. For example, if a certain size boiler furnished steam for a 40 horsepower engine it was called a 40 horsepower boiler; and if it supplied steam for a 60 horsepower engine it was called a 60 horsepower boiler. This method of rating gave no reliable information, it is now obsolete.

The *commercial horsepower* of boilers is now rated from their ability to evaporate water. The evaporation of 30 pounds of water per hour from a feedwater temperature of 100 degrees F. into steam at 70 pounds gage pressure; which is equivalent to the evaporation of 34.5 pounds of water from and at 212 degrees F. into steam at the same temperature is the standard rating for boiler horsepower. The A. S. M. E. give 970.4 British thermal units as required to evaporate 1 pound of water from and at 212 degrees F., hence $970.4 \times 34.5 = 33{,}479$ British thermal units per hour transmitted from the fuel and absorbed by the water. This constitutes the heat value in a boiler horsepower.

Evaporative performance tests are required to determine the rating and efficiency of a boiler. To compare the performance of boilers so as to determine their relative efficiencies, the practice is to reduce the actual evaporation to an equivalent evaporation from and at 212 degrees F. per pound of combustible. The reason for this is that different boilers may generate steam at different pressures, feedwater temperatures and methods of firing. The capacity of a boiler as a steam producer depends on the heating and grate areas and the steam space. The evaporation and rate of combustion varies, depending on the effective heating surface, nature of the fuel, intensity of the draft and methods of firing. The weight of water evaporated per pound of fuel depends on the heating value of the fuel, temperature of the feed water, management of the firing, proportions of the boiler parts, pressure of the steam and condition of the setting, stack and draft appliances. Ordinarily with a good design of boiler and operating conditions, from 8 to 9 pounds of water can be evaporated from the combustion of one pound of bituminous coal. The rate of combustion depends on the height of chimney varying from 10 pounds per square foot of grate area with chimney draft to 120 pounds per square foot in a locomotive under forced draft.

The American Locomotive Company has compiled data found to be consistent with results determined from actual tests. These data show in general the requirements entering into locomotive boiler calculations as follows:

It has been the practice in locomotive design to proportion the heating surface and grate area from certain fixed ratios and the cylinder volume in cubic feet. Thus, from 400 to 600 times the piston displacement in cubic feet was employed in determining the required heating surface.

The evaporation of water in pounds per square foot of heating surface per hour for the firebox areas equals 55 pounds; for the combustion chamber, 55 pounds per square foot; firebox watertubes, 55 pounds per square foot; 2-inch tubes, 18 feet in length, 15/16-inch spaces, 9.54 pounds per square foot of outside heating surface; and for 2¼-inch tubes, 18 feet long with 15/16-inch spaces, 10 pounds per square foot of outside heating surface.

The grate area for bituminous coal is based on the burning of 120 pounds of coal per square foot of grate and that an evaporation of 6¾ pounds of water per pound of fuel is a good average. With saturated steam boilers 27 pounds of steam is equivalent to a boiler horsepower. Thus, $27 \div 6\frac{3}{4} = 4$ pounds of coal per horsepower for saturated steam locomotive boilers. Since the economical rate of combustion is taken at 120 pounds per square foot of grate, the grate area required equals the boiler horsepower divided by 30 for saturated steam. For hard or anthracite coal from 55 to 70 pounds of coal per square foot of grate, according to the grade of fuel is employed in proportioning the grate area.

With superheated steam the heating surface per boiler horsepower is figured as 23 percent less than saturated steam boilers. Thus, the consumption in superheated steam engines when the degree of superheat is 200 degrees or more, is 23 percent less, or $27 \times 0.23 = 6.21$ pounds. $27 - 6.21 = 20.8$ pounds of steam per boiler horsepower for superheated locomotives. The reason for these conditions is due to the increased volume of the steam from the superheat and the reduction in condensation in the cylinders.

When the total area in square feet of the tubes, firebox, combustion chamber is known, the horsepower can be determined approximately from the evaporation requirements to produce a boiler horsepower for saturated and superheated locomotives as explained.

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H. W. PARSONS, formerly with the marine department of the General Electric Company, has recently joined the marine department of the Power Specialty Company to handle the well known Foster boilers and superheaters.

# Girder Stay Calculations

Q.—I would be very much obliged if you would publish answers to the following questions:

Will you please show me why there exists so great a difference (seems to me) between the Board of Trade and the A. S. M. E. Boiler Code rule for girder stays?

$$Maximum\ W.P. = \frac{C \times d^2 \times t}{(W - D) \times D \times W}$$

The notations in formulæ quite agree for both authorities with the exception of the constant $C$, which reads as follows:

$$(B\ of\ T)\ 1\ \frac{N \times 1320}{N + 1}\ \text{for odd stays}$$

$$(B\ of\ T)\ 1\ \frac{(N + 1)\ 1320}{N + 2}\ \text{for even stays}$$

$C$ (A.S.M.E.) = 7,000 for 1 supporting bolt
= 10,000 for 2 or 3 supporting bolts
= 11,000 for 4 or 5 supporting bolts
= etc.

—L. T.

A.—The Board of Trade, Bureau Veritas, A. S. M. E. and Lloyd's give practically the same rule for calculating the allowable working pressure on rectangular girder supports of fireboxes and combustion chambers. The values of $C$ for the respective authorities are given in the following table:

VALUE OF $C$ FOR STEEL GIRDER CALCULATIONS.

| No. of Stays | Bureau Veritas | Lloyd's | Board of Trade |
|---|---|---|---|
| 1 | 6,600 | 7,110 | 7,920 |
| 2 or 3 | 9,900 | 10,660 | 11,880 |
| 4 or 5 | 11,000 | 11,850 | 13,200 |
| 6 or 7 | 11,550 | 12,440 | 13,860 |
| 8 | 11,880 | 12,800 | 14,256 |

The Board of Trade formula for determining the allowable working pressure is stated in two ways, either of which gives the same result, viz.:

$$\frac{C \times d^2 \times T}{(W - P)\ D \times L} = working\ pressure$$

in which:

$$C = \frac{N \times 1{,}320}{N + 1}$$

$$C = \frac{(N + 1)\ 1{,}320}{N + 2}$$

$N$ = number of bolts.
$W$ = width of combustion chamber, inches.
$P$ = pitch of supporting bolts, in inches.
$D$ = distance between girders from center to center, in inches.
$L$ = length of girder, in feet.
$d$ = depth of girder, in inches.
$T$ = thickness of girder, in inches.

When the value of $C$ is determined according to either of the formulæ the length of the girder is given in feet. If the value of $C$ is taken from the table the length of the girder is given in inches.

*Example:* What is the allowable working pressure on girder supports, when $W$ = 34 inches; $P$ = 7.5 inches; $D$ = 7.75 inches; $d$ = 7.5 inches; $T$ = 2 inches; using 3 stays per girder?

*Solution:* Substituting the values in the formula for finding the value of $C$:

$$C = \frac{3 \times 1{,}320}{3 + 1} = 990$$

The allowable working pressure equals:

$$\frac{990 \times 7.5 \times 7.5 \times 2}{34 - 7.5 \times 7.75 \times 2\text{-}5/6} = 191.4 \text{ pounds per square inch.}$$

Using a value for $C$ of 11,880 as given in the table, and the length of 34 inches in the formula, the working pressure allowed equals

$$\frac{11{,}880 \times 7.5 \times 7.5 \times 2}{(34 - 7.5) \times 7.75 \times 34} = 191.4 \text{ pounds per square inch.}$$

The A. S. M. E. allows 10,000 for the value of $C$ for 2 or 3 supporting bolts, and substituting this value in the formula the allowable working pressure, equals

$$\frac{10{,}000 \times 7.5 \times 7.5 \times 2}{(34 - 7.5) \times 7.75 \times 34} = 161.1 \text{ pounds per square inch.}$$

The difference in the values of $C$ is due to the difference in the factor of safety, considered suitable by the respective authorities.

# Cast Steel Ash Pans

Q.—It would be appreciated very much if at your convenience you would give me all the information you can concerning cast steel ashpans. I understand that they are in use on some of the Western railroads. I would like to know how long they have been in use, and if they warp any from the heat? How much do they cost?—J. E. T.

A.—There are a number of cast steel ashpans on the market, one of which is the *Commonwealth* type known for its long life, resistance to warping and burning out. The

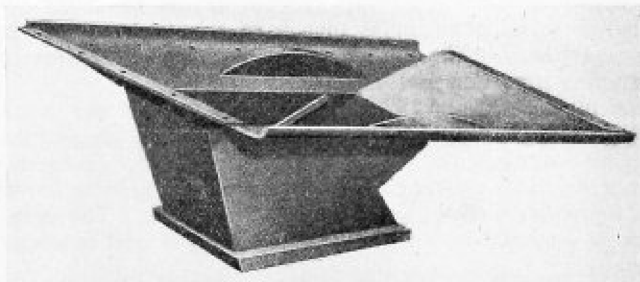


Fig. 1—New York Central Single Hopper Pan

built-up steel plate type is constructed with a large number of steel plate parts, rivets and angles. Owing to high temperatures arising in the ashpan from the fuel bed and live

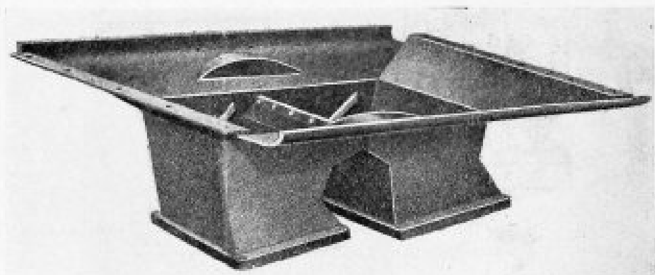


Fig. 2—Double Hopper Cast Steel Ash Pan

coals collecting in it, warping of the plate arises, which very often opens the seams, thus allowing air currents into the pan. This condition supports further combustion of the

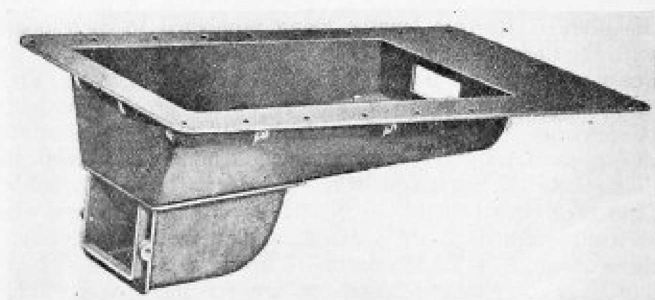


Fig. 3—Fire Pan for Oil Burning Locomotives

fuel that drops through the grate; this results in burned out plate and corrosion from the action of the gases. From the foregoing it is evident that cast steel resists heat and corrosion to better advantage than plate steel.

The New York Central Lines have some cast steel ashpans that have been in service twelve years and are still in good condition. In the accompanying illustrations three types of cast steel ashpans are represented. Fig. 1 shows a single hopper, Fig. 2 a double hopper and Fig. 3 a fire pan for oil-burning locomotives that forms the support for firebrick lining for any type of oil-burning equipment.

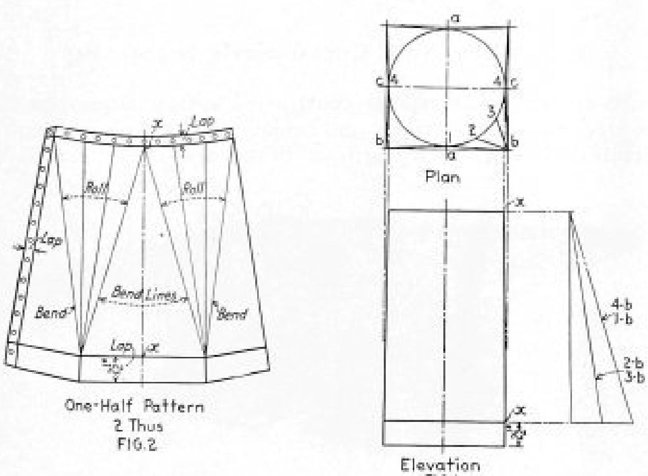
Additional information can be secured from superintendents of motive power of the railroads, or from the American Locomotive Company, 111 Broadway, New York, or the Baldwin Locomotive Company, Philadelphia, Pa.

## Square to Round Transition

Q.—May I ask you to give me the correct method of developing the transition piece described below. This transition piece is to be made square on one end with a flange to fit a joining member and round at the other end to fit into a 12-inch pipe; to be made of a 3/16-inch plate to fit on the outside of the joining member on the square end, and on the inside of a pipe on the round end. Thanking you in advance for any information that you can give me.—T. K.

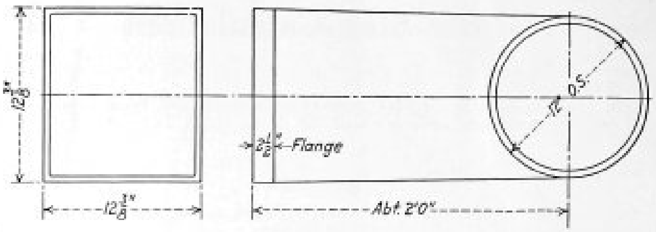
A.—The solution for this type of layout has been explained in other examples that have appeared recently in these columns. The method of triangulation is applied in handling transition problems of this kind.

A plan view is laid off to the neutral layer of the metal, Fig. 1. Since the circle representing the upper base and the square for the lower base are symmetrical about the center lines *a-a* and *c-c*, only one quarter of the plan need be set off in triangular sections, as, *1-b*, *2-b*, *3-b* and *4-b*. The elevation is indicated in Fig. 1, but this is not essential in actual



Layout of Transition Piece

work since the two bases are parallel, thus the height for triangles is the same. The required true lengths, *1-b*, *2-b*, etc., are found by laying off the triangles as shown to the right of the elevation. Their bases equal the radials as *1-b*, *2b* of the plan. The true lengths being numbered to correspond with the lines of the plan. Fig. 2 is a one-half pattern. The line *x-x*, Fig. 2, equals *x-x*, Fig. 1. Arc lengths *1-2-3-4*, Fig. 2, equal those in the plan, Fig. 1. These arc lengths may be determined by calculation which will give more accurate results than transferring their chord lengths. The neutral diameter of the circle equals 12 — 3/16 = 11 13/16 inches. Stretchout equals 11 13/16 × 3.1416 = 27.11 inches. In each quadrant there are 3 spaces, and in the complete circle there are 3 × 4 = 12 spaces. Therefore, 37.11 ÷ 12 = 3.092 inches required length of arc for the spaces. The assembly for the curved and flat sections of the pattern is



**Dimensions of Transition Piece**

made by the use of the true lengths of the triangles. Add the bottom lap or flange of 2½ inches and for the upper pipe connection.

## Testing Staybolts

Q.—A staybolt test was about to be applied to a locomotive boiler which had a straight side sheet firebox. The staybolts were old, as were the firebox sheets also. The water was warm and the pressure about 140 pounds per square inch. The tester took a fairly large hammer and commenced to hammer the staybolts near the leaks inside of the firebox. No one was holding on to the staybolts outside of the firebox. The delivery of the blows (double handed) was so severe that men near and some distance away wondered what was taking place. Later, the staybolts were examined and cracked and broken stays were displayed to a large number. The question is: Were the staybolts either cracked or broken while under pressure owing to the hard blows directed onto the staybolts?—J. O.

A.—The method followed in handling the test was entirely wrong. Evidently the person making the test did not understand the purpose of the test and what the results would be in striking heavy blows on stays that were not "bucked up." Furthermore, ignorance of the requirements is shown by the fact that by following such a method it would be impossible to determine the solid from broken stays. No doubt a large number of the good stays were damaged by this test.

## BUSINESS NOTES

A. A. Heller has taken over the management of the International Oxygen Company, Newark, N. J., in place of L. W. Hench, secretary and general manager, who has resigned.

The Florandin Equipment Company, New York City, which is New York representative of the Conveyors Corporation of America, Chicago, is also representing the Perfection Grate & Supply Company, Springfield, Mass., manufacturers of hand stokers and soot cleaners.

D. K. Hutchcraft, formerly vice-president of the Indiana Air Pump Company, Indianapolis, and one of the leading authorities on air lift pumping, has been appointed district manager of the Chicago Pneumatic Tool Company's branch office recently established at Tulsa, Okla.

The Minnesota Supply Company, manufacturers of railway and mill supplies, with offices in the Pioneer building, St. Paul, Minn., has been appointed northwestern representative for the Flannery Bolt Company, Pittsburgh, Pa. Blake C. Hopper, formerly with the American Steel Foundries, has been elected secretary-treasurer of the company.

The Norwalk Iron Works Company, manufacturing air and gas compressors for all purposes and also refrigerating machinery, with general offices and works, South Norwalk, Conn., has just opened a Chicago office, located at 627 W. Washington Boulevard. L. R. Bremser, who for thirteen years was with The Gardner Governor Company, is in charge.

The Wilson Welder & Metals Company, New York, is now represented exclusively in Maryland, Virginia and the District of Columbia, by the Alexander Milburn Company of Baltimore. A large stock of color-tipt welding metals and plastic-arc welding machines is available at this point for distribution throughout the territory and a complete demonstration plant is in operation.

# Letters from Practical Boiler Makers

**This Department Is Open to All Readers of the Magazine —All Letters Published Are Paid for at Regular Rates**

## Tank Bottom Layout

In your issue of THE BOILER MAKER dated September 22 I noticed a query from one of your correspondents signed "G. A. S." asking for information regarding the layout of the bottom of a large tank. The answer as given does not, in the writer's estimation, give the complete information required, and, as I have had large experience in this line of work in British India, I should be only too pleased to let "G. A. S." know my methods in this particular class of work. I know exactly what he is up against and I hope my suggestions will help him out. I am inclosing a sketch, Fig. 1, showing how easy it is to get the proper length of plates without laying the job down on the floor.

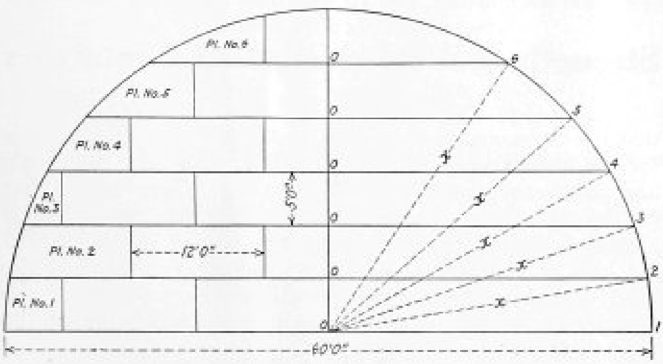



Fig. 1.—Method of Laying Out Large Tank Bottom

The sketch, Fig. 2, shows a simple method of laying out bottom of a large tank without having to lay section down full size on work to scale. Referring to this sketch it is evident that line X = radius of tank and this length remains constant. By having bottom constructed of equal width of plate (in this case 60 inches center to center of hole) the solution of the problem is reduced to a slight knowledge of the properties of the right angle triangle. Thus:

Length o — 1 = 30 feet
Length o — 2 $\sqrt{30^2 - 5^2}$ = 29.58 feet = 29 feet 7 inches
Length o — 3 $\sqrt{30^2 - 10^2}$ = 28.28 feet = 28 feet 3⅜ inches
Length o — 4 $\sqrt{30^2 - 15^2}$ = 25.98 feet = 25 feet 11¾ inches
Length o — 5 $\sqrt{30^2 - 20^2}$ = 22.36 feet = 22 feet 4 5/16 inches
Length o — 6 $\sqrt{30^2 - 25^2}$ = 16.58 feet = 16 feet 7 inches.

Having worked out this data it is a simple matter to mark off the end plates. Curves can be drawn in by a strip of wood or iron bent to the proper curve of tank. By exercising a little care, the holes can be laid out using the same template for marking off the angles.

Anyox, B. C. D. R. YOUNG.

## Is Boiler Making Being Overlooked?

On picking up most any modern magazine one can read various advertisements on "How to Become a Success." What good are they if the man studying such courses is not ambitious?

Most young men on entering their apprenticeship do not realize what opportunities are offered. If they do pick a trade it naturally would be one where the greatest opportunities are offered. Of all the most extensive trades or in-

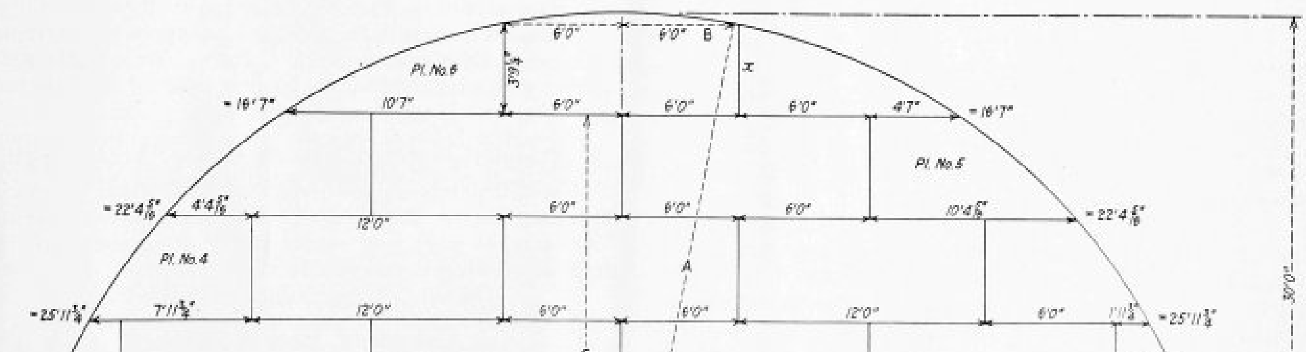



Fig. 2.—Plate Layout and Dimensions for Tank Bottom

dustries, boiler making offers more opportunities than the rest, yet fewer men follow it than the other trades. It seems that the young men of today are not keen on following a trade where there is sure to be much hard labor. If they do follow boiler making they seem satisfied to get no higher. In other words, they are satisfied to be just boiler makers.

Even the greater majority of apprentices do not care whether or not they learn the trade thoroughly and become first class mechanics. Of course, there are men who are good mechanics and have not the ability to hold down higher positions, but in most cases it isn't because they didn't try.

The pupil in school who observes and pays attention usually comes out ahead; so it is in the boiler shop. The apprentice who is always on the job and willing to do and learn everything he can will become a better mechanic than the one who thinks of nothing but "getting away with it."

It is very irritating to the mechanic to have an apprentice *working* with him who is never on the job. Probably it is a lack of interest that causes the apprentices to be this way. Something should be done to interest these young men in the boiler industry. Some people say "It Pays to Advertise," so why not try some advertising in the interest of both the apprentices and the boiler making industry.

There should be some means of advertising to show the wonderful opportunities such as railroad and insurance company boiler inspectors, foreman boiler maker, layer-out, etc., any of which a man who perseveres can reach.

In public, high or night school there are very few subjects taught in the mechanical courses which pertain to boiler making. Perhaps a little advertising would liven them up on this indispensable branch.

The boiler making industry no doubt has plenty of hard manual labor at the beginning, but for those who are ambitious it does not last very long.

As a last word, "anything that is worth while is worth working for."

Paterson, N. J. John M. Wylie.

## Retribution

Retribution dogs the footsteps of the most unwary and some things persist to confound their authors. In 1916 an article entitled "The Shop Executive" appeared over my initials, it gave me pleasure to write and its appearance in the December issue of that year added to the pleasure. With the exception that it was extracted elsewhere (always a pleasure to the most case hardened writer) it seemed naturally to have served its immediate purpose and, like most current periodical contributions, was buried in oblivion.

There is a persistence in fate, and remembrance, if not immortality, dogs my footsteps. In 1916 the number of subscribers to The Boiler Maker in this country must have been limited; its circulation here is now much larger. The resurrection occurred as follows: A very much alive foreman in a progressive shop not 100 miles from London recently asked his directors for a raise in salary. This is nothing unusual in itself but to clinch his arguments he produced my article, recited my perversion of Kipling's verse at the end, and got his raise. The management understood boilers but poetry got them down.

The directors are personally known to me and now half humorously point out that the increase in wages should be charged to my account. Unfortunately, I am not one of the directors otherwise the punishment would have fitted the crime more exactly.

The foreman as such still has my sympathy. If there are other similar cases, my position will be that of a public benefactor and a disguise will be necessary. But the preservation of my article for six years and its dramatic sequel leaves me chastened and humbled. Not one of all my contributions ever had so direct an effect on my own finances, perhaps because the coveted post of foreman never came my way. Perhaps my elocution is poor; it would never have occurred to me that the management of a boiler shop could be touched to finer issues by lyrical lines. Possibly had I been foreman an ordinary vocabulary would have been too temperate and the pen would have burnt the paper.

However, once again, here's to the FOREMAN, whose resiliency allows prompt rebound from affront from above and criticism from below. How he manages to bestride two horses at the one time (management and men—I nearly wrote the devil and the deep sea) has always been amazing to the onlooker. That an article of mine has had the above effect is a pearl of price amidst many vexations. Whether the same course will have the same effect elsewhere is not for me to say but I hope that it will not lead to a similar request to share the burden caused by sincere efforts to better the lot of the most deserving in the business.

London, England. A. L. Haas.

## Strength of Welded Pressure Containers

(*Continued from page 352*)

that the resistance to shear per linear inch of joint is greater for the welded joint. Measurements to determine the elastic and permanent protrusion of the container heads showed that for the two specimens so tested the welded container withstood a somewhat greater pressure without permanent distortion. In the case of the riveted containers, leakage occurred at the head joints under moderate pressures. In the case of the electrically welded containers there was no leakage at the head joint under any pressure.

### Efficiency of Electrically Welded Joints

While it is customary to speak of the efficiency of a joint, whether welded or riveted, meaning the ratio of the strength of joint to strength of plates joined, the writer does not believe that this ratio is especially significant in the case of electrically welded joints nor that any generally applicable value can be given.

It is apparent that while the strength of the plates joined is dependent solely on the physical properties of the base metal, the strength of the weld is in great measure dependent on the properties of the filling metal. Furthermore, the percent excess thickness of the weld, which influences its strength, varies with the thickness of the plates. Accordingly the efficiency of a weld depends on the properties of the base metal, the filling metal, and the thickness of the plates.

The writer believes that the correct method of computing the efficiency of an electrically welded joint is on the basis of a specified minimum strength of base metal, a specified minimum excess thickness of weld and an experimentally determined average (per square inch) of the metal, of which the finished weld is composed.

## Diagonal Boiler Patches

In the article "Chart Developed for Use in Designing Diagonal Boiler Patches" by Edward Hall, appearing on page 314 of the November issue of The Boiler Maker, additional information should have appeared along the top section of the chart giving the factor to be used according to rule 818 of the New York Boiler Code. The figures should begin at the extreme left starting with 1.0 and increase with each succeeding division on the chart by 0.1. Readers of the magazine will be able to add these figures; that is, 1.0 for the marginal division, 1.1 for the first, 1.2 for the second, 1.3 for the third, etc., thus making the chart absolutely complete.

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Assistant Chief Inspector—J. M. Hall, Washington, D. C.

### Steamboat Inspection Service of the Department of Commerce

Supervising Inspector General—George Uhler, Washington, D. C.

Deputy Supervising Inspector General—D. N. Hoover, Jr., Washington, D. C.

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### Boiler Code Committee of the American Society of Mechanical Engineers

Chairman—John A. Stevens, Lowell, Mass.
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William Atkinson, Assistant International President, suite 522, Brotherhood Block, Kansas City, Kansas.

Joseph Flynn, International Secretary-Treasurer, suite 504, Brotherhood Block, Kansas City, Kansas.

James B. Casey, Editor-Manager of Journal, suite 524, Brotherhood Block, Kansas City, Kansas.

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## TRADE PUBLICATIONS

TAPS AND DIES.—The Tap and Die Institute, New York, has issued a 17-page catalogue which contains a few of the more important standard tables which it has prepared and adopted in an effort to obtain a greater degree of uniformity in the dimensions of taps and dies.

DIE HEADS AND TAPPING DEVICES.—The Geometric Tool Company, New Haven, Conn., has just issued two illustrated catalogues, one of which covers the Jarvis line of tapping devices, tapping machine, quick change chucks and collets, and self-opening stud setter; the other, the Geometric style DS die head as applied to Brown & Sharpe automatics and other single-spindle automatics.

DURALOY.—Bulletin No. 221, of the Cutler Steel Company, Pittsburgh, Pa., contains a general description of the metal Duraloy, which has properties of resistance to oxidation, corrosion and abrasion. Duraloy is a chromium iron alloy developed as a low cost alloy to resist oxidation. It can be supplied in castings, bars, sheets and in rolled form responds to heat treatment in a manner similar to alloy steels.

THE GAP CRANE.—The H. K. Ferguson Company, Cleveland, Ohio, has issued a four-page leaflet illustrating the adaptation of the gap crane to an erecting shop for the handling of heavy locomotive repairs as worked out for the Hornell (N. Y.) shop of the Erie now under construction. This leaflet shows the manner of handling locomotives with this crane and points out the advantage of this new equipment.

FOSTER WASTE HEAT TYPE SUPERHEATERS.—Superheaters of the waste type for marine boilers have been installed in the ships of all nations. Details of such installations with complete descriptions of the superheaters are given in a bulletin issued by the Power Specialty Company, of New York. Thermometers and soot blowing apparatus with suitable safety valves for the superheaters are included. Operating records of superheaters on various ships and a list of ships equipped with Foster superheaters with their principal machinery details are also stated.

# SELECTED BOILER PATENTS

Compiled by

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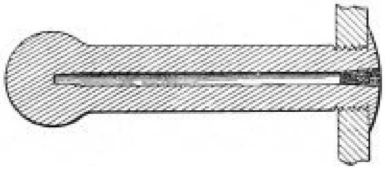
Readers wishing copies of patent papers, or any further information regarding any patent described, should correspond with Mr. Hutchinson.

1,428,541. STAYBOLT STRUCTURE FOR BOILERS. JOHN ROGERS FLANNERY, OF PITTSBURGH, PENNSYLVANIA, ASSIGNOR TO FLANNERY BOLT COMPANY, OF PITTSBURGH, PENNSYLVANIA.

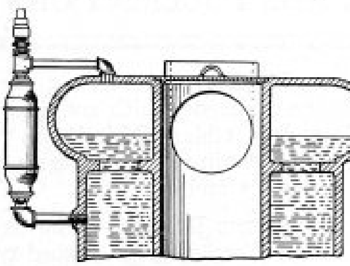
*Claim* 1.—A staybolt having a tell-tale hole provided with a porous closure. A staybolt having a tell-tale hole closed at one end, and a plus in the



other end of the staybolt constructed of granular material through which water or steam may percolate. Six claims.

1,433,968. BOILER FEED. OTTO NELSON, OF CHICAGO, ILLINOIS.

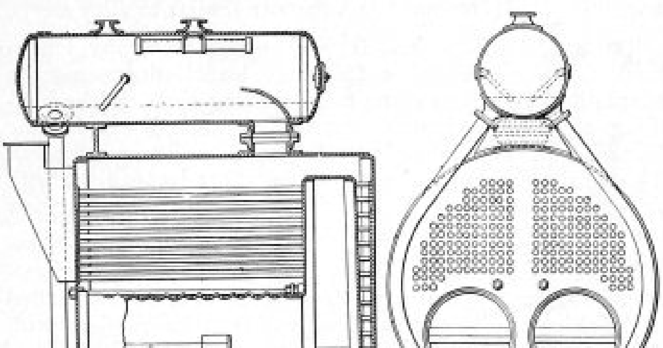
*Claim* 1.—A boiler comprising a float chamber positioned adjacent the boiler and extending above and below the water therein; a pipe connecting the upper portion of said chamber with the steam space of said boiler; a pipe connecting the lower portion of said float chamber with the water space in said boiler; a water supply pipe leading into the top of said float chamber



and provided with a valve seat above the upper wall of said float chamber controlling the discharge therefrom; a strainer arranged across said water supply pipe above said valve seat; a float in said chamber; a valve stem carried by said float and projecting upwardly therefrom through the upper wall of said float chamber, said upper wall acting as a guide for said valve stem; and a needle valve formed at the top of said valve stem co-operating with said valve seat, whereby the water level in the boiler is maintained substantially constant, substantially as described. Two claims.

1,434,502. STEAM BOILER. DAVID WENDELL ROBB, OF CLEVELAND, OHIO.

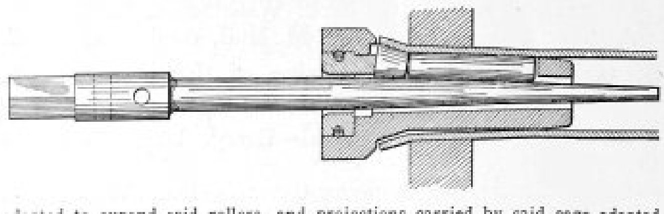
*Claim* 1.—In a marine boiler such as described, the combination with the boiler shell having fire doors therein, combustion chambers located within the shell and fire tubes extending from the rear end of the boiler to the front end for the passage of products of combustion, of a steam drum located in horizontal position above the boiler shell, a communicating neck connecting the shell and drum in proximity to the rear end of the shell and drum, said



neck terminating below the working water level in the drum, and an external circulating pipe connection spaced from the boiler and through which all of the circulating water passes from the drum to the shell, said pipe connection being located in front of the shell and extending downwardly at the side of the shell to give access to the fire doors, and said pipe connection being at its upper end in communication with the front end of the drum and at its lower end in communication with the lower front end portion of the shell whereby the water will circulate from one end of the shell to the other and in a single continuous path through the shell and drum. Four claims.

1,404,819. TUBE EXPANDER. OTTO WIEDEKE, OF DAYTON, OHIO, ASSIGNOR OF ONE-HALF TO GUSTAV WIEDEKE, OF DAYTON, OHIO.

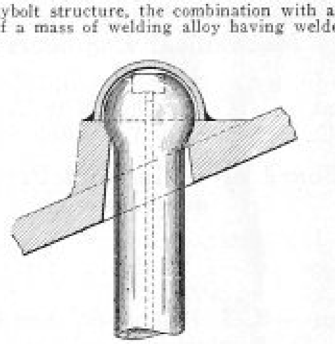
*Claim* 1.—In a tool for expanding a tube in a boiler head, a cage having pockets therein, tapered rollers mounted in said pockets, a tapered mandrel



adapted to expand said rollers, and projections carried by said cage adapted to hold said rollers in said cage, said projections having chamfered ends in engagement with said rollers and providing thrust members therefor. Four claims.

1,424,733. STAYBOLT STRUCTURE. ROBERT S. MENNIE, OF CHICAGO, ILLINOIS, ASSIGNOR TO FLANNERY BOLT COMPANY, OF PITTSBURGH, PENNSYLVANIA.

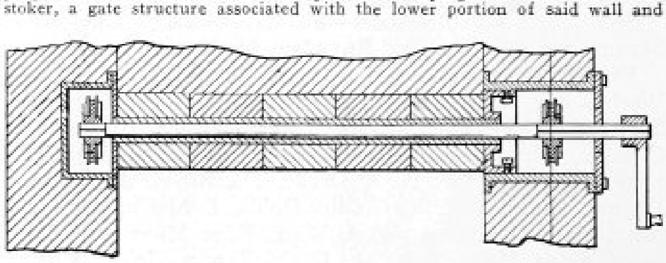
*Claim* 1.—In a staybolt structure, the combination with a boiler sheet having a bolt opening, of a mass of welding alloy having welded union with the



outer face of the boiler sheet and having a shape forming an annular boss around the opening in the boiler sheet, a closure engaging said boss of welding alloy, and a staybolt having a head enclosed by said boss and closure. Four claims.

1,428,636. FURNACE-BRIDGE-WALL CONSTRUCTION. FRANK A. HURLBUT, OF FLAT RIVER, MISSOURI.

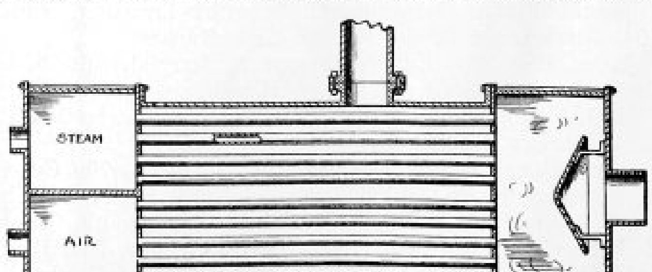
*Claim* 1.—A furnace construction comprising a fire chamber having a progressive feed stoker and a bridge wall overlying the rear end of said stoker, a gate structure associated with the lower portion of said wall and



comprising a transverse shaft having a gate member provided with a bearing loosely mounted on said shaft, and eccentric supporting means for said shaft operating, on turning of the shaft, to raise and lower said gate member, the shape of said bearing being adapted to permit independent self-adjusting movement of said gate member to accommodate itself to the material carried by the stoker. Four claims.

1, 436,379. SUPERHEATER. CHARLES E. CHAPMAN, OF FORT EDWARD, NEW YORK, ASSIGNOR OF ONE-HALF TO JOSEPH GOODFELLOW, OF FORT EDWARD, NEW YORK.

*Claim* 1.—A superheater for air and steam comprising separate groups of superheater tubes, means for feeding steam through one group, means for




feeding air through another group, and a mixing chamber common to the groups for receiving the discharge therefrom to commingle within the chamber. Five claims.