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THE BOILER MAKER

JANUARY, 1911

THE DESIGN OF A MARINE BOILER.

So many draftsmen have little opportunity of studying the design of a marine boiler that to treat the subject from the beginning might not be out of place. Unless one has worked continuously at boiler work for a time, no matter how well up in engine detail work he may be, in the most elementary boiler there might be room for improvement.

For this reason it it as well to commence at the beginning, and point out that there is a good system and a bad system of does not lose time hunting about for tensile strength of plates, and ultimately finding it among the tubes.

This methodical system should be used not only in setting out the boiler but in sizing up the various parts. Take, for instance, the shell plates; in how few cases do we get the sizes running in succession, more often we find the length of a shell on the bottom of a boiler, and the radius of flange of end plates on the top corner, if, indeed, it is marked at all. The

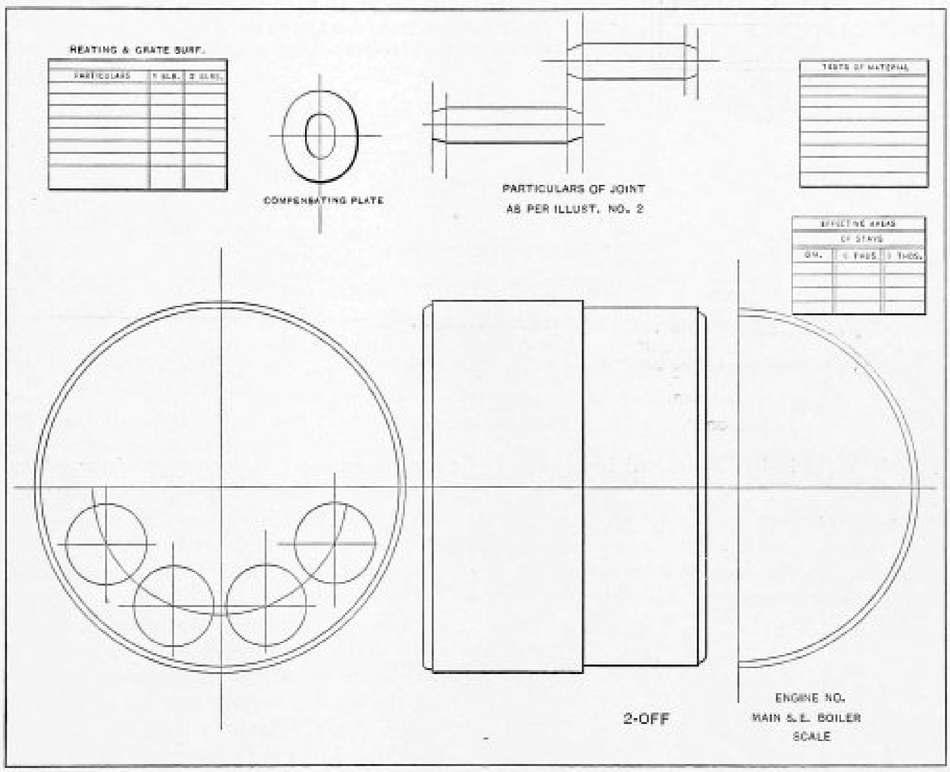


FIG. 1.

setting out the details of a boiler on a sheet of paper. On a drawing one ought to have everything in its proper place, so that it may be read off at a glance. Sometimes you find in one corner the particulars of a joint, and in another the working-pressure. Somewhere in the center of the sheet you may get the survey, tensile strength of the plates, etc. Now it is obvious, as the working-pressure, tensile strength of the plates and pitch of rivets in the longitudinal joint are all intermingled, depending on each other, the proper place to find these particulars is under the detail of the joint.

Suppose we have a sheet of paper standard size, then we want to set out the boiler drawing with all the principal particulars, as shown in Figs. 1 and 2. With this method as standard one has all the leading particulars before him, and correct system should be carried out as shown in detail in Fig. 2. This enables the boiler maker to set off his sizes without the uncertainty of calculating various bits.

Having mentioned the importance of having a correct system in drawing a boiler it is now necessary to make a start on the design. The draftsman usually gets the following particulars: Diameter, length of boiler, heating surface required, grate area, working-pressure, etc. Let us assume we have to design a boiler 15 feet 9 inches mean diameter by 12 feet mean length, 215 pounds working-pressure, Board of Trade and Lloyd's surveys, four furnaces 3 feet 3 inches inside diameter.

We set off the furnaces, first keeping the furnace mouths 5½ inches from the inside of the shell (Fig. 3). This size is necessary for admitting the rivet into the hole, and must not be less. The furnace will likely either be Morison's or Deighton's—they are similar for sizes and vary only in section. The distance from the inside of the corrugation to top of corrugation being 2⅛ inches standard. Now the furnace must be a ½ inch larger at the front for withdrawing, so the size of the furnace mouth will be for our furnace 3 feet 3 inches + twice 2⅛ inches + ½ inch = 3 feet 7¾ inches over mouth. The radius from center of boiler to center of furnaces therefore will be

the requisite water space between the wrapper plates, which must not be less than 4 inches, to allow the water to circulate freely.

Assuming we have located the best position for our furnaces, we may draw down the back end in the one-half and the furnace mouths in the other, as shown in Fig. 4. The back end of the furnaces calls for some attention. Board of Trade rules ask that the vertical axis should not exceed the horizontal axis

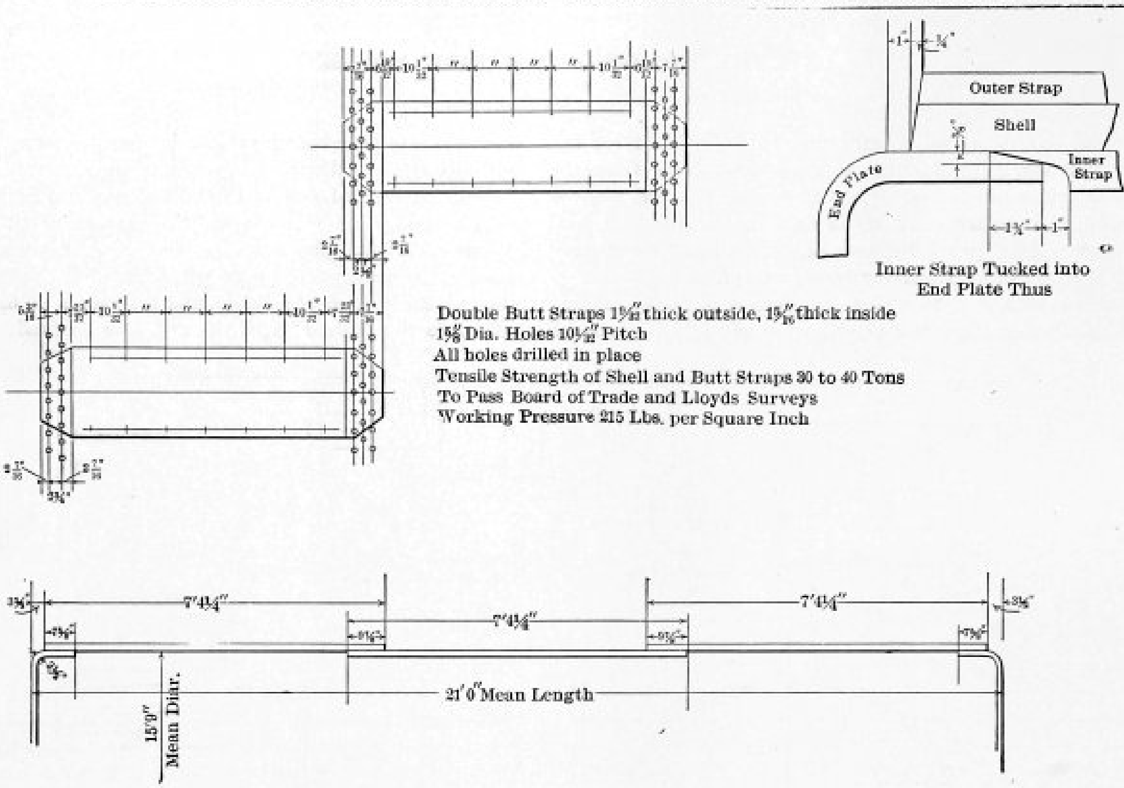


FIG. 2.

radius furnace mouth + 5½ inches subtracted from radius of boiler = 5 feet 7⅛ inches.

I have purposely chosen a four-furnace boiler, as the setting off in the boiler of the furnaces is a little more difficult than on a three-furnace one. In the case of a three-furnace one, you simply draw the center furnace on the center line of the

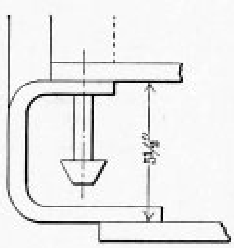


FIG. 3.

boiler at the 5-foot 7⅛-inch radius and the wing ones, keeping the 5½-inch space between the mouths, the back end of the wing furnaces being in a vertical straight line. In the four-furnace, however, it is slightly different; you have to consider the back end of the furnace, the center of which is inclined at an angle towards the center of the boiler, the off-set usually being 6 inches (see Fig. 4). Owing to this angle the wrapper plates are apt to be too close to the bottom of the wing furnace, if you were to adhere strictly to the 5½-inch space between furnace mouths. Sometimes this 5½ inches has to be increased (especially if the furnaces happen to be a trifle large in proportion to the diameter of the boiler), in order to give

by more than 14½ percent, also the set-up at the back should not exceed 8 inches. Now, this applies to all furnaces of this type, and Table II. (page 8) shows all sizes of furnaces worked out to suit Board of Trade rules. We will simply pick out the back end from Table II. against the diameter we want, and draw them in position (Fig. 4).

The next item is is the fixing of the tube spaces. The top row if the tubes is generally spoken off as being one-third of the boiler space; but we will soon find in practice the demands of the heating surface will not permit us all this space, especially if the boiler is a large one. Taking an example from practice, I find the top row of tubes from the mean diameter, 15 feet 9 inches, to be 5 feet 1 inch. Suppose, then, we fix the distance from the mean of the shell to the center of the top row of tubes at this, and we divide the nests into as equal number as possible, taking care to leave 11 inches between the outer edges of the tubes at the center and the outer edge of the tubes and the shell at the wings. Then we have a space about 9 inches from the top of the furnace to the nearest edge of the tube. In setting out the center nest of tubes for a four-furnace boiler it is better to widen out the throat of the combustion chamber, as owing to the long, narrow box the gases pass to the top at such a high velocity they are apt to miss the bottom rows of tubes unless you induce them to go through. (See Fig. 4.)

The water spaces for the tubes are usually 1¼ inches, and the pitch for 2½-inch tubes therefore is 3¾ inches by 3¾ inches. If we are tied very much for heating surface, and we want to take every inch out of the tubes, we may reduce the vertical water space to 3⅝ inches, as this does not retard the circulation of the water as much as if it were the horizontal pitch. Before leaving the tubes I may say the average diameter for forced draft boiler tubes is 2½ inches external diameter, and not longer than 8 feet 3 inches nor shorter than 7 feet 6 inches, and for a natural draft boiler the usual diameter is 3¼ inches or 3½ inches external diameter, and not longer than 7 feet 9 inches.

Next we draw the wrapper plates around the tubes, and they are usually carried down to about the center line of the furnaces. A joint being formed just below the line of flame, the front plate they are calked into the plate with a nut either side. The manhole between the furnaces are made 16 inches by 12 inches, if space permits, and 15 inches by 11 inches if space is cramped, and are flanged inwards to compensate the hole.

The longitudinal view presents no great difficulty to draw. The boiler which we started to design was 12 feet mean length. Our aim is to get as broad a box as possible and as decent a water space at back as possible. Say we take the box at 2 feet 10 inches over plates, and 8-foot 3-inch tube will give us

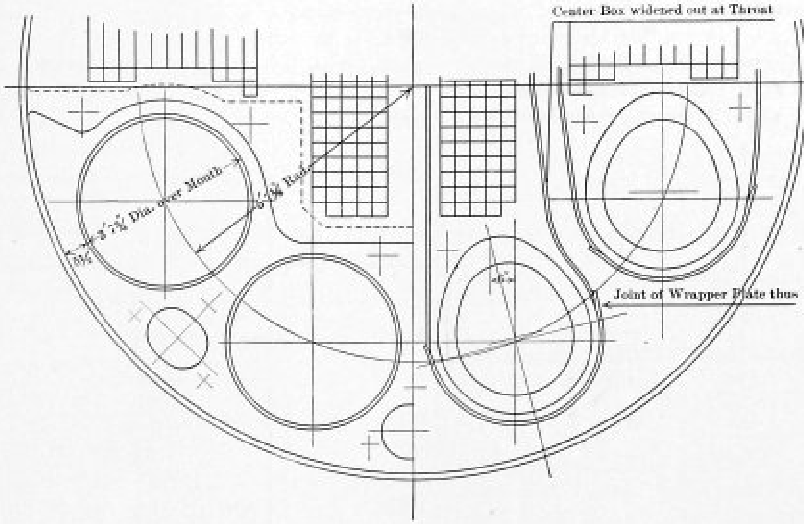


FIG. 4.

the thick plate forming the bottom of combustion chamber is set back on the outside of the wrapper plate (see Fig. 4). This does not hinder the circulation of the water, as it would tend to do were the wrapper plate on the outside, and consequently there is less chance of a leaky joint. After the wrapper plates are lined off we space the steam space stays and the girders simultaneously, the stays being arranged to suit each particular set of girders. Should the center box in a three-furnace boiler be too narrow to accommodate four girders easily, put in three, and stagger the steam space stays (see Fig. 5), being 11-inch water space at back, which is fairly good proportion. There is usually a taper on the combustion chamber back of about 3 inches in the length of the box, giving 9 inches water space at the bottom. This enables the bubbles of water to rise quite freely off the box, and not to crawl up the back, as they would tend to do were it parallel.

A half view looking on the back of the boiler showing the screwed stays to the combustion chamber back is all that is required to show the staying. These stays should, as far as possible, run in parallel rows, so as not to block up the scaling

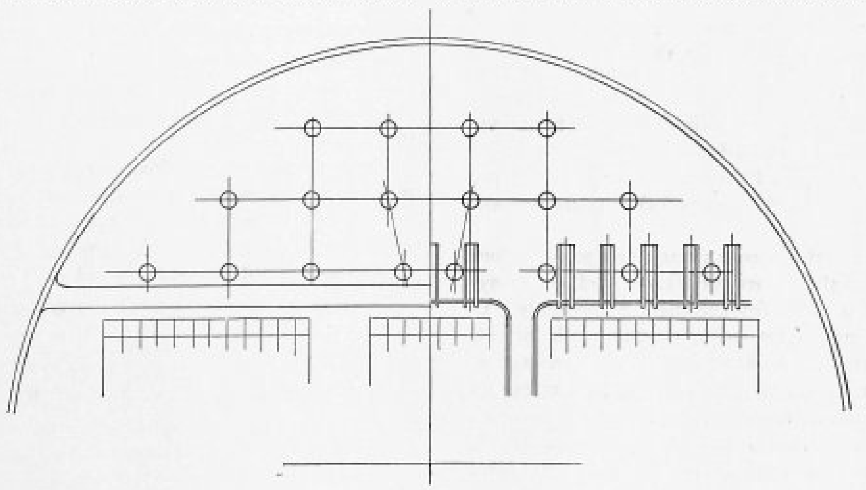


FIG. 5.

careful, of course, to keep the surface as evenly distributed as possible. After putting in the cross seams, making breadth of landing 4¾ inches, and riveting 1-inch diameter holes 4¾ inches pitch, double, as general standard, proceed to locate the best position for breast stays and manholes between the furnaces. The breast stays are screwed, six threads per inch, through the back tube plate with a nut inside the fire-box. In passages. The same applies to the combustion chamber sides. Sometimes the pitch of the combustion chamber wing sidestays through the shell have to be staggered if we have a narrow box, and the pitch falls much less than the longitudinal pitch of rivets in the butt-straps. This is because the Board of Trade and Lloyds would be entitled to calculate the percentage strength of the shell on this pitch. If we have 8¼ inches pitch, or 8½ inches, we usually can get the survey to pass this, as the number of rows of stays in line are not many, being as a rule only three.

So far we have not mentioned anything about thicknesses; they may safely be assumed for drawing purposes up to this point; but it is now necessary to fix up the strengths according to the Board of Trade and Lloyd's requirements. Regarding the percentage of rivet and plate section and thickness of shell, the first point to settle is the tensile strength of material. The higher the tensile strength, of course, the thinner the plate, but the higher the tensile strength the dearer the plate, unless what you lose in weight makes up for the extra price in tensile strength. The plate also must have a limit in thickness not more than 1⅝ inches or 1 21/32 inches, otherwise the enormous weight of plates would cause extra price for labor, etc. using the least percentage found; for shell thickness we have

$$\frac{67{,}200 \times .838 \times 3.25}{4.5 \times 189} = 215.1 \text{ pounds working pressure} =$$

1⅝" plate. Lloyd's plate percentage same as Board of Trade, and rivet

$$= \frac{5 \times 2.0739 \times 1.75 \times 85}{10.03125 \times 1.625} = 94.6 \text{ percent,}$$

and using least percentage found, therefore, will be for thickness of shell

$$= \frac{22 \times 30 \times 21 \times 83.8}{28 \times 189} = 219.5 \text{ pounds} = 23/16'' = 1\ 7/16''$$

plate.

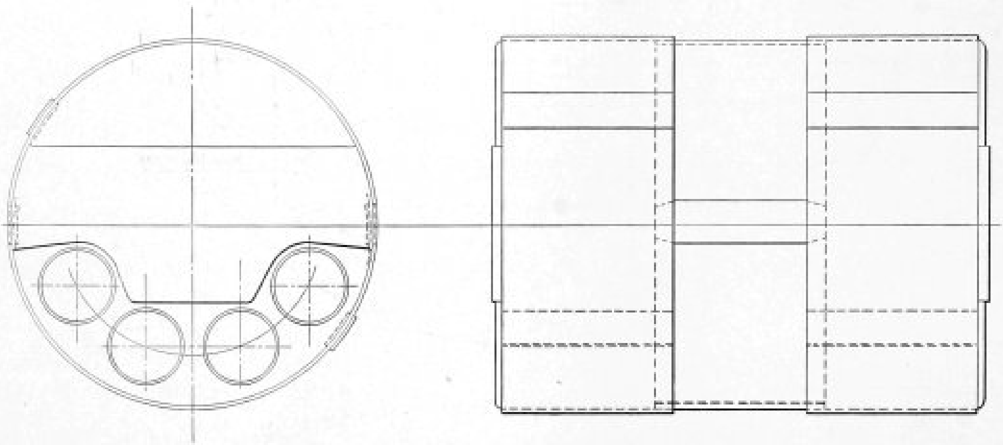


FIG. 6.

The best course for us to follow is to try what thickness, say 29 tons tensile strength, would give, and what price, also what thickness and what price, say 30 tons tensile strength, would give, and choose the least—of course, bearing in mind to have the limit 4 tons, such as 29 to 33 or 30 to 34, as the extra goes up with a 3-ton limit. I may mention here that the fixing of the position of butt-straps has a great deal to do with the price of plates, as by consulting a steel maker's list of extras, one sees at once that the extras increase double the amount per 5 hundredweights if the plate is over 6 tons in weight. Those plates can nearly always be arranged in halves, even though the strap comes in way of the screwed stays. This is a cheaper arrangement than having a long and a short plate, as by having a long plate in a large boiler there is no chance of having it under 6 tons, but if it is exactly half you can get it under and lessen the steel maker's extra. A good and cheap arrangement is illustrated in Fig. 6.

Say, then, we have fixed the tensile strength at 30 to 34 tons per square inch, and as the Board of Trade shell is always heavier than Lloyd's, we work for thickness accordingly. In considering the plate and rivet sections, the pitch of the longitudinal seam is arranged to give as high a percentage as possible, and for large boilers will vary about 10 inches, but not greater than 10½ inches, according to the result attained. Take our pitch at 10 1/32 inches and the rivet hole at 1⅝ inches diameter, which is ordinary practice, then our plate percentage for Board of Trade will be

$$\frac{(10\ 1/32'' - 1\tfrac{5}{8}'') \times 100}{10\ 1/32} = 83.8 \text{ percent,}$$

and our rivet percentage

$$= \frac{100 \times 23 \times 2.0739 \times 5 \times 1.875}{30 \times 10.03125 \times 1.625} = 91.3,$$

Now we see that this would have been a case where we might have gained a 1/32 inch off the shell had this been a Lloyd shell alone, by increasing the pitch of rivets slightly in the butt-straps, and thereby increasing the plate percentage, thus taking the pitch at 10½ inches

$$\frac{(10\tfrac{1}{2}'' - 1\tfrac{5}{8}'') \times 100}{10\tfrac{1}{2}''} = 84.5 \text{ percent;}$$

therefore, getting the shell for Lloyd's 1/32 inch less

$$= \frac{22 \times 30 \times 20.5 \times 84.5}{28 \times 189} = 216 \text{ pounds} = \frac{22\tfrac{1}{2}}{16} = 1\ 13/32''$$

plate.

I have specially chosen this example to illustrate the point, that while increasing the pitch of rivets would not materially benefit a shell to both surveys, it would have benefited a shell worked out to Lloyd's survey alone.

Thickness of butt-straps to Board of Trade alone would be

$$= \frac{5 \times T\ (p - d)}{8 \times (p - 2\,d)} = \frac{5 \times 13 \times 269 \times 32}{8 \times 8 \times 32 \times 217} = 1\ 9/32'' \text{ thick.}$$

The inner strap must be worked out to suit Lloyd's, which reads

$$\frac{3 \times T\ (p - d)}{4 \times (p - 2\,d)} = \frac{3 \times 23 \times 269 \times 32}{4 \times 16 \times 32 \times 217} = 1\ 11/32'' \text{ thick.}$$

But if we had started by making our longitudinal pitch 10½ inches instead of 10 1/32 inches Lloyd's shell would have been, we saw 1 13/32 inches thick, and our inner butt-strap would have been to this thickness

$$= \frac{3 \times 45 \times 269 \times 32}{4 \times 32 \times 32 \times 217} = 1\ 5/16'' \text{ thick,}$$

which would have saved us 1/32 inch in our inner butt-strap. This will bring the point clearly to us, when we are working for two surveys, to get best results to suit both requirements.

We have worked the straps out on the assumption that our shell plates were normal tensile strength, but they are not; we are making them 30 tons per square inch, therefore the straps will be and the thickness may be decreased in the proportion of 28 to 30. It now remains for us to draw the butt-straps as in Fig. 2. The inner butt-strap is tucked into the end plate, and into the inner shell of the end strake (Fig. 2).

The top end plate thicknesses are governed by the pitch of steam space stays, and sometimes, whether they are hand or machined flanged, also, of course, what type of plate, whether doubled or not. The usual thickness for high-pressure boilers and good flanges runs about 1¼ inches to 15/16 inches, and the cheapest method is not to fix any doubler or washer, even though you have a thinner plate; as a rule the expense of fitting and riveting a doubler more than runs away with the difference of thickness of plate.

Board of Trade top end plate =

$$W\ P = \frac{C \times (T+1)^2}{S-6} = \frac{150 \times 441}{(20 \times 15\tfrac{1}{4}'')} =$$

221.2 pounds = 1¼" plate.

Lloyd's top end plate =

$$W\ P = \frac{C \times T^2}{p^2} = \frac{175 \times 400}{316.2} = 221.3 \text{ pounds} = 1\tfrac{1}{4}''$$

plate.

The surface, of course, is taken as the largest, but it is the aim of the designer to have it as evenly distributed as possible, so that the material will not be wasted.

Steam space stays are generally of steel and a little heavier for Board of Trade than Lloyd's. Board of Trade being

$$\frac{\text{Surf.} \times W\ P}{9{,}000} = \frac{20'' \times 15\tfrac{1}{4}'' \times 215}{9{,}000} = 7.286 \text{ square inches,}$$

at six threads per inch = 3¼" diameter (see table VI.). Lloyd's being

$$\frac{\text{Surf.} \times W\ P}{10{,}400} = \frac{20'' \times 15\tfrac{1}{4}'' \times 215}{10{,}400} = 6.3 \text{ square inches, at}$$

six threads per inch = 3⅛" diameter (see table VI., page 9).

These steam space stays are usually fastened with nuts inside and outside of the plate. Sometimes they are screwed into the plates. In this case the diameter of stays is the same as found above, only care must be taken to have one end swelled ⅜ inch larger, to allow the stay to pass through the screwed hole in one end of the plate, also the thread in both ends of the stay is continuous.

The combustion chamber stays are fixed in the same manner as above, with the pitch usually about 8 inches by 8 inches. Screwed stays in combustion chamber to Board of Trade =

$$\frac{\text{Surf.} \times W\ P}{9{,}000} = \frac{8 \times 8 \times 215}{9{,}000} = 1.52 = 1\tfrac{5}{8}'' \text{ diameter at}$$

ine threads per inch (see table Vi.).

Screwed stays in combustion chamber to Lloyd's =

$$\frac{\text{Surf.} \times W\ P}{\left(\begin{matrix}8{,}000 \text{ if below } 1\tfrac{1}{2}'' \text{ smallest diameter} \\ 9{,}000 \text{ if above } 1\tfrac{1}{2}'' \text{ smallest diameter}\end{matrix}\right)} =$$

$$\frac{8 \times 8 \times 215}{8{,}000} = 1.72 = 1\tfrac{5}{8}'' \text{ diameter at nine threads}$$

per inch (see table VI.).

Had these screwed stays been iron, tested to 21½ tons tensile strength, they would have been allowed the same stress as steel. These stays are fitted with solid forged iron nuts, except the combustion chamber wing stays through shell. They are simply allowed to stick ⅜ inch through the shell and are calked tight.

The thickness of the combustion chamber wrapper plates is found for Board of Trade by the following formula:

$$\frac{C \times (T+1)^2}{S-6} = W\ P = \frac{100 \times 132.25}{58} = 228 \text{ pounds}$$

plate 21/32" thick, and Lloyd's

$$\frac{C \times T^2}{p^2} = W\ P = \frac{135 \times 110.25}{64} = 232.5 \text{ pounds}$$

plate 21/32" thick.

The thickness of the plates at combustion chamber backs and diameter of stays are found in exactly the same manner, also the back end of boilers in nest of stays. The marginal stays at back end of boiler are similar, only they must support a larger surface.

Surface to Board of Trade:

$$(11\tfrac{1}{8}'' \times 8'') - 6.$$

Surface to Lloyd's:

$$\frac{11\tfrac{1}{8}^2 + 8^2}{2}$$

The thickness of the plate at wide space in the back end of the boiler is found in the same manner as flat plates, only constant for Board of Trade is 112.5 at this part, and for Lloyd's same as before, 135. Should there be a doubler at the wide space then the thickness of the back plate is fixed in the nest of stays, and the thickness of the doubler from the following formula:

$$\frac{C\ (T+1)^2 + 2/3\ C\ (T_1+1)^2}{S-6} = W\ P.$$

With regard to the bottom back end plate, the thickness is very similar to the mid-back plate, as the surfaces run out

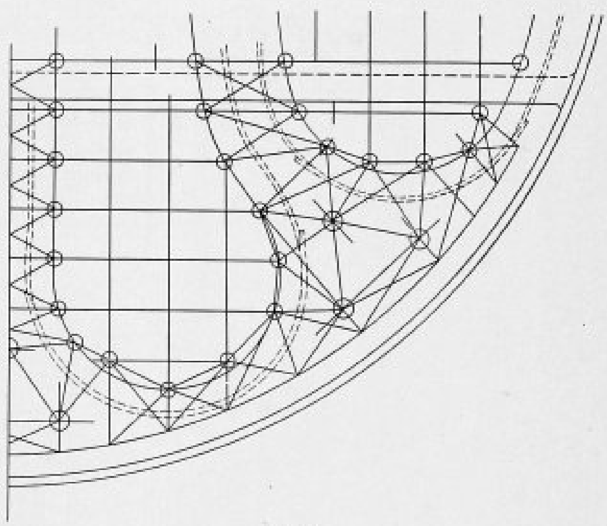


FIG. 7.

pretty much the same. However, the surfaces ought to be tried separately in some fashion similar to Fig. 7, and the same constants used as applied to mid plates.

In the bottom end of the front plate there are no large spaces to support. Owing to the circular furnace mouths the plate is naturally strong, and as there is usually a breast stay

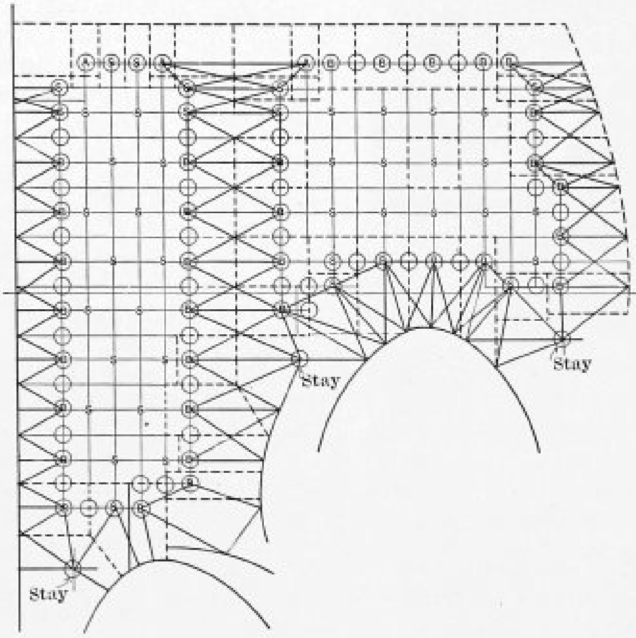


FIG. 8.—DIAGRAM SHOWING SPACES TO SUPPORT ON FRONT TUBE PLATE AND BACK TUBE PLATE. DOTTED SQUARES SHOW TUBE SURFACES. FULL SQUARES SHOW PLATE SURFACES.

at either side of the wing furnaces, and one at the center side of the center furnace, any space there is, is divided up pretty thoroughly; then the landing of the mid plate and bottom plate forms a doubling at the part where it is weakest. Nevertheless, this plate should not be too thin, were it for nothing else than the working of the plate in the fire. Its thickness is found more from experience than from actual calculation, and taking the practice of a number of boilers from 180 pounds working pressure upwards, 13/16 inch thick seems to be general practice. From below 180 pounds working pressure ¾ inch thick may be adopted, but not any less, as apart from having to stand the water test it has more chance of corroding, due to wet ashes, etc., than any other plate. In double-ended boilers, where the bottom stays are very long and inclined to yield a little, 13/16 inch is none too thick for this plate, ⅞ inch, or, indeed, 1 inch for very high pressures, such as 215 pounds, is not lost material.

The front and back of the tube plates are the next to come under consideration. The front tube plate at the wide water space may have a doubler or not. The tendency is nowadays to do away with all doublers, and have the plate strong enough to stand the pressure at the weakest part. Suppose there is no doubler, the wide water space will determine our thickness, and as the horizontal pitch at the wide water space for 2½ inches diameter tube will be 13½ inches, to allow us the 11 inches clear between tubes it follows the vertical pitch of stay tubes must not be greater than at every tube, unless we want the thickness of the plate to come over 1 inch thick, which is not usual.

Take, then, the front tube plate at wide water space, our pitch of stay tubes will be 13½ inches by 3¾ inches, and every alternate tube will have a nut (see Lloyd's conditions). Plate to Lloyd's =

$$\frac{C \times T^2}{p^2} = \frac{170 \times 240.25}{182.25} = 224 \text{ pounds, plate } 31/32'' \text{ thick.}$$

Note, 170 is Lloyd's constant applicable to a tube plate with every tube in row a stay-tube, and each alternate tube fitted with a nut. Now, this plate to Board of Trade would have been very much less in thickness, beside having each alternate tube a stay-tube instead of as in Lloyd's each tube a stay-tube.

Board of Trade working pressure =

$$\frac{C \times (T+1)^2}{\frac{D^2 + d^2}{2}} = \frac{100 \times 256}{119.25} = 214.6 \text{ pounds, plate } 15/16''$$

thick.

Therefore, we see if we reduced the vertical pitch of tubes to 3⅝ inches, had the boiler been to Board of Trade alone, we

	BOARD OF TRADE	LLOYDS	
Constant for Surface of Plate	112.5 Nuts, 77 No. Nuts	135 Nuts 100 No. Nuts	
" in Nest of Tubes	66	140	
" at Wide Water Space	100 Nuts, 66 No. Nuts	120 to 170 See Conditions	
" at Bottom Front Plate	112.5	135	
" at Steam Space Stays	150 to 240 See Conds.	175 to 240 See Conds.	
" at Wide Space	112.5 Nuts, 77 No. Nuts	135 Nuts, 100 No. Nuts	
	100 Nuts, 77 No. Nuts	90 to 135 Nuts 90 to 110 No.	Back Plate in Nest
	112.5	135	At Bottom Back Plate
	112.5 Nuts, 77 No. Nuts	135 Nuts, 100 No. Nuts	Surface at Side

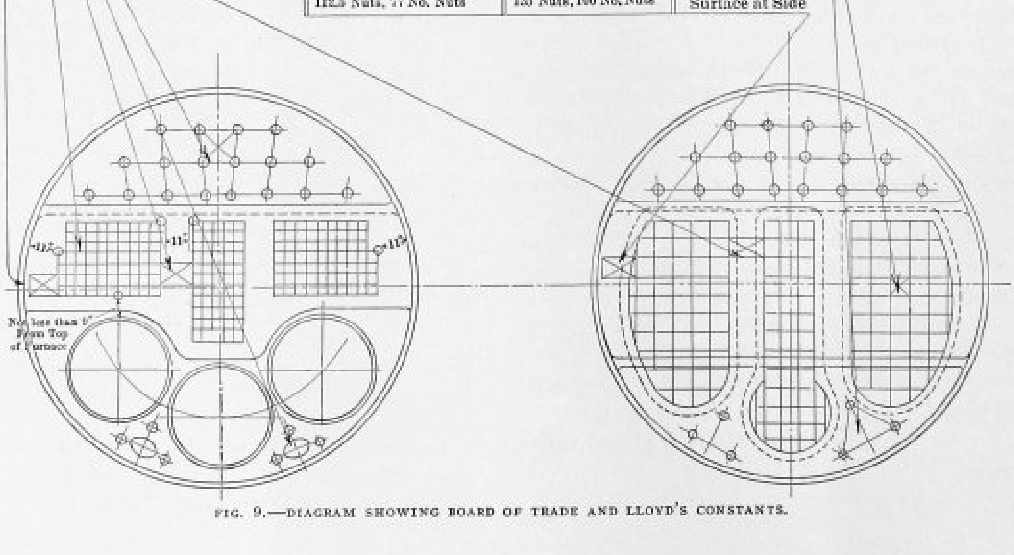


FIG. 9.—DIAGRAM SHOWING BOARD OF TRADE AND LLOYD'S CONSTANTS.

would have got this plate to work at 15/16 inch thick. Thus

$$\frac{100 \times 256}{117.4} = 218 \text{ pounds working pressure} = 15/16'' \text{ plate.}$$

Suppose this plate had a doubler, then the thickness to Board of Trade would have been

$$\frac{C \times (T + 1)^2 + 2/3\, C\, (T_1 + 1)^2}{\dfrac{D^2 + d^2}{2}} =$$

$$\frac{(66 \times 240.25) + 2/3\, (66 \times 225)}{119.25} =$$

216 pounds working pressure with 29/32" plate and 7/8" doubler. Notice the constant is 66 in this case, because with a doubler you can get a good thickness of plate without nuts on the stay-tubes. Lloyd's thickness under similar conditions would be very much easier, thus

$$\frac{C \times (T + t/2)^2}{p^2} = W\,P,\quad \frac{140 \times (13 + 8/2)^2}{13.5^2} = \frac{140 \times 289}{182.25}$$

= 222 pounds = 13/16" plate and ½" doubler.

In a nest of stay-tubes there are no nuts to trouble one, so the Board of Trade constant is 66 and Lloyd's 140; the surface of plate supported by stay-tubes for Board of Trade requirements is found in the same manner as flat plates, and care should be taken to deduct the requisite number of holes for ordinary tubes. For Lloyd's in the nest they take the mean of the squares of pitches and deduct the holes also. There is, of course, no wide water space to support in the back tube plates, and as a rule the weakest part of this plate is found at the top of the furnace (see Fig. 8). Before leaving the tube plates it is as well to notice that should we be considering a surface from the wing tubes to shell the constant for Board of Trade is 112.5 with nuts and 77 without nuts, Lloyd's 135 and 100, as this part of the plate is not exposed to flame, being outside of the smoke-box.

The stress allowed for iron tubes to Board of Trade is 6,000 pounds and Lloyd's 7,500 pounds. Board of Trade section of tube must not be less than ¼ inch in thickness. This means unless you have the tube swelled up at the ends the least thickness you can have will be 5/16 inch, as 5/16 inch thick under thread at nine threads is just ¼ inch. To have a 5/16-inch thick tube, however, is cheaper than to have one ¼ inch thick and ends up-set to suit the ¼-inch thick at the thread. Lloyd's will accept a tube ¼ inch thick less thread provided it stands the pressure.

The thickness of the tubes is found in the same manner as stays, and the surfaces to support are found by consulting the dotted squares in diagram showing spaces to support in the front and back tube plates (Fig. 8). Thicknesses of common, plain tubes are found from the following formula:

$$\frac{D \times P}{9{,}000} + .085,$$ D being outside diameter and $P = W\,P$.

The girders for Board of Trade and Lloyds are very much the same weight. Board of Trade =

$$\frac{C \times d^2 \times T}{(W - P)\, D \times L \text{ in feet}} = \frac{990 \times 81 \times 1.5625}{25.5 \times 8.125 \times 2.75} = 220$$

pounds = two plates 9" high and 25/32" thick.

Care to be taken that W is width of combustion chamber over box in inches, and L is length of combustion chamber over box in feet. Lloyd's girder =

$$\frac{C \times d^2 \times T}{(L - P) \times D \times L} = \frac{10{,}660 \times 81 \times 1.5625}{23.75 \times 8.125 \times 32} = 218 \text{ pounds}$$

= two plates 9" high by 25/32" thick.

Care to be taken in Lloyd's case to see that L is equal to the distance inside the box in inches.

Finally, we may fix the thickness of the furnace, Morison's or Deighton's being the same, Board of Trade =

$$\frac{14{,}000 \times T}{D} = W\,P,$$

and Lloyd's =

$$\frac{1{,}259 \times (T - 2)}{D} = W\,P.$$

D in case of Board of Trade being least outside diameter and Lloyd's greatest diameter in inches.

Of course, we should have had an approximate idea of the grate area and heating surface and ratios before starting the final design, and it will now be necessary to fill in these particulars exactly before we finish the boiler. The heating surface of the tubes is the outside diameter by length between tube plates by number of tubes = 5.3996 × 454 tubes = 2,451 square feet. The heating surface of the furnaces is taken between the mean diameter outside and the top of the corrugations. The diameter outside of a 3-foot 3-inch inside diameter furnace is 3 feet 3 inches + twice the thickness = 3 feet 4¼ inches, and the mean between 3 feet 4¼ inches and the top of the corrugations would be 3 feet 5¾ inches diameter. Therefore, half the circumference of 3 feet 5¾ inches + 3 inches below the center line of the furnace on either side (because the line of fire-bars comes 3 inches below the center of the furnace) = 5 feet 5½ inches + 6 inches = 5 feet 11½ inches × length between tube plates + ¾ inch for each corrugation × four furnaces will give us the heating surface of the furnaces. The heating surface of the combustion chamber backs is simply the area of the backs taken also to 3 inches below the center of the furnaces. The back tube plates have the same area as the combustion chamber backs less the area of the tube holes, also less the area of the part of the hole for the furnace back end. The front tube plate is not taken into account generally when making up heating surface. The combustion chamber

TABLE I.—HEATING SURFACE OF TUBES.

LENGTH.	Diameter 2½ Inches, Percent.	Diameter 2¾ Inches, Percent.	Diameter 3 Inches, Percent.	Diameter 3¼ Inches, Percent.	Diameter 3½ Inches, Percent.
Inches					
1/16	.0034	.0037	.0041	.0044	.0048
1/8	.0068	.0075	.0082	.0089	.0095
3/16	.0102	.0112	.0123	.0133	.0143
1/4	.0136	.0150	.0164	.0177	.0191
5/16	.0170	.0187	.0205	.0221	.0239
3/8	.0205	.0225	.0245	.0266	.0286
7/16	.0239	.0262	.0286	.0310	.0334
1/2	.0273	.0300	.0327	.0355	.0382
9/16	.0307	.0337	.0368	.0399	.0430
5/8	.0341	.0375	.0409	.0443	.0477
11/16	.0375	.0412	.0450	.0487	.0525
3/4	.0409	.0450	.0491	.0532	.0573
13/16	.0443	.0487	.0532	.0576	.0621
7/8	.0477	.0525	.0573	.0620	.0668
15/16	.0511	.0562	0.614	.0664	.0716
Area Sq. Ins.	4.9087	5.9395	7.0686	8.2958	9.6211
Area Sq. Ft.	.034088	.041247	.049087	.057610	.066813
Inches.					
1	.0545	.0600	.0654	.0709	.0764
2	.1091	.1200	.1309	.1418	.1527
3	.1636	.1800	.1964	.2172	.2291
4	.2182	.2400	.2618	.2836	.3059
5	.2727	.3000	.3272	.3545	.3818
6	.3272	.3600	.3927	.4254	.4581
7	.3818	.4200	.4581	.4963	.5345
8	.4363	.4800	.5236	.5672	.6109
9	.4909	.5400	.5890	.6381	.6872
10	.5454	.6000	.6544	.7090	.7636
11	.6000	.6600	.7199	.7799	.8399
Feet.					
1	.6545	.7199	.7854	.8508	.9163
2	1.3090	1.4399	1.5708	1.7017	1.8326
3	1.9635	2.1598	2.3562	2.5525	2.7489
4	2.6180	2.8798	3.1416	3.4034	3.6652
5	3.2725	3.5997	3.9270	4.2542	4.5815
6	3.9270	4.3197	4.7124	5.1051	5.4978
7	4.5815	5.0396	5.4978	5.9559	6.4141
8	5.2360	5.7596	6.2832	6.8068	7.3304

sides include the distance round the outside edge of the wrapper plate from 3 inches below the center line of the furnace by the mean breadth of the box.

The grate area of the boiler is simply the inside diameter of the furnace by length of fire-bar, and the ratio of the grate to the heating surface, in a well-designed forced draft boiler, ought to be 1 to 40, and in a natural draft boiler about 1 to 30 or 35. The grate area should be equal to six times the area through the tubes, and the tube surface about thirty-three times the grate; also about 5 cubic feet of steam space should be allowed per square foot of grate.

It is hoped that the foregoing remarks may be found useful, particularly to beginners in boiler design, together with the few tables supplied, which will help him in his calculations. At the same time it is only by constant practice that one gets familiar with the numerous conditions and the various practical points which continually crop up.

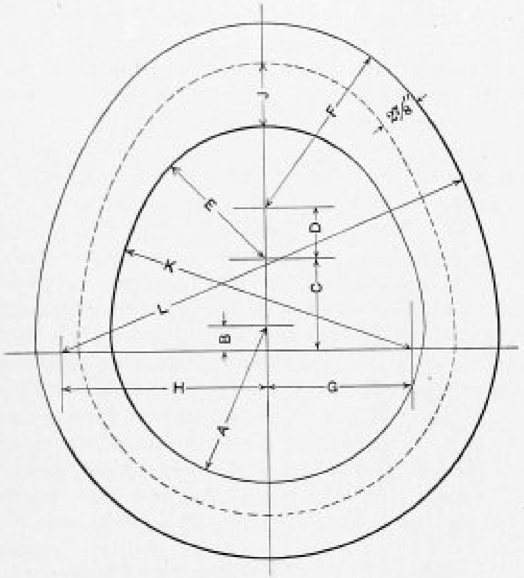


DIAGRAM TO ACCOMPANY TABLE II., SHOWING DIMENSIONS FOR BACK END OF FURNACES.

TABLE III.—AREA THROUGH TUBES.

Exterior Diameter.	Gage I. W. G.	Equivalent Thicknesses.	Area Square Inches.	Area Square Feet.
Inches.				
2	11	.116	2.492	.0173
	10	.128	2.388	.01658
	9	.144	2.307	.016
	8	.16	2.216	.0154
	..	3/16	2.073	.0137
	..	1/4	1.767	.01227
	..	5/16	1.484	.0103
2 1/4	10	.128	3.122	.0217
	9	.144	3.023	.021
	8	.16	2.925	.0203
	7	.176	2.829	.01964
	..	3/16	2.761	.01917
	..	1/4	2.405	.0167
	..	5/16	2.073	.0144
	..	3/8	1.74	.01208
2 1/2	10	.128	3.955	.02746
	9	.144	3.8429	.02655
	8	.16	3.732	.02591
	7	.176	3.6237	.02516
	..	3/16	3.546	.0246
	..	1/4	3.141	.02181
	..	5/16	2.761	.01917
	..	3/8	2.405	.0167
	..	7/16	2.0739	.0137
	..	1/2	1.77	.01241
2 3/4	14	....	......	.03658
	9	.144	4.76	.033
	8	.16	4.637	.0322
	7	.176	4.576	.0317
	..	1/4	3.976	.0275
	..	5/16	3.546	.0246
	..	3/8	3.141	.0228
	..	7/16	2.7612	.0218
	..	1/2	2.4053	.0167
3	8	.16	5.641	.03917
	7	.176	5.507	.03824
	6	.192	5.374	.03732
	..	1/4	4.908	.03408
	..	5/16	4.43	.03076
	..	3/8	3.976	.02761
	..	7/16	3.5466	.02462
	..	1/2	3.1416	.02181
3 1/4	9	.144	6.822	.0473
	8	.16	6.742	.0468
	7	.176	6.596	.0458
	6	.192	6.451	.0448
	..	1/4	5.9396	.0412
	..	5/16	5.4119	.0375
	..	3/8	4.9087	.0340
	..	7/16	4.4301	.0307
	..	1/2	3.9761	.0276

NOTE—No. 14 I. W. G. thick is Howden's Standard air tube.

TABLE II.—PRINCIPAL DIMENSIONS OF BACK END OF FURNACES. (THE LETTERS REFER TO THE DIAGRAM GIVEN ABOVE.)

Diagram.		A	B	C	D	E	F	G	H	J	K	L	M
Feet	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
3	0	13 3/8	1 1/4	6	4 1/2	12	14 7/8	11 1/4	14 1/4	4 1/2	24 5/8	32 1/2	8
3	1/2	13 5/8	1 1/4	6 1/4	4 1/2	12	14 7/8	10 1/2	13 3/8	4 1/2	24 1/8	31 7/8	8
3	1	13 3/4	1 1/8	6 1/2	4 1/2	12	14 7/8	11 1/8	14 3/4	4 1/2	24 7/8	33 3/8	8
3	1 1/2	14	1 1/8	6 3/4	4 1/2	12	14 7/8	10 5/8	13 1/2	4 1/2	24 3/8	32 5/8	8
3	2	14 1/8	1	6 3/4	4 1/2	12 1/4	15 1/8	11 5/8	13 3/4	4 1/2	25 3/4	32 3/4	8
3	2 1/2	14 5/16	15/16	7	4 1/2	12 1/4	15 1/8	10 1/2	13 3/4	4 1/2	24 13/16	32 15/16	8
3	3	14 1/2	7/8	7	4 1/2	12 1/2	15 3/8	10 3/4	14 1/2	4 1/2	25 1/4	33 7/8	8
3	3 1/2	14 3/4	7/8	7 1/4	4 1/2	12 1/2	15 1/2	9 1/2	13 1/4	4 1/2	24 1/4	32 7/8	8
3	4	14 15/16	13/16	7 1/2	5 3/8	12 1/2	14 1/2	11 1/16	15 3/16	4 1/2	26	35	8
3	4 1/2	15 1/8	3/4	7 1/4	4 1/2	13	15 7/8	11	13 1/2	4 1/2	26 1/8	33 1/2	8
3	5	15 3/8	3/4	7 1/2	5 1/2	13	14 7/8	10 1/4	13	4 1/2	25 5/8	33 1/4	8
3	5 1/2	15 9/16	11/16	7 1/4	5 1/8	13 1/2	15 3/4	11	13 3/4	4 1/2	26 9/16	34 9/16	8
3	6	15 3/4	5/8	8	5 3/8	13	15	11 1/4	13 3/8	4 1/2	27	36	8
3	6 1/2	16	5/8	8 1/2	4	12 3/4	16 1/8	9 1/2	14 1/4	4 1/2	25 1/2	35 1/8	8
3	7	16 1/4	5/8	8 1/2	4 1/2	13	15 7/8	9 7/8	14 1/4	4 1/2	26 1/8	35 3/8	8
3	7 1/2	16 1/2	5/8	8 1/2	4 1/2	13 1/4	16 1/8	9 7/8	14 1/4	4 1/2	26 3/8	35 5/8	8
3	8	16 3/4	5/8	9	5 3/8	13	15	8 3/4	12 5/8	4 1/2	25	34	8
3	8 1/2	17	5/8	8 3/4	4 1/2	13 1/2	16 3/8	10	13 5/8	4 1/2	27	35 1/2	8
3	9	17 1/4	5/8	7 1/2	4 5/8	15	18	11 3/8	15 1/2	4 1/2	28 1/2	37 1/2	8
3	9 1/2	17 1/2	5/8	8	4 1/2	14 3/4	17 5/8	10	14	4 1/2	27 1/2	36 3/8	8
3	10	17 3/4	5/8	8 1/2	3 7/8	14 1/2	18	9 3/4	13 7/8	4 1/2	27 1/2	36 1/2	8
3	10 1/2	18	5/8	8	4 1/2	15 1/4	18 1/8	12	16 1/2	4 1/2	30	40 3/8	8
3	11	18 1/4	5/8	8	4 1/2	15 1/2	18 3/8	11 1/4	14 1/4	4 1/2	29 1/2	37 3/8	8
3	11 1/2	18 3/8	1/2	8 3/4	4 1/2	15 1/2	18 5/8	10	13 1/2	4 1/2	28 5/8	36 3/4	8
4	0	18 7/16	5/16	8 3/4	4 1/2	15 3/4	18 5/8	10 3/4	15 5/8	4 1/2	29 3/16	38 11/16	8

TABLE IV.—EFFECTIVE AREA OF STAY TUBES.

Exterior Diameter.	Thickness.	Number of Threads per Inch. 8	9	10	11	12
Inches	Inches					
2	1/4	.89	.94	.98	1.02	1.04
	5/16	1.18	1.23	1.27	1.31	1.33
	3/8	1.43	1.48	1.52	1.56	1.58
2 1/4	1/4	1.03	1.09	1.13	1.17	1.21
	5/16	1.36	1.42	1.46	1.5	1.53
	3/8	1.66	1.72	1.76	1.8	1.83
2 1/2	1/4	1.1589	1.224	1.277	1.33	1.357
	5/16	1.5393	1.6046	1.6581	1.7190	1.7374
	3/8	1.8952	1.9605	2.0140	2.0669	2.0933
	7/16	2.2266	2.2919	2.3444	2.3983	2.4247
	1/2	2.5334	2.598	2.6522	2.7051	2.7315
2 3/4	1/4	1.2924	1.36	1.423	1.4713	1.5115
	5/16	1.7219	1.79	1.8525	1.9008	1.941
	3/8	2.1269	2.2	2.2575	2.3058	2.346
	7/16	2.5073	2.578	2.6379	2.6862	2.7264
	1/2	2.8632	2.934	2.9939	3.0421	3.0823
3	1/4	1.4260	1.505	1.5691	1.6245	1.6650
	5/16	1.9046	1.9838	2.0477	2.1031	2.1436
	3/8	2.3586	2.447	2.5017	2.5571	2.5976
	7/16	2.7881	2.8673	2.9312	2.9866	3.0271
	1/2	3.1931	3.2723	3.3362	3.3916	3.4321
3 1/4	1/4	1.5594	1.645	1.7151	1.7722	1.8211
	5/16	2.0871	2.1733	2.2428	2.2999	2.3488
	3/8	2.5903	2.6765	2.746	2.8031	2.852
	7/16	3.0689	3.1551	3.2246	3.2817	3.3306
	1/2	3.5229	3.609	3.6786	3.7357	3.7846
3 1/2	1/4	1.6930	1.7861	1.8611	1.9231	1.9724
	5/16	2.2691	2.3629	2.4379	2.4999	2.5496
	3/8	2.8220	2.9151	2.99	3.0521	3.1018
	7/16	3.3497	3.4428	3.5178	3.5798	3.6295
	1/2	3.8529	3.9460	4.021	4.083	4.1327

TABLE V.

Inside Diameter of Furnace. Ft.	Ins.	Grate per Furnace. 5 Ft.	5 Ft. 3 Ins.	5 Ft. 6 Ins.	5 Ft. 9 Ins.	6 Ft.	*H. S. Per 1 Inch Run of Tube.
2	6	12.5	13.125	13.75	14.375	15.	.385
2	6 1/2	12.708	13.3439	13.9793	14.6147	15.25	....
2	7	12.9165	13.5623	14.208	14.8539	15.499	.4
2	7 1/2	13.125	13.78125	14.4385	15.09375	15.75	....
2	8	13.3335	14.0	14.6668	15.3335	16.0	.42
2	8 1/2	13.5415	14.2185	14.8956	15.5727	16.2488	....
2	9	13.75	14.4375	15.125	15.8125	16.5	.432
2	9 1/2	13.9595	14.6564	15.344	16.0522	16.75	....
2	10	14.1665	14.8898	15.5831	16.2914	16.9998	.46
2	10 1/2	14.375	15.09425	15.8125	16.53125	17.25	....
2	11	14.5835	15.3126	16.0418	16.771	17.5	.469
2	11 1/2	14.7915	15.531	16.2706	17.0102	17.7498	....
3	0	15.0	15.75	16.5	17.25	18.0	.481
3	1/2	15.2085	15.9689	16.7293	17.4897	18.2502	...
3	1	15.4157	16.1873	16.9581	17.7289	18.4998	.489
3	1 1/2	15.625	16.4062	17.1875	17.9687	18.65	....
3	2	15.8335	16.6251	17.4168	18.2095	19.0	.493
3	2 1/2	16.0415	16.8435	17.6456	18.4477	19.2498	....
3	3	16.25	17.0625	17.875	18.6875	19.5	.50
3	3 1/2	16.4585	17.2814	18.1043	18.9272	19.7408	....
3	4	16.6665	17.4998	18.3331	19.1664	19.9998	.534
3	4 1/2	16.875	17.7187	18.5625	19.4162	20.25	....
3	5	17.0835	17.9376	18.7918	19.646	20.5002	.548
3	5 1/2	17.2915	18.156	19.0206	19.8852	20.7498	....
3	6	17.5	18.375	19.25	20.125	21.0	.55
3	6 1/2	17.7085	18.5939	19.4793	20.3647	21.2502	....
3	7	17.9165	18.8123	19.7081	20.3039	21.4998	.57
3	7 1/2	18.125	19.0312	19.9375	20.8437	21.75	....
3	8	18.3335	19.2501	20.1668	21.0836	22.0	.582
3	8 1/2	18.5415	19.4685	20.3956	21.3227	22.2498	....
3	9	18.75	19.6875	20.625	21.5625	22.5	.59
3	9 1/2	18.9585	19.9064	20.8543	21.8022	22.7502	....
3	10	19.1665	20.1248	21.0831	22.0414	22.9998	.6
3	10 1/2	19.375	20.3437	21.3125	22.28125	23.25	....
3	11	19.5835	20.5626	21.5418	22.521	23.5	.621
3	11 1/2	19.7915	20.781	21.77	22.76	23.7498	....
4		20.0	21.0	22.0	23.0	24.0	.636

* For corrugated furnaces only.

Pipe Siphons for the Catskill Aqueduct.

The East Jersey Pipe Company, of Paterson, N. J., is now working on fourteen steel-pipe siphons for the Catskill aqueduct. The diameters of the pipes are 9 feet 6 inches, 9 feet 9 inches and 11 feet 3 inches, the thicknesses being 7/16, 1/2, 9/16, 11/16 and 3/4 inch. This pipe is riveted up at the works in 15-foot sections, which are shipped to their respective destinations and there riveted together. Mr. James King, foreman of the East Jersey Pipe Co., is in charge of this work.

TABLE VI.—EFFECTIVE SECTIONAL AREA OF STAYS.

Outside Diameter.	Sectional Area.	Whitworth Screws.		Number of Screw Threads per Inch. 6	7	8	9	10	11	12
Ins.	Square Ins.	No. of Threads.	Square Ins.	Square Ins.	Square Ins.	Square Ins.	Square Ins.	Square Ins.	Square Ins.	Square Ins.
3/4	.44	10	.30	.....	.....	.....	.....	.30	.31	.32
7/8	.60	9	.42	.....	.....	.....	.42	.44	.45	.46
1	.79	8	.55	.....	.....	.55	.58	.60	.61	.63
1 1/8	.99	7	.70	.....	.70	.73	.76	.78	.80	.81
1 1/4	1.23	7	.89	.....	.89	.93	.96	.99	1.01	1.03
1 3/8	1.48	6	1.06	1.06	1.12	1.16	1.19	1.22	1.24	1.26
1 1/2	1.77	6	1.30	1.30	1.36	1.41	1.45	1.48	1.50	1.52
1 5/8	2.07	5	1.47	1.56	1.63	1.69	1.73	1.76	1.79	1.81
1 3/4	2.40	5	1.75	1.85	1.93	1.99	2.03	2.07	2.10	2.12
1 7/8	2.76	4 1/2	1.99	2.17	2.25	2.31	2.36	2.40	2.43	2.45
2	3.14	4 1/2	2.31	2.51	2.59	2.66	2.71	2.75	2.78	2.81
2 1/8	3.55	4 1/2	2.66	2.87	2.96	3.03	3.09	3.13	3.17	3.20
2 1/4	3.98	4	2.93	3.26	3.36	3.43	3.49	3.54	3.58	3.61
2 3/8	4.43	4	3.32	3.67	3.77	3.85	3.91	3.96	4.01	4.04
2 1/2	4.91	4	3.73	4.11	4.22	4.30	4.37	4.42	4.46	4.50
2 5/8	5.41	4	4.17	4.57	4.68	4.77	4.84	4.90	4.94	1.98
2 3/4	5.94	4	4.64	5.05	5.18	5.27	5.34	5.40	5.45	5.49
2 7/8	6.49	3 1/2	4.94	5.56	5.69	5.79	5.87	5.93	5.98	6.02
3	7.07	3 1/2	5.45	6.1	6.23	6.33	6.41	6.48	6.53	6.57
3 1/8	7.67	3 1/2	5.98	6.66	6.8	6.90	6.99	7.06	7.11	7.15
3 1/4	8.29	3 1/4	6.41	7.24	7.39	7.50	7.59	7.65	7.71	7.76
3 3/8	8.94	3 1/4	6.93	7.85	8.0	8.12	8.21	8.28	8.34	8.39
3 1/2	9.62	3 1/4	7.58	8.48	8.64	8.76	8.85	8.93	8.99	9.04
3 5/8	10.32	3 1/4	8.15	9.14	9.31	9.43	9.53	9.60	9.67	9.72
3 3/4	11.04	3	8.67	9.82	9.99	10.12	10.22	10.30	10.37	10.42
3 7/8	11.79	3	9.34	10.53	10.71	10.84	10.94	11.03	11.15	11.25
4	12.56	3	10.03	11.26	11.44	11.58	11.69	11.77	11.85	11.9

THE BREAKAGE OF STAYBOLTS.

BY B. E. D. STAFFORD.

The alternating stresses to which a stay-bolt is subjected in locomotive fire-box service demand a material with a tough, fibrous structure. A good grade of charcoal iron, puddled, refined, reworked and developed to the wrought bar under various methods of piling to obtain a strong center structure, produces a material which is the safest and most reliable for stay-bolt purposes. Stay-bolt breakage, however, is not a question of material so much as of construction. When rigidly stayed, the locomotive fire-box affords but slight provision, if any, for the difference in the amount of expansion that naturally exists between the fire-box and the wrapper, or outer sheet, of the boiler under varying temperatures of furnace operation. While the thin fire sheets, by distorting, bending and buckling, accommodate to a certain extent the added stress due to the difference in the amount of expansion when rigidly stayed, the inevitable consequence is that the stay-bolt gives way under excessive stress, regardless of the material used, and the sheets gradually deteriorate, due to the continual bending and distortion.

The most important feature that has been demonstrated in connection with the method of staying the locomotive fire-box was recently brought to the notice of the railway world in a paper read before the New York Railway Club on May 20 of this year by D. R. MacBain, on the subject of "Inequality of Expansion in Locomotive Boilers and the Possibilities of Eliminating the Bad Effects Therefrom." For the purpose of practically demonstrating the theories on which earlier experiments were based, with partial flexible and rigid stay-bolt installations, a high-pressure locomotive was selected whose fire-box was completely stayed with flexible stay-bolts. It was placed in heavy passenger service, and the records and data which were obtained show clearly the advisability of giving careful attention not only to the use of the flexible stay, but also to the method of its application to render the fire-box less liable to the effects of expansion. From the practical experiments made, it was found by tramming the inside of the fire-box side sheet and the outer sheet when the boiler was cold, and comparing the measurements when the boiler was hot, that the difference of expansion of both sheets was too significant to be ignored.

To compensate for the difference in the amount of sheet expansion, adjustments were made in the application of the flexible stay-bolts by turning back the bolt head from its sleeve seat certain parts of a turn, before riveting over the fire-box end of bolt. This was done in the outer rows of the side sheets, back head and throat sheet, the amount of release being varied according to the size of the fire-box and the relative showing in the difference of sheet expansion. By so doing, it enabled the fire-box and outer shell to expand under less restraint, and the stay-bolts to assume the load with less liability of being strained than under former practice of no adjustment. The results obtained proved satisfactory, the experiment and practice extending over a sufficient number of years to obtain comparative data and form reasonable conclusions, not only as to the life of the stay-bolts but as to the condition of seams, rivets, side and flue sheets, all of which showed no perceptible indication of strain or distortion.

Further investigation by others not connected with but interested in the aforementioned experiment disclosed the fact that when flexible stay-bolts were adjusted, especially in the throat sheets, to compensate for the longitudinal extension of the wrapper sheet over the fire-box sheets, in instances where this method was applied to old fire-boxes, when the stay-bolts were removed for fire-box renewals it was discovered, by nicking and bending the iron in the bolt proper, that the material was as fibrous and as strong as when first incorporated. The bolt head showed a distinct bearing surface at the sleeve seat, demonstrating that, under the adjustments made, it served its purpose as a stay, resisting the load due to pressure without becoming strained, and that the difference in the relative sheet expansion is largely compensated for by the adjustment which the flexible stay affords. Expansion of all heat-absorbing parts in a locomotive fire-box, if restricted, will affect the entire assemblage and prove disastrous to the weaker part of the construction.

The value of the difference in the amount of expansion between the fire-box sheets and the roof or wrapper sheet has never been seriously considered to any extent until quite recently. It was supposed that most of the expansion was confined to the fire-box proper, while the relative amount of expansion between the wrapper and the fire-box sheets, and the resultant effect therefrom on the complete construction, was overlooked in most instances as a vital point to consider in dealing with methods of staying.

The distortion of sheets has more or less lengthened the life of the rigid stay, while the sheets deteriorated by reason of continual bending. While the relative expansion of the outer shell and the fire-box varies with each type of boiler, and is largely influenced by methods of fire-box and boiler operation, the difference in the amount of expansion is at times so great as to throw an excess stress on stay-bolts in the throat, back head and rigid corners of the side sheets. Regardless of sheet distortion, the bolts then assume a load too severe to withstand and are gradually rendered weak and break.

The flexible stay-bolt has had much to contend with on points of cost compared with the rigid stay, and not until the question of economy of maintenance was earnestly considered, where ultimate costs determined the true value of a product based on service rendered, could we point to any great advance in the use of the flexible stay, or the methods of staying. Flexible stay-bolts found but little favor until within the last six years. The early designs were either too large or ungainly, or too weak in sections to cope with fire-box conditions. The two-piece bolt of the Johnston type made great headway as a simple and strong device to serve the purpose of a water-space stay, but was soon declared obsolete by reason of the fact that inspection was impossible without removing the entire bolt. Incrustation in bad-water sections rendered the connection rigid, cementing both the plug and the bolt intimately together.

The principle of the three-piece design for a flexible stay was recognized as the most acceptable on which to base improvements and modifications soon led to shapes and sections involving the round-head bolt. This affords greater shearing strength, and more readily releases itself under conditions of incrustation than similar designs of the flat or sloping heads. The line of demarkation between serviceable and non-serviceable stay-bolts of the flexible type is determined largely on the merits which enable the bolt to operate under conditions of incrustation. The flaring mouth on the end of the sleeve of the round-head bolt extending toward the water space serves to loosen and throw out all deposits which collect within the water space in adjusting itself to accommodate the relative sheet expansion under various temperatures.

The round-head bolt design, with its strong sections of bolt area, capped over with sufficient clearance between the cap and the bolt head to allow for suitable adjustment to the difference of sheet expansion, affording a ready means of inspection, with its several sizes of sleeves to suit the various angles and sheet contours of boiler design, adapted to take several diameters of bolt and affording interchangeability of parts, simple and economic in its application, forms an assemblage which readily establishes itself as an acceptable article of economic merit and serviceable value, and is fast proving the fact that flexible connections in fire-box construction are absolutely needed.

The demand for flexible stay-bolts is due to the effort to curtail not only the resultant expense of stay-bolt renewals, but more largely to reduce the number of shoppings of engines for the purpose of renewing broken stay-bolts and repairing cracked fire-sheets, which not only deprives the service of power, but contracts the earning value of each engine in direct proportion to the maintenance cost and the service rendered.

Essential to the economic solution of overcoming cost of maintenance in fire-box repairs is the step that will first favor the construction of parts to more readily resist the stress of expansion without the strain of distortion, heretofore found so disastrous to all materials involved, and provide sufficient means to allow all heat-absorbing surfaces to act under less restraint than that afforded by the complete system of rigid staying. Until locomotive boilers are measured to obtain the true amount of the difference of expansion from the cold to the hot state, and provisions are made to accommodate the relative amount of expansion between the wrapper sheet and fire-box, the cause of stay-bolt breakage, fire-sheet and flue-sheet cracking, will remain an issue of misleading conclusions, if, as in the past, quality of material forms the basis of solution, and the destructive forces due to the inequalities of expansion are ignored.

The flexible or adjustable stay-bolt so far has favored the theories of those who are mindful of the fact that steam boilers must breathe or expand under less restraint than that allowable with rigid staying. In the experiments and practical demonstrations made in the application and adjustment of the flexible stay-bolt to high-pressure locomotives, covering, in many instances, years of constant service without stay-bolt breakage, side seams leaking, and sheets cracking, and obtaining a great reduction of breakages in most cases, the value of the service rendered compared to the cost of repairs is a unit of economic comparison, which not only credits the flexible stay-bolt as being superior to the rigid stay in localities of greatest sheet expansion, but also points conclusively to the advantage gained in the judicious use of the flexible or adjustable stay-bolt as a compensating medium of great utility in affording sufficient flexibility to the fire-box construction, enabling such to more safely cope with the alternating stresses due to expansion.

The general recognition given to the flexible stay-bolt in late years, as an article of economic use and of practical utility, and to the methods of its application and adjustments necessary in the rigid localities of greatest sheet expansion to relieve the bolt of excess tension; the judicious layout in the effort to fully cover the breaking zone according to each type of fire-box, and to minimize the effects of the alternating stresses so disastrous to stay-bolts—all features of vital importance—have, to the extent of the consideration given and the practice followed, accomplished much to advance the general proposition of eliminating stay-bolt breakage and fire-sheets cracking, inasmuch as the cause of breakage is traced to its true source.—*Railway Age Gazette.*

LEGAL DECISIONS OF INTEREST TO BOILER MAKERS.

WARRANTIES OF BOILERS—EVIDENCE OF BREACH—SUBSTITUTION OF TESTS.

The plaintiff contracted for the equipment of two horizontal return tubular boilers at the plant of the defendant, with underfeed mechanical stokers, according to specification. In the contract certain express warranties were made under the head of "Guaranties" as to economy, capacity and smoke abatement. Time for completion was not of the essence of the contract. This being the case it was held in an action for the balance of the contract price that letters merely complaining of delays in shipping certain material in the commencement of the work of installation were immaterial and properly rejected as evidence. The defense was non-compliance with the warranties and a denial that tests had been made as stipulated in the contract. Letters showing that the defendant had given notice of defects in the machinery were also properly excluded. If it was held the machinery was actually defective and failed to measure up to the guaranties, that was a matter which could be shown by competent evidence, and not by letters written by the party complaining of the defects to the party furnishing and erecting the machinery. While the contract provided for certain tests of the machinery, the court was of opinion that it was competent for the plaintiff to show that the tests contemplated had been waived, or that another test had been agreed upon and substituted for the particular test contemplated; and there was evidence in the case authorizing the jury to find that the tests originally intended had been waived, and another test, considered sufficient by the plaintiff and by the authorized agent of the defendant, had been substituted therefor. The court properly instructed the jury that they might determine whether the tests had not been waived from the fact that part of the second payment for the installation was made without requiring the specific tests provided for in the contract. Judgment for the plaintiff was affirmed.—*Gulfport Cotton Oil, Fertilizer & Manufacturing Company vs. Underfeed Stoker Company of America. Supreme Court of Georgia.*

INJURIES TO BOILER MAKERS' HELPER—EVIDENCE OF NEGLIGENCE—DUTY TO WARN.

A boiler maker's helper was directed by his foreman to assist in unloading boiler plates from a railway car. He had never been engaged in this work before. While so engaged a plate fell upon him and caused injuries for which he sued his employer. Judgment in his favor was reversed on appeal and the case remanded for a new trial. The plates were moved by means of clamps. The case was submitted to the jury on the theory of a defective clamp and of failure to warn the plaintiff of the danger of the plates slipping. On appeal the court held that the accident might have been the result of other causes, such as: First, the clamp might not have been of the proper size; second, the plate might not have been inserted far enough into the jaw; third, the employees might have been negligent in not inserting blanks or wedges; fourth, the slipping might have been due to the presence of some foreign material or to the consistency of the jaws or the sheet of steel. If the plaintiff did not know that plates had formerly slipped and fallen from the clamps, his master was bound to warn him of the fact. As to this duty the foreman was not a fellow servant of the plaintiff, but a vice-principal, charged with the duty of warning, and for whose neglect the master was liable.—*Ashcroft vs. Davenport Locomotive Works. Iowa Supreme Court.*

INJURIES TO LOCOMOTIVE BOILER REPAIRER—AMOUNT OF RECOVERY.

A boiler maker whose duties were to make repairs upon locomotive boilers belonging to his employer, had made certain repairs upon an engine, and started to leave his work by the passageway between the engine and tender. As he did so the bottom of his trouser leg or overalls caught upon a loose strip of molding extending along the bottom of the tender, which was out of repair and out of place. He was tripped and thrown to the ground, sustaining injuries for which he sued his employer, and recovered damages. The evidence tended to show that the defect existed for some days prior to the accident and could readily have been discovered and repaired. The evidence did not justify the conclusion that the plaintiff was guilty of contributory negligence, as a matter of law. The accident happened in the night-time, and it was a fair question for the jury whether he could, by reasonable prudence, have discovered the projecting molding and avoided coming in contact with it. The plaintiff sustained a broken rib and other injuries. He claimed that he also suffered a severe strain of the back, disabling him from any kind of manual labor. As to this the medical expert evidence on each side conflicted. The court found no sufficient reason for considering a recovery of $3,500 excessive—*Simpson vs. Great Northern Railway Company. Minnesota Supreme Court.*

ENGINE AND BOILER SOLD CONDITIONALLY REMAINS PERSONALTY THOUGH ATTACHED TO REALTY.

A seller of an engine and boiler for farm ginning took purchase-money notes and delivered possession, retaining title as security, and the contract was registered according to statute. The buyer insured the property under a policy which was therein declared to be avoided if the subject of insurance was personalty, and should be or become incumbent by a chattel mortgage. The property was burned, and the insurance company denied liability on the ground that the engine and boiler were personalty. It was held that, though attached to the realty, the engine and boiler retained their character as personalty both as between the parties and others claiming adversely to the lien.—*Lancaster vs. Southern Insurance Company. North Carolina Supreme Court.*

A Novel Steam Boiler.

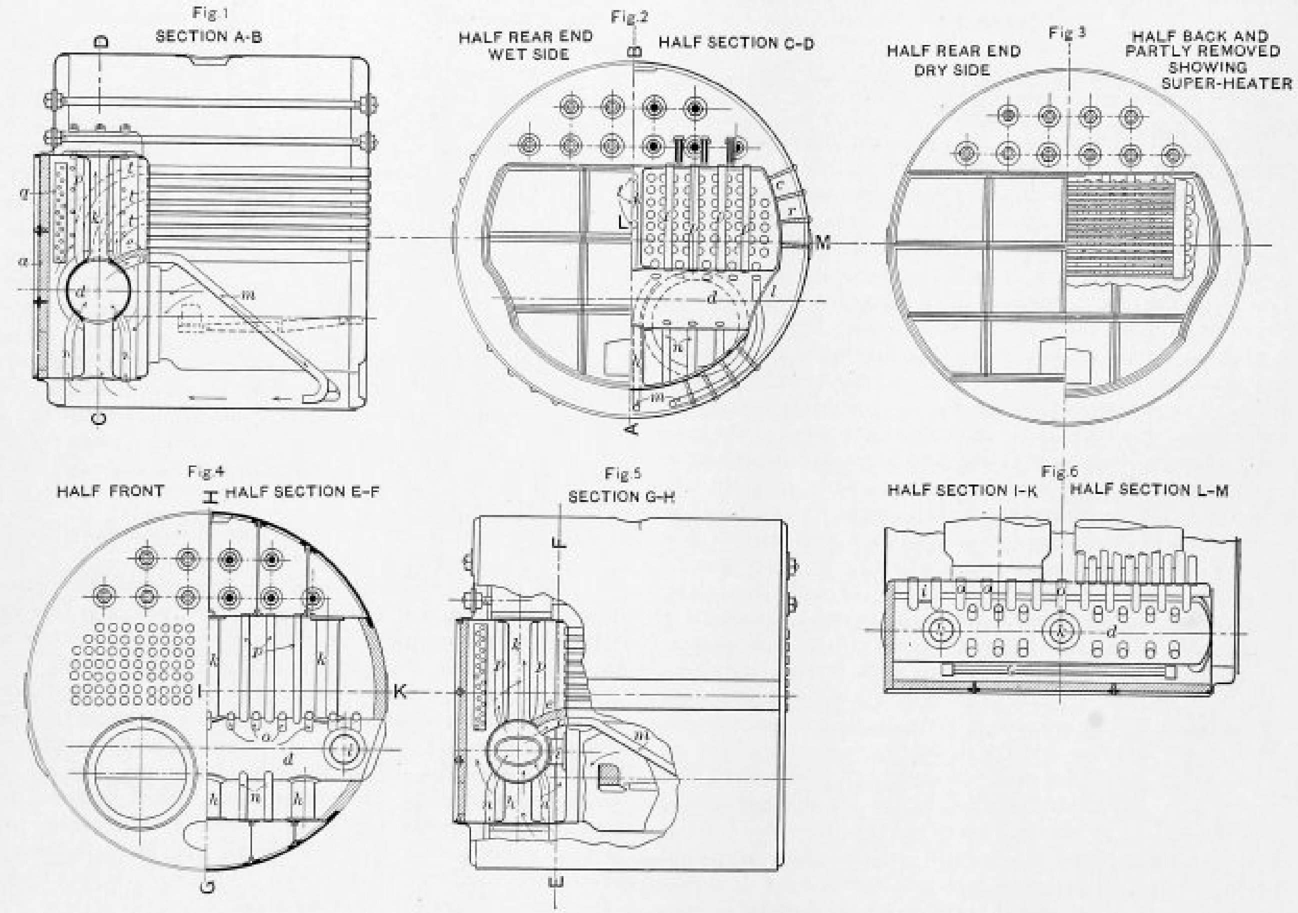
According to one of our contemporaries a steam boiler and furnace of peculiar construction, which require no chimney, because the combustion gases are mixed with the steam which is admitted to the cylinders of the steam engine, have been in successful operation for some time on a Russian torpedo boat. Liquid fuel is used, and the combustion gases, which have an initial temperature of from 3,300 to 3,600 degrees F., have a temperature of about 1,800 degrees F. when they leave the heating surfaces of the boiler. The gases then enter a tube into which a fine spray of cold water is injected under pressure. The gases are thus cooled to between 650 and 900 degrees F., and the water is converted into superheated or unsaturated steam of the same temperature. The mixture of steam and combustion gases is conducted into the upper part of the boiler and flows thence, mixed with steam generated in the boiler, to the cylinders. In addition to dispensing with the chimney, the new boiler possesses the merit of very high efficiency, utilizing 90 and even as much as 97 percent of the heat produced by the combustion of the fuel.

AN IMPROVED TYPE OF MARINE BOILER.

BY C. M. OLSEN.

A new type of marine boiler which involves certain improvements over horizontal multi-tubular steam boilers of the common Scotch, or similar types, having one or more furnaces, single or double-ended, is shown in Figs. 1-6. The improvement consists in, that the water-filled space round the combustion chamber is dispensed with, and in the space thus gained is arranged a watertube system and a superheater, if such is desired. The advantage of this arrangement is claimed to be twofold: First, the use of stay-bolts is avoided, and, wet walls with stay-bolts can be dispensed with altogether in the combustion chamber.

A cross cylinder *d* is arranged in a horizontal position, extending through the combustion chamber, and if wet side walls are used it is connected to these in such a way that water communication is obtained through the openings *l*, Fig. 2. When dry side walls are employed, water communication between the cylinder *d* and the main boiler is obtained through the pipes *i*, which are arranged on both sides. The cylinder *d* also communicates with the top of the boiler by the vertical pipes *k* and *p*; and with the bottom part of the boiler in the same manner through the pipes *h* and *n*. Another row of tubes



NEW DESIGN FOR A DRY-BACK SCOTCH BOILER WITH IMPROVED CIRCULATING AND SUPERHEATING ARRANGEMENTS.

second, higher economy is obtained by the more efficient utilization of the heating surface and the improved water circulation in the boiler.

Fig. 1 shows a longitudinal section of the boiler. Fig. 2 shows the back end of the boiler, and the manner in which the sheet iron covering with its angle frames for the wet side walls is constructed. In Fig. 3 the left half shows the shape of the back end for the dry side walls, and the right half shows part of the back wall removed to show part of the superheater. Fig. 4 shows the cross cylinder *d* and its pipe connections with the other parts of the boiler, while in Fig. 5 part of the shell is removed, so the cross cylinder *d*, its pipe connections and communications with the other parts of the boiler can be seen. Furthermore, part of the furnace shell is cut away to show the fire bridge and grates. The arrows show the course of the fire through the combustion chamber.

The rear wall of the combustion chamber can be made of some fireproof material and inclosed by a sheet iron wall, and the side walls may be constructed in the same manner, so that *o* connects the cylinder *d* with the tube plate in the combustion chamber. These tubes form a bridge to carry a layer or roof *e* made of firebrick or similar material. The object of this roof is to force the fire around the cylinder *d*, as shown by the arrows.

On each side of the furnaces, in connection with the tubes *o* on the inside of the tube plate, the tubes *m* are arranged, which curve around the furnaces, both outside as well as inside between them, running on a slant down to the bottom and front end of the boiler, where they terminate in a rearward bend. These tubes are designed to increase the circulation in that part of the boiler which is least effected by the heat. The water also will be drawn up from the bottom of the boiler through the tubes *h* and *n*, and carried to the water surface through the tubes *k* and *p*.

If desired the heating surface can be still further increased by arranging one or more rows of curved tubes *t*, shown in dotted lines on Fig. 1, running from the cylinder *d* through the tube plate and into the wide waterspace in the middle of the boiler between the tube nests. These tubes will also promote the circulation in the boiler.

A superheater can be fitted in the combustion chamber, as shown in Fig. 6. As the cylinder *d* and those tubes connecting the combustion chamber with the main boiler are directly exposed to the heat from the furnaces, it is claimed that the circulation of the water will commence as soon as the fire is started, and thus maintain a more even temperature throughout the boiler.

The greatest fault in the now mostly used marine boilers is bad circulation of the water. The steam pressure may be taken up to its full height without the water in the bottom hardly affected thereby, and this is surely one of the essential causes to leaky boilers and their short lifetime, and which frequently causes cracking of the material, on account of the great difference in the temperature, which again prevents the material from even expanding.

The invention described and illustrated will increase the heating surface about 15 percent, but can be still more increased.

The heating surface of this boiler is about 15 percent greater than that of a Scotch boiler of similar dimensions, so that for the same power the size of the boiler can be greatly reduced, which is an important consideration on board ship. Not only this, but since the boiler is economical in the consumpton of fuel the weght of fuel and consequent expense can also be reduced, thus, in a measure, offsetting the increased cost of this type of boiler.

It is evident that a boiler built in this manner is more expensive than the ordinary Scotch boiler. But where economies in weight and size of the boiler and in fuel consumption are gained this is not a serious consideration.

The most obvious objection to this type of boiler is the use of a number of joints in the combustion chamber where the parts are exposed to the fire.

It is claimed, however, that experience has shown that these joints are not easily destroyed, nor are leaks frequent. The argument is that the circulation of the boiler is so active that even temperatures are maintained in the various parts, so that the expansion and contraction is uniform, and there is consequently little opportunity for either leakage or failure.

BOILERS STRUCTURALLY WEAK.

Some years ago several boiler shops began building horizontal tubular boilers with one sheet on the bottom, extending from head to head, having two horizontal lap seams located up on the sides. The upper half of the shell was either a duplicate of the lower or composed of two or three half sheets. In either case there were the two longitudinal lap seams running straight from head to head.

This design was vigorously opposed by many experts as being much weaker than boilers built in ring courses, one sheet only to a course and with a longitudinal seam breaking joints on opposite sides. With the latter the seams would be half the amount in length and located above the lugs, where they could be examined readily from the inside, and by removing the upper cover could be examined outside. The horizontal seam of a cylinder is, of course, the weakest part, and with the one-sheet design, we have doubled the length of the seams, together with locating same below the lugs, so that no examination can be made either internally or externally on account of the tubes and the side walls. A joint of this design is weak, owing to the rolls springing in, curving a long sheet, and to the fact that it is impossible to have the seams truly cylindrical. Hence, there is more flexure in this form of lap seam than if built in ring courses. In addition, we have no girth seams to strengthen and stiffen the cylinder as hoops hold and strengthen a barrel. The value of the girth seams is apparent when one recalls that a vessel subjected to internal pressure tends to assume the form of a sphere.

We have always objected to the one-sheet construction and refused to design boilers built in this manner. Our opinion on the matter has been asked and given to several large shops, and others have expressed the same objections, and, as a result, this method of construction has been abandoned by almost all shops. There are, however, a number of boilers of this construction in service, exactly how many it is impossible to state. It is to these we desire to call attention, having in view the fact that there have been three disastrous explosions within ten months of boilers of this design, and in each case the initial failure or rupture took place at the horizontal seams. The explosions were at Shelton, Conn., Midvale, Ohio, and Canton, Ohio. In each case the property damage was very high and a number of lives were lost as a result of structural defects which permitted excessive flexure, that, extending over a period of several years, resulted finally in explosion.

We went over the evidence carefully, and believing it our duty to protect our patrons from similar explosions, issued instructions to our inspectors to use a higher factor of safety, and recommending a hydrostatic test be applied at regular intervals to determine the actual condition of such boilers. Within two weeks after receiving the instructions, one of our inspectors applied the water test to a boiler of this type and a horizontal seam failed in such manner that it was necessary to abandon the boiler at once, as it was beyond repairs.

No doubt exists, had this boiler been allowed to run without a water test, another disastrous explosion would have occurred within a short time, and our prudence in the matter prevented such a result. The case confirms our position in the matter with positive certainty.

We are not responsible for the design, having fought it from its inception. The factor of safety on boilers of this design is, indeed, a factor of ignorance, and a water test is necessary with the seams exposed to determine their actual condition. Nor do we approve of allowing as much pressure as on a boiler of the same design but built in ring courses.

We are bringing this matter to the attention of our patrons operating such boilers, urging special care be given in operation, and that they assist us in the matter of hydrostatic tests, and that steps be taken toward replacing this type of boiler with new ones of better design.—*Monthly Bulletin of the Fidelity and Casualty Company of New York.*

Oil Fuel.

Tests recently made at the Las Cascadas air-compressor plant, Panama Canal Zone, on California crude oil burned under boilers gave an equivalent evaporation of 14.40 pounds of water from and at 212 degrees F. per pound of oil, and 14.63 pounds of water per pound of combustible. The tests were made on six return fire-tube boilers, there being two trials of seven and one-half and nine hours, respectively. A similar test was made at the Mount Hope pumping station on a locomotive-type boiler, which gave 13.11 pounds of water from and at 212 degrees F. per pound of oil, and 13.40 pounds per pound of combustible.—*Electrical World.*

Boiler Explosions in Germany.

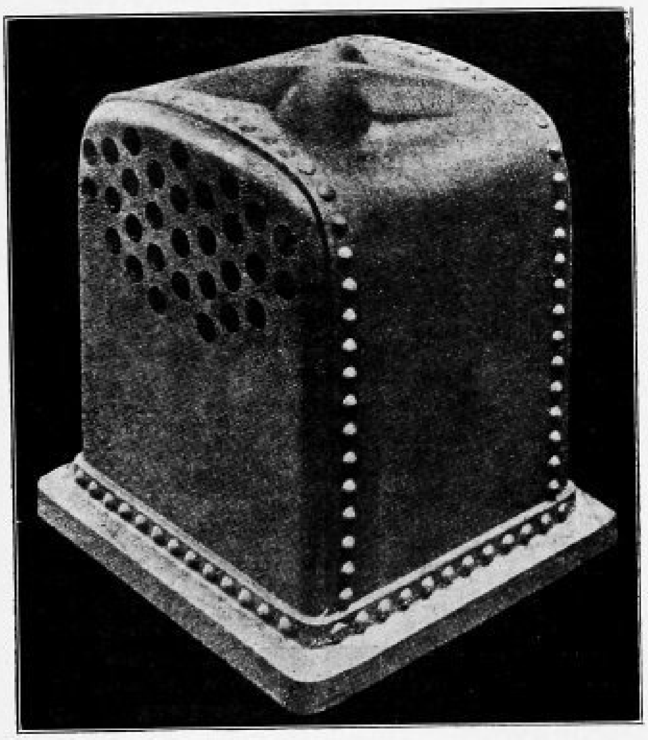
"What man has done, man can do." The appalling number of boiler explosions constantly taking place in the United States may be ascribed by interested parties to the inherent depravity of inanimate objects. That, on the contrary, it is due to the inherent depravity of *animate* objects is conclusively shown by comparison with the boiler explosion statistics of Germany.

In the German Empire during the year 1909 there were only nine boiler explosions, six of which were attended by personal casualties. Altogether five persons were killed, eight seriously wounded and twenty-three slightly injured. Within the last thirty-three years there have been 518 explosions, by which 344 persons were killed, 211 severely and 509 slightly injured. By average, this is about ten explosions per year, killing ten persons, wounding six persons seriously and sixteen slightly. These figures are still more significant when analyzed, since in the recent years, when there must have been many more boilers in use, the actual number of disasters has run about the same, or even less, than in earlier years. The greatest number of explosions on the record is thirty-five, in 1894, and the highest account of deaths thirty-six, in 1879.

Of the nine explosions in 1909, five are believed to have been caused by low water; one by defective material; one by weakening of setting; one by corrosion, and one by breakage of a manhole bolt from too energetic use of the wrench, or otherwise. It does not appear that there was a watertube boiler among them.—*Power and the Engineer.*

Marshall's Fire-Box with Stayless Roof.

The application of the principle of corrugation to fire-box tops of the portable locomotive type of boiler has recently been the subject of experiment on the part of Messrs. Marshall,



MARSHALL'S FIRE-BOX WITH STAYLESS ROOF.

Sons & Company, Ltd., Britannia Iron Works, Gainsborough, England, with the result that this firm has brought out the type of fire-box shown in the illustration herewith. In this box the corrugations along, or across, the box are replaced by two arranged diagonally across the roof, as shown in our figure. This method of corrugation gives a very stiff roof, rendering roof staying unnecessary, an advantage both from the point of view of construction and working. A box of this type has been tested, we understand, with a pressure of 360 pounds per square inch, without showing any deflection of the roof. Other tests are, we believe, in progress in Germany, where this design has been submitted to the authorities, in view of the new and complicated boiler laws introduced there.—*Engineering.*

Overloads on Boiler Plants.

The development of boiler design and the change in views regarding the boiler capacity needed to carry peak loads were discussed by Dr. D. S. Jacobus, advisory engineer of the Babcock & Wilcox Company, in a lecture before the Franklin Institute of Philadelphia on November 10. The problem of the manufacturer to-day is to build a boiler capable of operating economicaly at an ordinary load and also capable of being driven to a capacity limited only by the amount of coal that can be burned in the furnace. In central station work it is also desirable to have a boiler that can be put under steam quickly from a banked fire or cold state. Dr. Jacobus does not believe in adding to the water capacity to increase the thermal storage factor to a degree which will sacrifice ability to get up steam quickly, for an increase in the thermal storage capacity can improve matters but little for the conditions met in ordinary power plant work compared with ability to get a reserve boiler in on the line in the shortest possible time. To make thermal storage a material factor, he said, the steam pressure must fall 25 pounds or so, and after the pressure falls the thermal storage will act against the recovery of the pressure and the rate of combustion of the fuel and the heat imparted to the boiler must then be greater than with the boilers having a less thermal capacity.

It is good modern practice to drive Babcock & Wilcox boilers daily at double the ordinary rating during heavy load periods, according to Dr. Jacobus. This does not mean that the boiler is driven to an overload in the sense that it is under a strained condition of running, as the rating of 10 square feet per boiler horsepower is simply a nominal one. He believed that eventually boilers would be driven harder than this in daily practice during peak load periods, and that additional plant economy would be secured thereby. The progress in this direction is exemplified by the installation of the Commonwealth Edison Company at Chicago, where the first 5,000-kilowatt turbines erected in this country were installed. This was in 1903, and eight boilers, each having about 5,000 square feet of heating surface, were supplied for running a turbine. The maximum rating for these turbines was 7,500 kilowatts. Later on 12,000-kilowatt (maximum rating) turbines were installed, each with eight boilers of the same size, as provided for the 5,000-kilowatt machines. Still later machines of 14,000-kilowatt maximum were run with the same size and number of boilers that were selected for the operation of the original machines of 7,500-kilowatt maximum.

Boiler Flanging.

A prominent manufacturer of firetube boilers inserts the following clause in his specifications: "Hydraulically flanged heads are not to be used under any circumstances. Heads are to be machine-flanged by the spinning process." The writer does not see why hydraulically flanged or pressed heads are not superior in every way to spun heads. In the first place, the pressed heads of each size are of uniform diameter, making it easy to properly fit the courses to the heads. This uniformity is of considerable importance where a number of boilers of one size are built together, because, owing to the difficulty of keeping the shell plates and heads separate for each individual boiler in the shop, the person laying out the work in the case of the spun heads of varying diameter, usually endeavors to strike an average for the lot that will best suit all; this usually results in a poor fit for some.

Again, the flange on a pressed head is thicker than the plate from which the head is made; this is a desirable feature, and is due to the upsetting of the metal in the flanging process. With the spun-head the flange is usually slightly thinner than the plate from which the head is made. The surface on the flange of a pressed head is smoother than that on a spun-head, the latter often containing grooves made by the rolls of the spinning machine; this smoothness is important in making tight head seams without undue calking. Furthermore, the surface of a pressed flanged head is usually straighter than one which is spun, permitting the use of uniform tube lengths without the necessity of springing the heads into position. The value of this feature after the boiler is constructed is only thoroughly appreciated by the workman who has to put in a new set of tubes, the owner being affected only by the increased cost of the work.

With the multiplicity of diameters called for at the plate mill, the spinning process is by far the most practical for general purposes, but it would seem that a boiler manufacturer who intends to have complete equipment for the manufacture of high-grade boiler work would flange his boiler heads on a press. It seems that the condemnation of the hydraulically flanged head is a subterfuge intended to mislead the purchaser who is not well informed upon the subject.—*F. O. Jones in Power.*

WOODEN BOILERS.*

The following extract, from a recent issue of the New Haven *Evening Register,* may be of interest to those who were unaware that wood was sometimes used as structural material for the manufacture of boilers in the early days of steam engineering:

"The newspapers of New London, Conn., have long occupied a prominent place in the opinion of those who seek accurate information respecting marine affairs. This was so even back in 1817, when the New London *Gazette* was being pulled out of the press; for that paper 'explained' the real reason for the accident that 'befell the Norwich steamboat on July 2, 1817,' and the points brought out were so important that the Connecticut *Herald* of Tuesday, July 15, 1817, reprinted the *Gazette's* story of the accident, assigning as its cause the fact that a wooden boiler was used. Think of a wooden boiler, and figure out where the ocean skimmers would wind up if such boilers were used nowadays!

"The *Gazette* disliked the idea of misleading the public, as do all good newspapers, and herewith is reproduced the true story of the accident to the Norwich boat, which, as shown, was due entirely to the desire of someone to save money:

"'The account given of the accident which befell the Norwich steamboat on the 2d inst., and running through the public papers, is calculated to mislead those who are unacquainted with steamboats. The facts are as follows:

"'The boat in question is a small vessel, lately built, and owned by a few individuals in Norwich, to ply between Norwich and New London. The proprietors, wishing to save the expense of Fulton and Livingston's patent right and an expensive engine, have put into her a simple engine upon a new construction, and entirely experimental, with high-pressure cylinders and (extraordinary as it may seem) *wooden* boilers, without condensers, safety valves or balance wheels. As was predicted her wooden boilers burst, and three persons were hurt, though not dangerously.

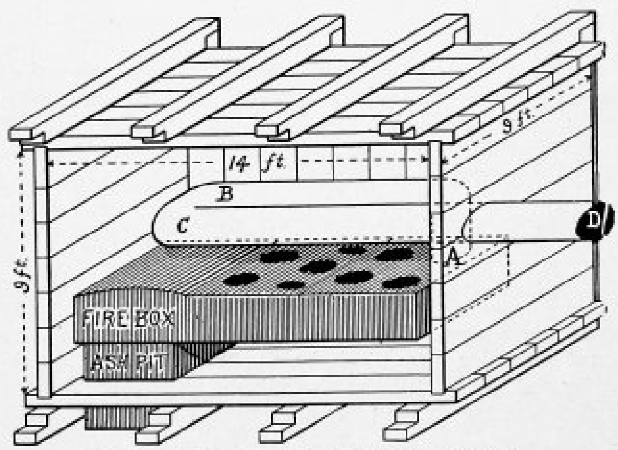
"'It is a fact worthy of notice that the steamboats upon the North River and Long Island Sound, constructed upon the Fulton and Livingston plan, have been running ten years without a single person ever being injured; and it is impossible that any serious injury should happen to them, since their safety valves are calculated to relieve an excess of steam sponstaneously.

"'Editors who think the public ought to be correctly informed upon this subject are requested to publish the above.'

"Great boiler this—made of wood without balance wheels, condensers or safety valve!

"The Connecticut *Herald,* from which the foregoing presumably truthful account of this accident is taken, is a well-preserved copy, owned by John Lucy, former station master at the Union station, New Haven, Conn. The *Herald* was published by Steele & Gray, printers, on State street, New Haven."

We are not quite sure whether the next-to-last paragraph of the foregoing was evolved by the present management of the *Register,* or by his respected fellow-townsman, the former



WOODEN BOILER USED IN PHILADELPHIA, 1801-1804.

editor of the *Herald,* long since gone to his reward. If we *did* know with certainty we should try, by United States post or through some efficient spiritualistic medium, to let the responsible individual know that balance wheels and condensers are not regarded as in any way essential to the safety of steam boilers, whether the said boilers be made of steel or wood or putty.

Wooden boilers were used to a limited extent when the steam engine was in its infancy, and when the pressures that were employed were to be measured, as we might say, in *ounces* per square inch instead of pounds. (The term "high-pressure," as employed in the foregoing extract, is not to be interpreted in the modern sense, of course, but merely as meaning a pressure higher than was commonly employed in other boilers at the same period.) The *Scientific American Supplement* of Nov. 4, 1876, gives some highly interesting data respecting a wooden boiler that was in regular use for nearly four years in the pumping station of the Center Square Water Works at Philadelphia, Pa. This boiler began its service on Jan. 21, 1801, and its use was continued up to Dec. 1, 1804.

The Center Square boiler had the form of a rectangular chest, and was made of white pine planks, 5 inches thick. It was 9 feet square inside at the ends and 14 feet long in the clear. It was braced upon the sides, top and bottom with oak scantling, 10 inches square, the whole being securely bolted together by 1¼-inch iron rods passing through the planks. Inside of this chest was placed a fire-box 12 feet 6 inches long, 6 feet wide and 1 foot 10 inches deep, with vertical flues, six of 15 inches diameter and two of 12 inches diameter. Through these flues the water circulated, the fire acting around them and passing up into an oval flue situated just above the fire-box.

The fire-box and the water flues appear to have been made,

* From *The Locomotive.*

at first, entirely of cast iron. A wrought iron fire-box was next tried, the water flues still being of cast iron. This arrangement was found to be unsatisfactory on account of leakage, which was attributed to the unequal expansion and contraction of the two metals, and eventually the water flues were also made of wrought iron.

So far as we can judge from the data at hand, the smoke flue *A, B, C, D* was made of wrought iron from the first. Thus under date of July 4, 1800, Thomas Cope says of a similar plant, having a similar wooden boiler, and located on the Schuylkill River at the foot of Chestnut street: "The wrought iron for the flue of the boiler over the fire will be imported from England, and is in sheets 38 inches by 32 inches. That yet made in this country is clumsy stuff of different sizes, the largest being 36 inches by 18 inches, with rough edges, which have to be cut smooth by the purchaser."

The low heat-conducting power of wood was supposed to be of great advantage on the score of economy, and the water flues, running vertically through the fire-box, were also supposed to be highly important for like reasons.

As might be expected, great difficulty was experienced in keeping these wooden boilers tight, and the one at the Center Square works was replaced on Dec. 1, 1804, by a boiler having a cast iron shell.

A FLUE CUTTING DEVICE.

BY W. H. SNYDER.

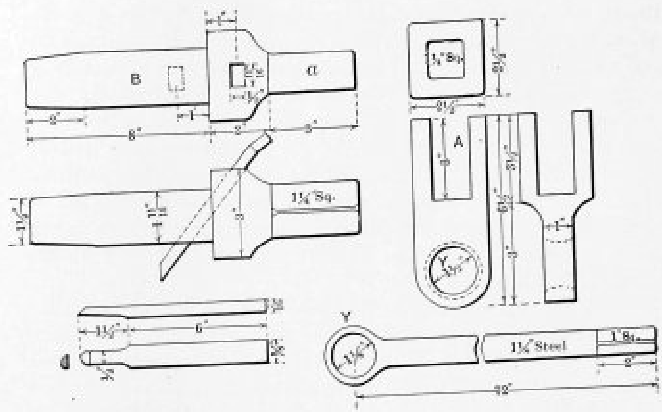
The photograph and drawings illustrate a device for cutting flues from a locomotive boiler. The tool holder *B* is first inserted in the flue, after which the cutting tool is placed into the holder and the point driven through the tube. The socket *A* is then attached to the tool holder at *a*. The 1⅛-inch steel rod, with a square on one end to fit the spindle *T* and an eye on the other end, which is welded into the socket at *Y*, drives the cutter, and the eye forming a knuckle allows the cutter to be inserted into any flue without changing the device. One revolution cuts off the flue.

The photograph shows clearly the assembled device and the method of hanging it up with a block and fall. The chains shown on the lower part of the device are very important. They are fastened to the frames in order to steady the device and keep it from swinging around.

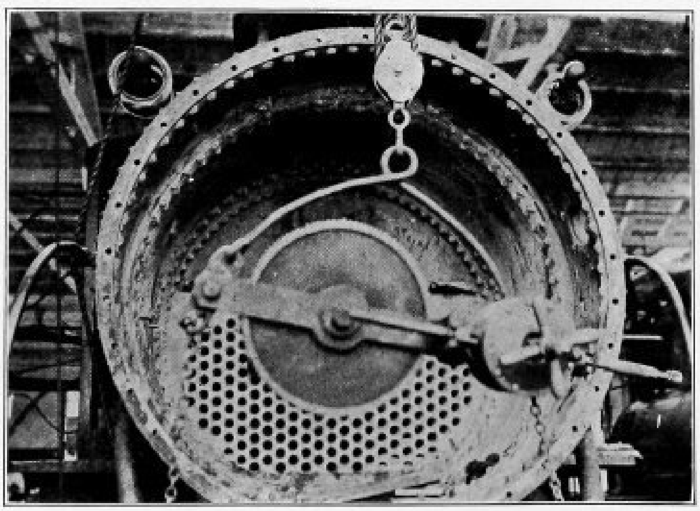
The large gear wheel is mounted on the spindle *u* which drives the cutting tool, and the power of the motor is transmitted through gears *V* and *W*. This arrangement greatly increases the power and at the same time reduces the speed. The flexibility of this device for adjusting it from one flue to another is a feature that should recommend it to any one.

The frame *A* must be made to suit the motor you wish to use; a good, powerful motor must be used with a capacity of drilling a 3-inch hole in order to get the best results. The frame *A*, when made to fit the motor, must be bolted to the side plate in order to allow the spindle *V* to project through so the motor can be connected to drive the device.

When first commencing to use this device you may experience some difficulty in grinding the cutting tool so that it will give the best results, but with a little care and judgment you will very soon overcome this little difficulty.



DEVICE FOR CUTTING FLUES FROM A LOCOMOTIVE BOILER.



FLUE-CUTTING DEVICE IN OPERATION.

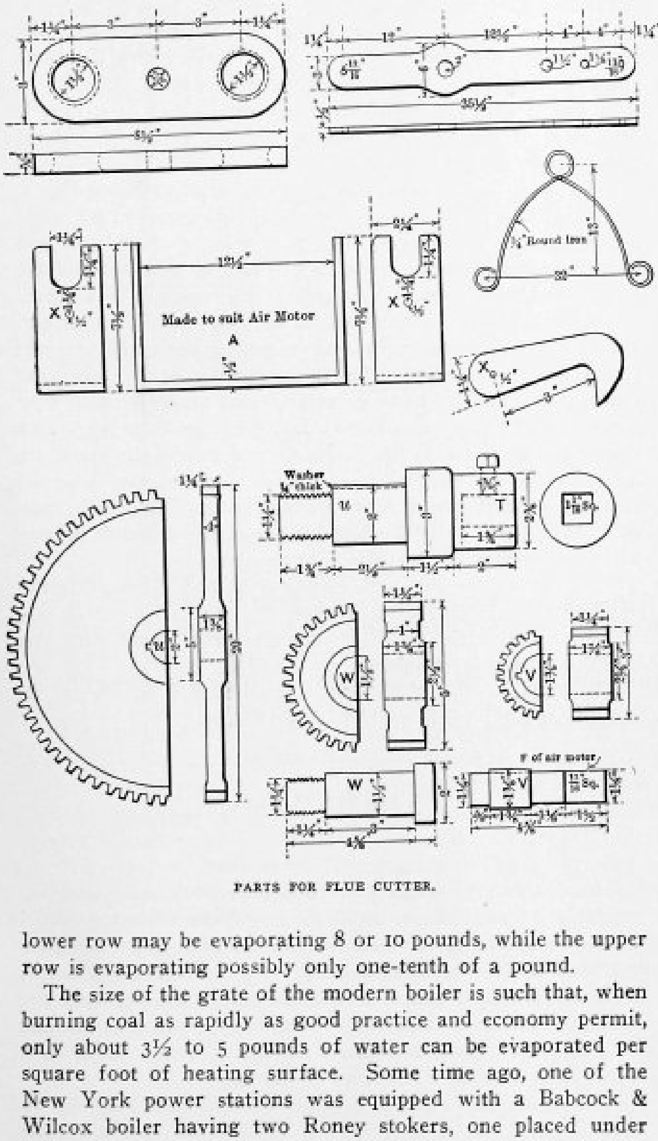
PROBABLE FUTURE BOILER PRACTICE.*

BY JAMES E. STEELY.

The capacity of a boiler is a variable factor. Builders usually allow about 3½ pounds equivalent evaporation per square foot of heating surface in rating a boiler. Under the present standard of construction this is about the evaporation which is possible without forcing. However, no two sections of the boiler will do the same work; the part close to the fire will generate a large portion of the steam, while that near the flue

* From *Power and the Engineer*.

will generate very little. Some idea of the relative amounts done by the various rows of tubes was given by an instrument, used some time ago, to indicate circulation in the boilers of the Geological Survey plant at St. Louis. The bottom row of tubes were entirely inclosed in a fire-clay baffle; notwithstanding this protection from the heat the machine made three times as many revolutions when placed in one of the bottom row of tubes as when placed in the tube immediately above it. When placed in the third row from the top it revolved very slowly. This demonstrates that the first row of tubes does many times as much work as any of the others and that the upper rows do very little. Now if the average evaporation is 3½ pounds of water per square foot of heating surface, the



PARTS FOR FLUE CUTTER.

lower row may be evaporating 8 or 10 pounds, while the upper row is evaporating possibly only one-tenth of a pound.

The size of the grate of the modern boiler is such that, when burning coal as rapidly as good practice and economy permit, only about 3½ to 5 pounds of water can be evaporated per square foot of heating surface. Some time ago, one of the New York power stations was equipped with a Babcock & Wilcox boiler having two Roney stokers, one placed under each end of the boiler, thereby doubling the grate surface. About 75 percent overrating was obtained by this arrangement without any considerable decrease in efficiency. This would indicate that the trouble with our modern standards is that the ratio of heating surface to grate surface is too large. The arguments for this practice of high evaporation are low first cost, economy of room and smaller loss due to radiation; those against it are increased maintenance cost and rapid deterioration of the boiler.

The capacity of a boiler is approximtely proportional to the velocity of the gases and water. Thus the more rapid the circulation of water in the boiler or the more rapid the passage of the gases, the more rapid will be the generation of steam. Probably every engineer has seen diagrams showing the difference in ebullition between where there is circulation and where there is none. Theoretically, the correct way to get the highest economy is to have the water circulating in the opposite direction to the hot gases, but the writer knows of no way in which this opposed current could be obtained and still allow free circulation of water in the boiler. If the circulation were restricted, the steam would be liberated with violence. It may be stated, however, that when a watertube boiler of the Babcock & Wilcox or Stirling types is set with vertical baffles, this opposed current arrangement is secured to some extent. This is about as much as can be expected without sacrificing the free circulation of the water in the boiler, which is more important. The opposed flow should be secured by stages just as steam is expanded in doing work. It is out of the question to economically obtain a complete expansion of steam in one long cylinder, but the same end is arrived at with excellent results in two, three or four stages. While there is no analogy between steam expansion and heat absorption, the same principle may be applied to obtain the best results. In other words, the boiler and economizer are better when separated than combined in one. If a two or three-stage economizer were used it would cool the flue gases as low as any boiler which could be built and with much less complication. Plants using noncondensing engines usually have enough exhaust steam to heat the feed-water as hot as it is possible to handle it in the pump, and when this hot water is further passed through a good economizer it is raised to almost the temperature of evaporation, leaving merely the work of evaporation to the boiler. If the exhaust steam were not available, a second economizer could be used in tandem, but the temperature of the flue gases would be so low as to seriously affect the chimney draft.

It has been stated that efficiencies as high as 90 percent are attainable. If one closely examines the heat balance of an ordinary boiler test it will be seen that it is almost impossible to obtain any such result except perhaps with a very bulky and expensive layout. The "unaccounted for" losses and the loss due to incomplete combustion usually amount to over 10 percent, and it would be necessary to return the burnt gases to the air at the same temperature as they were received. When temperatures are taken for calculating the chimney losses they are taken before the gases pass through an economizer, and when the loss up the stack figures 18 to 25 percent it must be kept in mind that the economizer will take up considerable of this apparently lost heat. Thus while the efficiency of the boiler might be only 65 percent the efficiency of the boiler and economizer might be 75 percent. The results of recent investigations show that a high furnace temperature means a high stack temperature, and that a large increase in the combustion chamber temperature is accompanied by very little increase in efficiency.

The problem of heat absorption is discussed fully in the Geological Survey bulletin No. 325, and considerable experimental data as well as conclusions drawn therefrom are set forth. Everyone interested in heat absorption should study these experiments carefully, as many of them result contrary to the logical method of reasoning.

In the writer's opinion a boiler should be proportioned so that all the heating surfaces would do equal work. If this result could be attained, two or three times as much steam would be generated per unit as that which is now possible.

American Institute of Steam Boiler Inspectors.

The second meeting of the American Institute of Steam Boiler Inspectors was held at Boston, Mass., on Oct. 26, 1910. Papers were read by Prof. Miller, of the Massachusetts Institute of Technology; Joseph McNeill, chief boiler inspector of the State of Massachusetts; Thomas Hawley and George R. Richardson, of the Hartford Steam Boiler Inspection & Insurance Company. The officers of the institute are as follows: President, C. D. Noyes, Hartford Steam Boiler & Inspection Company; vice-president, J. F. Mulloy, Mutual Insurance Company; secretary, E. R. Doherty, Mutual Insurance Company.

THE SPIRAL PIPE.

BY CLARENCE REYNOLDS.

In the October issue of THE BOILER MAKER we find a very interesting article by John Jasky on how to find the strength of a spiral-riveted joint; there are several valuable facts made clear, and we also find that a much greater efficiency can be obtained by using the spiral seam than can be obtained by using the longitudinal seam. This being true it will no doubt come into practical use for pressure more and more each day because of its marvelous strength, therefore we should devote a little of our time to the developing of this pipe.

To layout the pipe without allowing for the thickness of material we find to be very simple, but when allowing for this thickness we find it makes the problem more complicated.

In laying out most problems the thickness of material must be taken into consideration, and we find this changes the method of developing considerably, therefore a student should devote a great deal of his time to the thickness of material rather than to develop his problems as if there were no thickness. It is true, in many cases, we draw up the object as if there was no thickness, and in the layout of the pattern we allow for it, as on an elbow or a ball.

The first step in this problem, as in most any other, is to draw the center line *X-X*, then the plan, Fig. 3, which is two circles, the smaller is the center line of material of the inside edge of the plate and the larger the center of material of the outside edge; divide these circles into any number of equal spaces, in this case sixteen, then carry lines down from these points parallel to line *X-X* of indefinite length; divide the center line of the material 4'-4 (Fig. 1) into the same number of equal spaces, carrying the same spaces to the bottom of the pipe as shown; draw lines from these points perpendicular to *X-X*, cutting the corresponding lines as shown at *c*, *e*, 5', etc.; these points form the center line of material of the outside edge, and *d*, *f*, 5 etc., form the center line of the inside edge, which is nothing more than constructing a helix.

It is not necessary to draw all the lines as shown in Fig. 1, the only lines needed in the general outline are the center lines of material, the base line and line 4'-2'.

Now draw the triangles by drawing the lines 5'-5, *e-f*, *c-d*, etc.; connect these by diagonal lines 5'-*f*, *e-d*, etc.; you will notice there are only four lengths of lines used in constructing the true triangles, they are *H*, *h*, 1, 2; to find the length *H* construct a right-angle triangle, one side equal to *p* and one equal to *A'* (Fig. 3), the hypotenuse will equal *H*. To find the length *h* construct a right-angle triangle, one side equal to *p* and one equal to *B'* (Fig. 3), the hypotenuse will equal *h*. To find the length of line 1 construct a right-angle triangle, one side equal to *P* and one equal to *D* (Fig. 3), the hypotenuse will equal line 1. To find the length of line 2 construct a right-angle triangle, one side equal to *P-p* and one equal to *C* (Fig. 3), the hypotenuse will equal line 2.

A more accurate way to find the lengths *H* and *h* is as follows:

Let $N =$ Number of turns the spiral makes (in this case 1½).

$E = E$, Fig. 3.

$F = F$, Fig. 3.

$M =$ Number of spaces into which each circle is divided.

$$\text{Then } H = \frac{\sqrt{(E \pi N)^2 + (N P)^2}}{N M}$$

$$h = \frac{\sqrt{(F \pi N)^2 + (N P)^2}}{N M}$$

In Fig. 2 we find another way. *A B* is the length of the pipe, $A\ C = E \pi N$, *B C* is the length of the outside center line, Fig. 1, and is to be divided into as many spaces as the spiral in Fig. 1; this will give the length *H*; *D E* (Fig. 2) is the length of the pipe, $D\ C = F \pi N$, *E C* is the length of the inside center line, Fig. 1, and is to be divided into the same number of spaces as *B C*; this gives the length *h*.

In Fig. 4 you will notice that only one-fourth of a turn is developed by the use of triangles and the rest is developed from this by diagonal lines.

Draw line 4'-4, the length of which is equal to line 1, Fig. 1, and line 2, Fig. 1, is equal in length to line 4-*a*, *b-c*, *d-e*, f-5'; 4'-4 is equal to *a-b*, *c-d*, *e-f*, 5'-5, then using 4' as a center and *H* as a radius strike an arc at *a*; using 4 as a center and 4-*a* as a radius cut the small arc just struck; using 4 as a center and *h* as a radius strike an arc at *b*; using *a* as a center and *a-b* as a radius strike an arc at *b*, cutting the small arc just struck, and so on until one-fourth turn is developed; then using 5 as a center and 5-4 as a radius, strike an arc at 6, using 5' as a center and 5'-4' as a radius strike an arc at 6'; using 5' as a center and 4'-5 as a radius strike an arc cutting the small arc at 6; using 5 as a center and 5'-4 as a radius strike an arc cuttin gthe small arc at 6', this develops another fourth; continue this operation until you have the required length pointed off, then connect these points with an arc.

Now to get the end cuts 0-1'-2'-3'-4' and 6-7-8-9-10; 1'-1 equals one-fourth of 1"-1, 2'-2 equals one-half of 2"-2, 3'-3 equals three-fourths of 3"-3; connect these points with arcs and the pattern is completed.

The length 4'-5'-6'-7'-8'-9'-10 is equal to *B C* in Fig. 2; the length 0-1-2-3-4-5-6 is equal to *E C*, Fig. 2.

A HAND PUNCH.

BY ELGOMO.

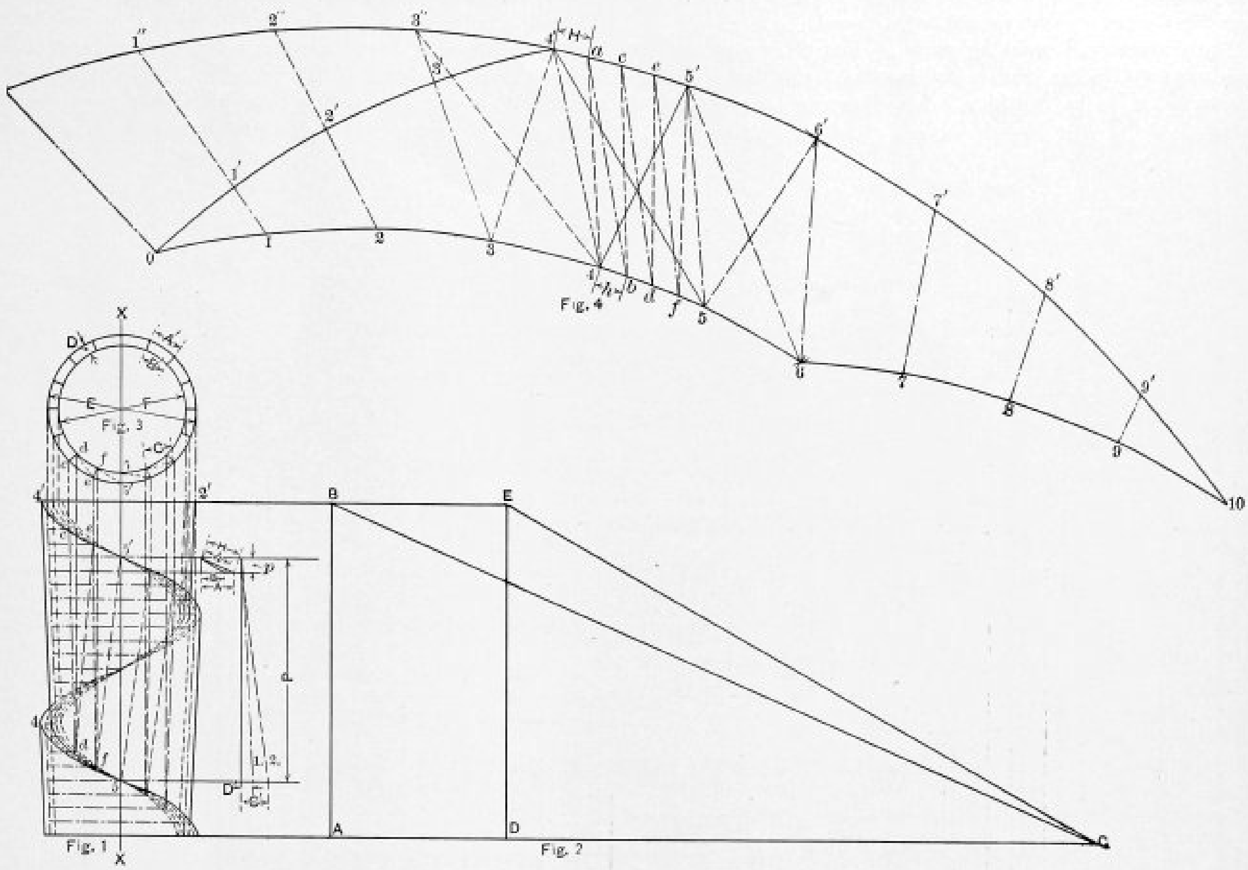
Those who have worked on sheet iron work years ago, particularly in small shops, no doubt recall the old screw punch as an important factor. At the present time there are many types of up-to-date hand tools on the market for punching light work and at prices to suit the purchaser, yet there are, no doubt, instances in small shops where by reason of location, etc., they are unable to obtain such, and it is for conditions of this character that this article is written.

The photograph shows a small hand punch made by the writer. It is simple in design and suitable for light work, particularly for assembling work away from the shop. With a hole drilled and tapped in the bottom, back and top it could be secured in the position most suitable for the work at hand.

The punch shown in sketch was made from 3-inch by 1½-inch soft bar steel. The height is 4 inches and the depth 3 inches. The working parts were made from 1⅛-inch cold-rolled steel, the punch and die from tool steel. The principal tools required for the making were the drill press, hack-saw and file.

Fig. 1 shows an end view with the lever piece in position.

Fig. 2 shows the side of the frame, also the location for drilling and cutting.



LAYOUT OF A SPIRAL PIPE, ALLOWING FOR THICKNESS OF MATERIAL.

Fig. 3 shows the punch assembled.

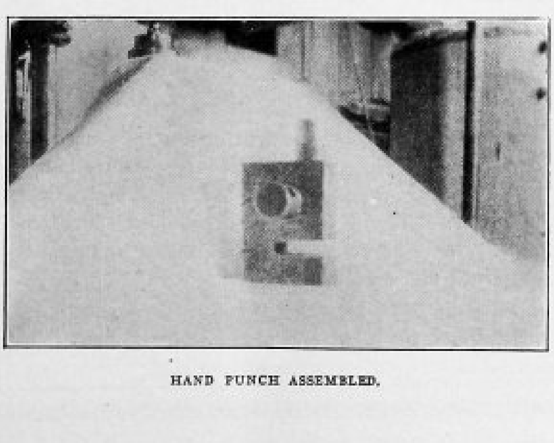
Fig. 4 will explain the manner of forming the movement.

Fig. 5 shows the die. The weight of the punch complete is 5 pounds.

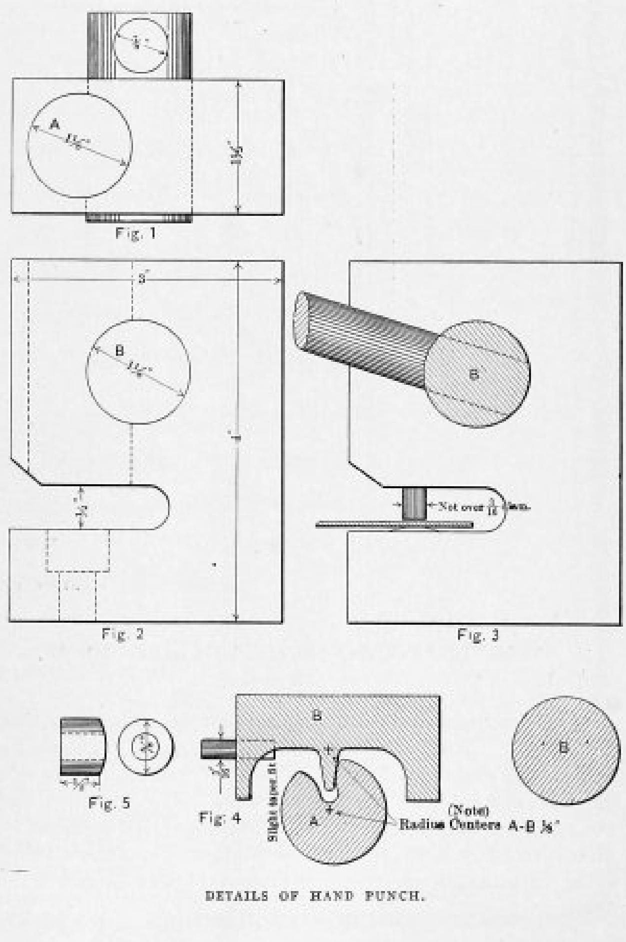
The first operation in making the punch is to drill the hole *B*, Fig. 2, after which plug this hole to enable drilling hole *A* in the end, as shown in Fig. 1; then with a suitable drill drill the hole for retaining the die, after which use a smaller drill for the hole to allow the punchings to fall out at the bottom. Next drill a hole at the throat, after which cut out the opening with a hack-saw.

The part *A* shown in Fig. 4 requires drilling or cutting 1½ inches in length and shaped as shown. Also drill through at the opposite end for the lever.

Much of the work upon *B*, Fig. 4, can be cut with a hack-saw, also drill the end of the same for the punch. Not more than a 3/16-inch diameter punch should be considered with this small tool.



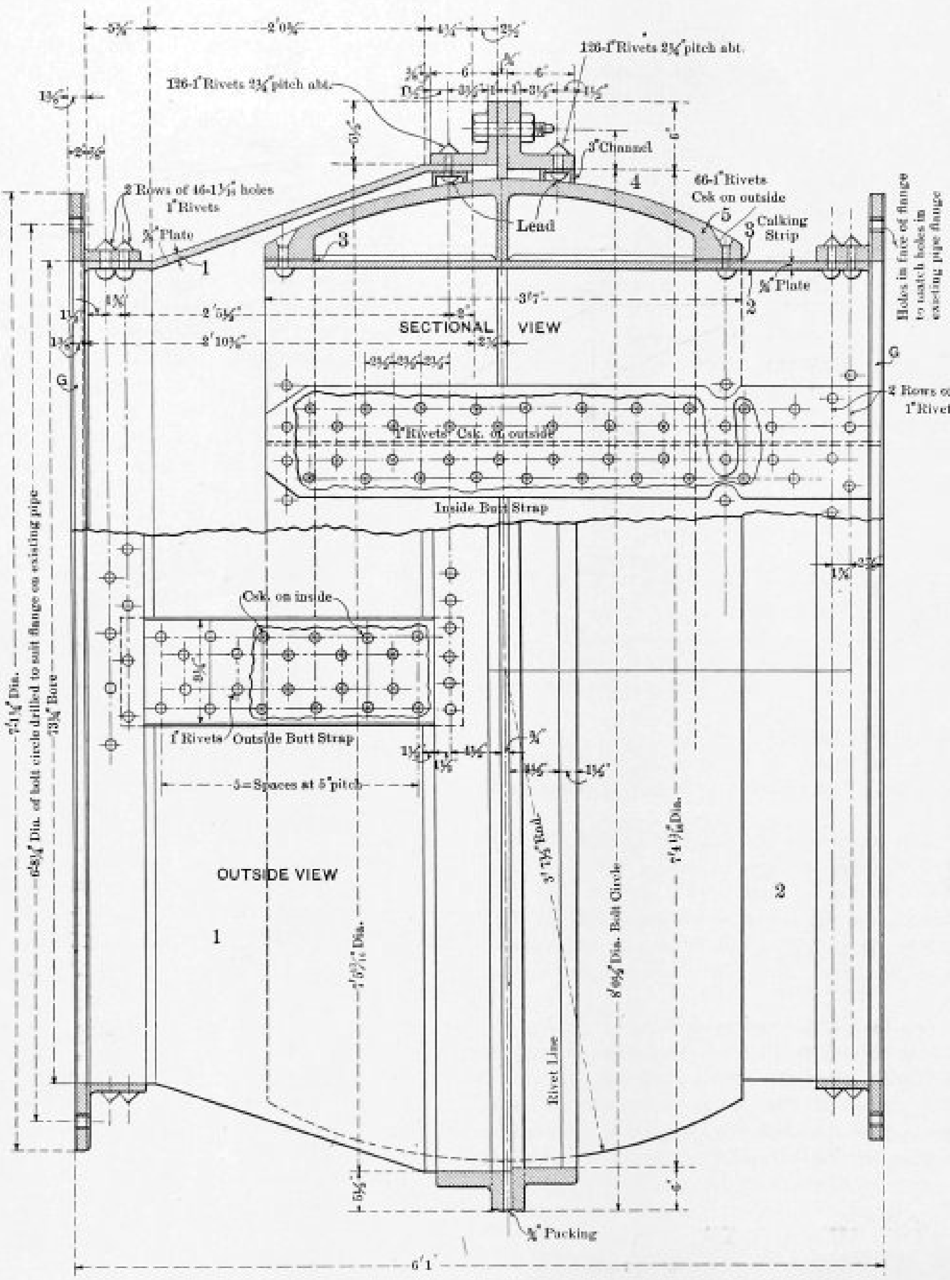
HAND PUNCH ASSEMBLED.



DETAILS OF HAND PUNCH.

In making the punch and die the die requires at least 1/32 inch for clearance; both should be hardened.

The diameter of working parts *A* and *B* in the case at hand was 1⅛ inches, and in drilling the frame for *A* and *B* allowance is to be considered for clearance to avoid extra fitting.



A FLEXIBLE JOINT FOR AN INTAKE PIPE.

A SEVENTY-TWO-INCH FLEXIBLE JOINT.

BY S. HARRISON.

The accompanying sketch shows a rather unusual job for boiler shop work. It is a flexible joint designed by C. H. Rust, chief engineer of the city of Toronto for the extension of the in-take pipe for the city water works. It is designed to accommodate itself to the bed of the lake. Two joints were made to fit in between three sections of pipe, each 168 feet long 72 inches diameter. The plate used was ⅝ inches thick. No. 1 was the outside plate, which was made as a cone, being flanged at both ends to fit cast steel flanges. It was made with a butt joint, with straps outside and the rivets countersunk inside to miss the cast iron bearing. No. 2 was the inside shell, made with a butt joint with a strap inside and rivets countersunk outside. No. 3 was the calking strip and No. 4 a 3-inch channel riveted to cast steel flanges and turned to suit the radius of the bearing. It was filled in with red lead. No. 5 was the cast iron bearing, turned ball-shape to a 3-foot 7½-inch radius, thus making a ball and socket joint which enabled the pipe to turn in any direction which might be necessary to accommodate the bed of the lake.

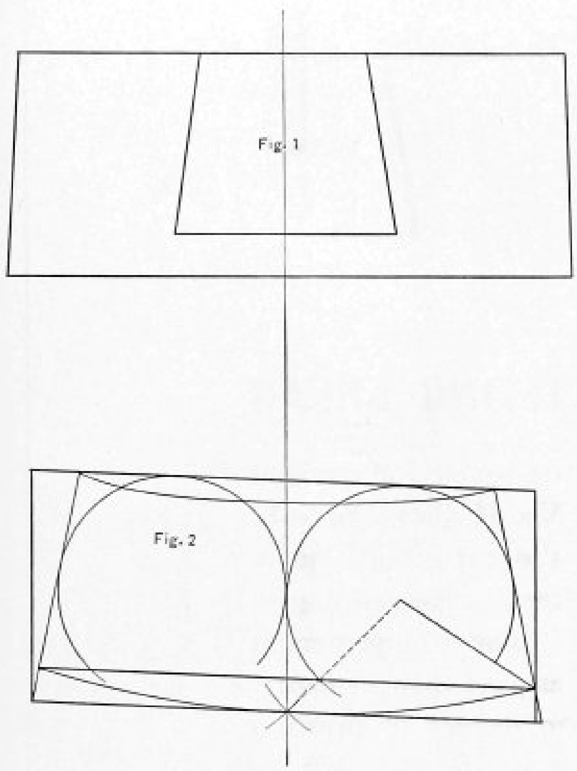
This joint was built by the Canada Foundry Company, Toronto, Ontario, Can., and proved a good, tight job, which is a credit to both the designer and builder.

THE LAYOUT OF A TAPER SHEET.

BY JOHN A. HIGGINS.

In the December issue of THE BOILER MAKER a method of laying out a taper sheet was described which is very good, but as not all boiler makers are expert with figures the following method may prove simpler for some:

Select a sheet 2 or 3 inches wider than the height of the course; draw a center line in the sheet, as shown in Fig. 1; also draw a full-size view of the cone, as shown in Fig. 1, and find the circumference of the top and bottom ends by multiplying the respective diameters by 3 1/7. Lay off one-half of the circumference of the small end on each side of the center line, and strike the height of the course full across the sheet.



SIMPLE METHOD OF LAYING OUT A TAPER SHEET.

On this line lay off half the circumference of the large end on each side of the center line and then strike in the side lines.

Now find the center of a circle which will strike three sides of your layout, as shown in Fig. 2, and from that center spread your trammels to the high corner and bisect the center line. You have then found the cord of the arc, and with a batten held at the outer points and sprung in the center to touch the point on the center line, draw in the curve around the batten. Now lay off the height of the cone on the center line and transfer the batten to the top and draw in the upper curve. The top and bottom lines are the lines to which the pattern should be cut while the side lines locate the centers of rivet holes.

With a little care on the part of the layer-out this method will be found satisfactory, and it will give sufficiently accurate results.

A serious fire occurred on the night of Dec. 1 at the plant of the Philadelphia Iron Works, 418 North Eighteenth street, Philadelphia, Pa. Damage to the extent of about $24,000 was reported, but the company is still doing business, as a portion of the building was saved.

Seamless Boiler Shells.

A large share of the expense and much of the weakness in a boiler shell is due to the riveted joints. The tendency in recent years has been to reduce the number of riveted joints as much as possible by using large plates with a single plate to a course, thus reducing the number of both longitudinal and girth seams. Some progressive boiler makers have even predicted the entire elimination of riveted joints and the substitution of welded joints, but under present conditions the uncertainty of the strength of welded joints is such as to practically preclude their use for boiler seams subject to high pressure. There is another way, however, by which joints of all kinds can be eliminated from boiler shells, and that is by rolling the shell complete from the solid bloom at the steel works.

The possibility of this method of manufacturing boiler shells has already been demonstrated on a small scale by Messrs. Yarrow & Company, of Scotstoun, Scotland, who are having the steam drums of the watertube boilers which they are installing in recent British torpedo boat destroyers made seamless and rolled to the requisite diameter from the solid bloom. We understand that the first of these steam drums has recently been produced successfully at the Sheffield works of Messrs. John Brown & Company, Ltd. This work is a practical development of previous work of this character which has been done in the production of rotor drums for steam turbines. Already methods have been devised whereby drums of considerable weight and of large size have been successfully rolled in this way, the largest being over 12 feet in diameter and weighing 24 tons. It is interesting to note that the actual rolling of this huge ring or tube of metal occupied only about twenty-six minutes. The steam drums for the Yarrow boilers are 11 feet 6 inches long by 4 feet 2 inches internal diameter throughout. When rolled to the correct internal diameter the drum is 1 9/16 inches thick, this thickness being necessary in way of the tube holes. Measured over its circumference, however, the drum is planed down to the requisite thickness to withstand the steam pressure carried.

The advantages of these solid, seamless drums are apparent, for besides saving work in the construction and obviating the risk of imperfect riveting, they are much lighter for the same strength—a matter of great importance in small high-speed vessels, where every pound of weight must be considered most carefully. Of course, the cost of producing such work is at present high, but now that the possibilities of the method have been demonstrated sucessfully it is perhaps not too soon to predict that solid rolled boiler shells of considerable size will be brought within practical limits of cost in the near future.

An Uncommon Defect in Steam Boilers.

Our attention has recently been called to a defect discovered in a return-tubular boiler by the inspector of one of the prominent boiler insurance companies. The defect is by no means uncommon, but it is one which could easily be overlooked if the most rigid inspection were not maintained.

In the case to which we refer the boiler was supported by three lugs on each side, and slight indications of an incipient crack were found just above the center lug on the left-hand side of the shell. Upon striking the shell with his hammer at this point the inspector found a well defined crack about 8 inches long, extending all the way through the plate. The crack was undoubtedly caused by an overload on the center lug, as it was observed that this lug was carrying all of the load, which should have been distributed equally among all three lugs on that side of the boiler. This case should serve as a warning that too many points of support may be a menace instead of a safeguard. It is practically impossible on account of the distortion of the boiler and the setting to make all supports bear equally; even if the boiler is correctly placed when installed the conditions to which we have referred can easily develop after a certain length of service. This case seems to point to the advisability of supporting a boiler at not more than two points on either side, placing as many lugs at each point as may be necessary to support the load.

points *b'*, *c'*, etc. These points mark the position of the spaces on the plate after it is straightened out. Next draw lines in the front elevation from the points *a*, *b*, *c*, etc., parallel to the line *A-F*. Extend these parallel lines an indefinite distance and project across from the side elevation the points *b'*, *c'*, *d'*, etc. The intersection of the vertical and horizontal lines at the points *b'*, *c'*, *d'*, etc., in the front elevation will be points on the development of the edge of the plate, and by drawing the

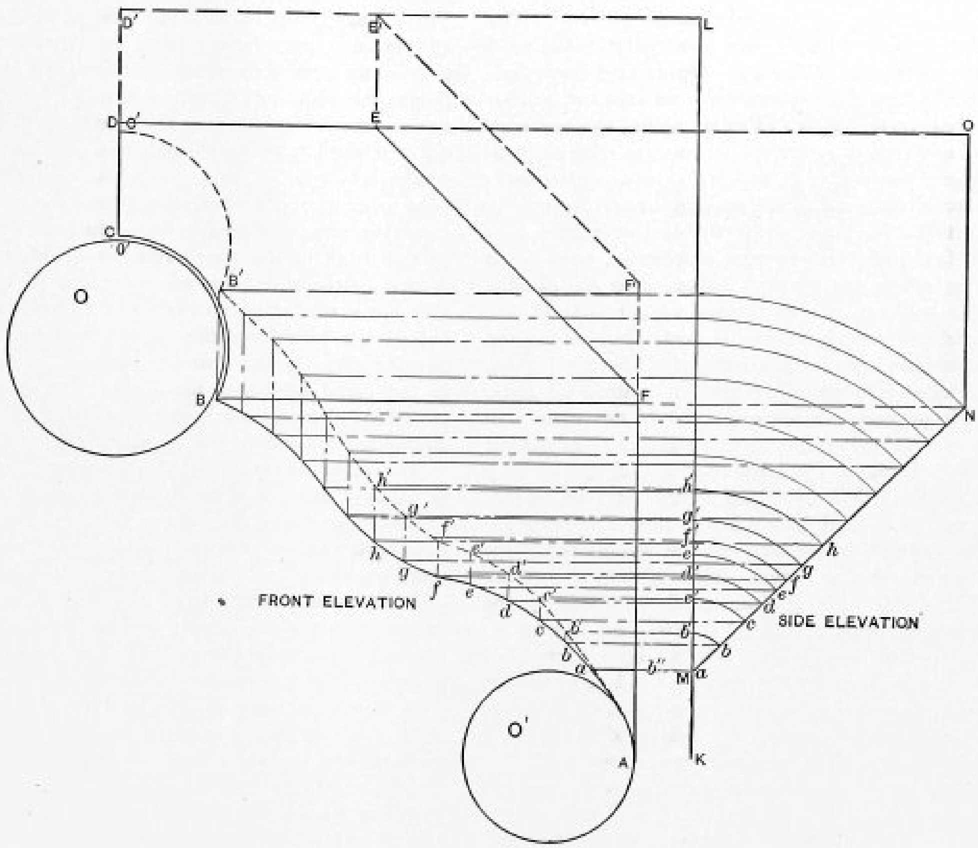


DIAGRAM SHOWING LAYOUT OF AN IRREGULAR PLATE FOR AN UPTAKE.

LAYOUT OF AN IRREGULAR PLATE FOR AN UPTAKE.

BY FRANK T. SAXE.

Some time ago I had to solve the problem shown in the sketch. The large circle *O* represents a steam drum and the small circle *O'* a mud drum. The irregular curve *AB* is the shape of the tubes that connect both drums. The plate *A-B-C-D-E-F-A* is a front elevation of the up-take; *K-M-N-O* is an end view, showing the manner in which the plate was bent along the lines *B-F* and *a-b"*. From this it is evident that the front elevation is a foreshortened view, and since *AB* is an irregular curve care must be used in developing the pattern. The following is the method which I used and which will be found very useful on many other problems of a similar nature:

First divide the line *B-A* into any number of equal or unequal parts, as shown by the points *a*, *b*, *c*, etc. Now, having drawn the line *K-M-N-O*, showing the offset in its true relation to the elevation, the various points *a*, *b*, *c*, etc., can be projected to the line *M-N*, intersecting *M-N* at the points *a*, *b*, *c*, etc., in the side elevation.

Now draw an imaginary line, as *K-L*, assuming this to represent the plate after it is flattened out. Then with the compasses set from *a* to *b*, *c*, etc., in the side elevation, and using *a* as a center, draw the arcs *b-b'*, *c-c'*, cutting the line *K-L* at

smooth curve *A-B'* (shown dotted) we have located the development of the line *A-B*. It is now evident that the point *B* has been projected to the point *B'*, and that the center of the circle *O* must be moved up the same height, and also the points *C*, *D* and *E* must be projected a corresponding distance. These points will, therefore, be located at *o'*, *C'*, *D'* and *E'*. With the dividers set from *D* to *E*, locate the point *E'* on the line *D'-E'*. The bend line will now be at *B'-F'*. We have, therefore, located the dotted figure *A-B'-C'-D'-E'-F'-A*, which is the complete pattern for this plate.

Steam Boilers in Switzerland.

The Schweizerische Verein von Dampfkesselbesitzern tested during the year 1909 altogether 5,121 boilers, of which 4,577 were provided with internal furnaces. The average age of the boilers was 16.6 years, and 73 percent of them were built in Switzerland. As regards the heating surface, the 4,939 land boilers had an average heating surface of 418 square feet, and the 182 marine boilers of 772 square feet. The tests were conducted under the superintendence of Mr. J. A. Strupler. They involved 247 fuel tests at the Zurich Polytecnikum. Of the boilers, 122 belonged to the government, and 222 were put out of use or disqualified at the end of the year 1909 for various reasons, among these being displacement by electric power.

EFFECT OF FORCED DRAFT ON BOILER CAPACITY AND ECONOMY.

A discussion of the influence of forced draft on boiler capacity and economy, written by Mr. C. E. Roehl, forms part of a committee report presented to the American Street and Interurban Railway Engineering Association on October 11. By forced draft the author indicated that caused by an increase of pressure below the fire, in distinction to induced draft due to a reduction of pressure above the fire. The author was of the opinion that where low-grade fuel is used forced draft is a necessity. Where low-grade fuel means anthracite screenings forced draft possesses an inherent advantage over induced draft. This lies in its ability to cope with one of the trying features attendant on the use of anthracite screenings, namely, the quality of packing on the grate, whereby great resistance is offered to the passage of air through it. In induced draft this lowering of the fuel-bed resistance does not occur. A fuel bed of anthracite screenings, even when actively burning, offers far greater resistance to the passage of air than the walls of air ducts and ash-pit connections. As air ducts and connections of forced-draft systems are not designed to efficiently convert the energy of the air leaving the fan or impeller into potential form measured by static pressure, the air pressure valves measured in ducts and ash pits refer to rapidly moving air—air moving far more rapidly than can be used without dissipation of energy by eddying currents and jets beneath the fuel bed. Each particle of coal is struck and moved around in the layers near the grate before the air moves sufficiently through the bed to reach the incandescent particles for oxidation. This shifting of position of individual particles of coal does much to break up the otherwise abnormally high resistance of the fuel bed to air flow. The shifting of fuel bed may be slight, moderate or excessive, depending upon the air pressure. When excessive, the coal is blown from the grate and a good part of it is kept dancing in the furnace, sometimes to a height of 2 feet.

Capacity is fundamentally a matter of rate of firing. Firing rates vary widely, whereas efficiencies with a given grade of fuel do not; therefore, it follows that it is only necessary to get coal into a furnace and burn it to cause the rate of steaming to vary very nearly in proportion to the rate of firing. This practical response of the rate of steaming to the rate of firing follows logically from the modern recognition that with boiler equipment actually in service at the present day the limitation of the heat-transmitting ability of the metal of the heating surface is not approached. It also follows by analogy from the enormously higher evaporating rates used in locomotive practice than in stationary practice.

In large power stations great attention can well be given to studies of the relation of rapid firing by one man in charge of moderate grate area as against moderately slow firing of a large grate area represented in practice by having one man fire relatively many doors.

With low-grade fuel, forced draft practically always secures increased efficiency, so far as heating surface alone is concerned. At very high combustion rates the furnace efficiency is apt to fall sufficiently to offset the rising boiler efficiency. This, however, under proper conditions of control, occurs only near the upper limit of the usual attempts at forcing, and when forcing is necessary efficiency is not a ruling factor.

Higher steaming capacity usually reduces labor charges and inevitably reduces investment charges. It reduces the labor charges because, as a rule, more coal per man is being fired and more steam per pound of coal is being obtained. Investment charges are reduced because greater power is obtained per boiler. Maintenance charges increase, but the increase is practically confined to the furnace and, except in very special cases, while an offsetting factor, it is not a ruling one.

One of the most seriously limiting factors in what otherwise appears a field where the higher the pressure the higher the over-all station efficiency is the blowing of coal from the grate after a critical pressure has been exceeded. Very fine coal is not only blown from the grate, which would be no serious matter if it came down again, but it is blown over the bridge wall, and in some cases is blown through the heating passes and into the flues in considerable quantities. Once in the flues, a good deal is apt to go out at the top of the stack. The economic loss is not often serious, but in cities the trouble and expense may be considerable. Another limiting condition in increasing capacities obtained by increasing combustion is the inability of the lower water tubes to stand the too severe demands which may be made upon them. When forced draft is used with very small-size coal and a high average combustion rate is being maintained it is practically impossible to avoid spots where for a time the combustion rate becomes extremely high and the endurance of isolated sections of the tubes in the lower rows is severely tested. The approach to the safe limit of endurance of the metal is probably not a matter of its limit of thermal transmitting ability, but of the failure of the water-circulating arrangements to provide properly for heat absorption. It is not unlikely that in the trend of boiler modification to meet the surely approaching demand for higher steaming rates this matter of circulation will receive large attention.

Moderate increase of evaporating rate, 100 or 150 percent, or perhaps more, over the present nominal rate of 3.45 pounds of water per hour per square foot, referred to a 650-horsepower Babcock & Wilcox boiler, from and at 212 degrees Fahrenheit, must be brought about. Installation of very large capacity turbines has forced this and in isolated instances a good deal has already been accomplished. There seems little reason to doubt that the best which has at present been accomplished will in a few years become standard practice.

In electric railway power-plant work forced draft must be adapted to varying steaming rates. The maintenance of steam pressure but slightly below the setting of the safety valve is the desideratum, Mr. Roehl said, and as the fluctuations in steaming demands are large in relation to the steam storage capacity of water-tube boilers, the adaptation of the forced-draft system to varying rates must be accurate and prompt. Steaming rates are varied, of course, only by variation of the combustion rates. Efficiency, therefore, demands that the forced-draft system be adapted to permit variation of the combustion rate over wide ranges, and this requires variation of the air pressure. While variation of air pressure will cause variation in the rate of combustion of coal already in the furnaces, it will not do more. Therefore, the problem is, where hand labor is concerned (and automatic stokers are not commonly used with high air pressures), to cause the firemen to vary their rate of firing to meet the varying rate of combustion necessary for the coal already in the furnaces. This, then, is the crucial problem in the attainment of high efficiency to cause the firemen in forced-draft plants in some manner not only to vary their rate of firing with the draft (using the term in a broad sense), but to make their manner of varying it approach as near as possible to the correct manner. This problem is yet to be solved in a really practical way.

In work of large magnitude the ruling conditions in the use of forced draft with the attainment of good firing are most onerous, yet the quality of the labor is most unfavorable; not that the labor is cheap labor, but it is looked on en masse and necessarily so, resulting very often in almost entire loss of individuality in the relation of the man to the boiler. The labor, while reasonably well paid, is largely foreign and not infrequently low in intelligence, thereby excluding the skill which in isolated plant work is sometimes of sufficient merit to make firing approach the level of a skilled trade. In addition to the other handicaps, rapid changes in personnel are not rare.

A few years ago great interest was aroused by the development of automatic CO^2 recorders, but the hopes that they aroused as to a solution of the problem of guidance in the attainment of high efficiency have not been realized, Mr. Roehl said. More light is at present available on the cause of the disappointment than was available after the CO^2 recorders had been in sufficiently extensive use to make the disappointment evident. This light is, of course, that concerning the relation between gas velocities and thermal transmitting ability of the heating surface.

The same strictures may be made against the somewhat extensively exploited balanced draft systems. Unquestionably they at once gave very high CO^2 values. The claims of their sponsors in this respect were not exaggerated. Necessarily used only in conjunction with forced-draft systems, they involved the danger of flare-backs from the furnace doors, and aside from this they raised the furnace temperature so high that the tax on men required to stand up in front of the furnace doors and throw in coal was severe.

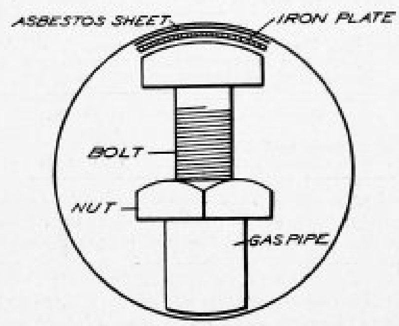
It has been recognized that high CO^2 values, which are very readily obtained with forced-draft systems, may easily become too high. In addition to the objections just mentioned, high CO^2 is an excellent direct measure of furnace temperature. Furnace temperatures so high as to be destructive to the furnace brickwork were all too easily obtained. Before the research work of the United States Geological Survey and others had made it evident why highest CO^2 values did not correspond with highest efficiencies the best practice had settled down to ruling against more than 12 to 13 percent CO^2.

The problem of handling forced-draft systems in electric railway power plant service comes back then to that of getting firemen to fire well at the varying rates which are demanded by the varying load. The general tendency of poor firemen under all conditions is to throw so much coal in one door without stopping that a long interval elapses before the firing operation is repeated. A general corrective expedient for this, and one which, while very simple, is decidedly practicable, is the limitation of the number of shovelfuls permitted to be fired in any one door without stopping. This number may be six or eight, preferably six, and while no limitation to the rate of firing, this at once goes a long way toward establishing the practice of light, thin fires as against heavy, thick ones, whether during the rush hours with high steaming rates or at other times. Equally important, if not more important than thin fires, is the correct adaptation of the firing rate to the draft or, in more specific terms, the ash pit or air-duct pressure. With 1 inch air pressure in the duct, should the rate of firing with a given grade of coal and boiler equipment be 16 pounds or 20 pounds per square foot of grate surface, or some other rate? On the answer to this the resulting economy of the evaporation apparently hinges. Extensive experimental work appears to show that there is a definite relation between air pressure and rate of firing, which gives the best evaporative economy over wide ranges of steaming. Differential gages reading to 0.01 inch water column have been tried and are accurate and reliable, but the difficulty is to devise a simple system for their use.

The problems which in their solution will probably mark the most significant advance in forced-draft practice appear to be the better proportioning of air ducts and sealed ash pits, particularly the intakes of the latter from the former, as now large losses of pressure are frequent; the modification of furnaces and boilers to allow the use of higher pressures and gas velocities which are necessary for the utilization of more intense evaporative rates; and the development of simpler means for the control of efficiency, which leaves at present more to be done in the way of control of firing than in control of the air pressure or draft. It is hard to say whether the second of these problems, that of control of capacity, or the third, that of control of efficiency, is the more important.

Repair for Fire Tube Boiler.

The sketch shown here illustrates how a leak in a 6-inch fire tube was repaired while the boiler was in use, it being near the end of the tube in the front head. Any amount of pressure could be put on the sheet packing by running the nut down on the bolt, in effect making a jack with the bolt and gas pipe. The job remained tight almost a year, when the boiler was replaced by a new one of the watertube type.—*The Practical Engineer.*



REPAIRS TO A LEAKY FIRE TUBE.

Recent Boiler Explosions.

A horizontal tubular boiler which had been in service twenty-two years exploded on Dec. 12 at the silk mill of the Reed & Lovatt Manufacturing Company, Wetherby, Pa., instantly killing two men and wrecking the boiler house. The boiler was 16 feet long and 66 inches in diameter; the plates were of steel, 3/8 inch thick and the heads 9/16 inch thick. A 36-inch steam dome was fitted to the boiler, and there were five boilers in the battery. The explosion was due to an old crack that extended from one-half to two-thirds through the plate in line with the second longitudinal row of rivets in the rear sheet. This crack was of the usual type that appears in lap-seam boilers after many years' service. The usual steam pressure carried was between 85 and 90 pounds.

Another 16-foot return tubular boiler exploded on Dec. 9 at the planing mill of Arthur S. Allen & Company, New Bedford, Mass., wrecking the building and seriously injuring the proprietor and six workmen. This boiler was also of lap-seam construction and was installed in 1885. The shell plates were 5/16 inch thick, and the working steam pressure 75 pounds per square inch. This explosion is also said to be due to a lap-seam crack.

One of the most disastrous boiler explosions of the year occurred at Pittsfield, Mass., Dec. 29, when the boiler at the Morewood Lake Ice Company exploded, killing fifteen men and injuring more than twenty. The boiler was of the locomotive type and was used only a short time each year during the ice harvesting season, during the remaining months of the year it was idle. The explosion occurred shortly after starting up the boiler, it having been idle since last winter. It is stated that the boiler was properly inspected a short time ago by the State inspectors, and that a new safety valve had just been fitted. Further details of this explosion will be published later, as a rigid investigation is now being conducted regarding its causes.

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

NOTICE TO ADVERTISERS.

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

Flue Failures.

The discussion of Mr. J. W. Kelly's paper on "Flue Failures," which was read at a recent meeting of the Western Railway Club at St. Louis, and which was published in our December issue, showed that flue failures on locomotives are more perplexing to-day than ever before. This is due largely to conditions of service on the road and the pooling of engines. Present-day demands on motive power are so great that the size and power of locomotives have steadily increased, multiplying what in smaller boilers were minor evils into great ones. Further than this, the modern practice of pooling engines places the locomotive in the hands of a number of different operators, and it is seldom that a man has the opportunity to become as thoroughly acquainted with his engine as he did in the old days, when it could usually be said that the engineer "owned" his engine.

No one branch of railroad management can be held responsible for flue failures. The designer of the boiler, the one who is responsible for its maintenance, and the operating engineer all have something to do with it. It seemed to be the general opinion at the meeting to which we have referred that locomotive builders generally follow out a mistaken policy of crowding into a boiler as large a tube-heating surface as possible at the expense of trouble with flues and flue sheets, whereas better results could be secured by leaving out 40 or 50 or even 60 tubes, increasing the size of bridge to 13/16 inch, and leaving at least 2½ inches between the tubes and the flange of the tube sheet. Mr. Kelly's method of taking out flues in a V-shaped space near the bottom of the box where trouble was always experienced with leaky flues was generally approved. Great emphasis was laid upon the importance of the proper care of the engine while on the clinker pit. The men should be educated to realize the bad effects of sudden wide variations in temperature in the boiler which can be occasioned by the improper handling of the engine while on the clinker pit.

There has been some complaint recently regarding the quality of the material of which boiler flues are made. At the last boiler manufacturers' convention, Mr. Charles S. Blake, secretary of the Hartford Steam Boiler Inspection & Insurance Company, stated that the manufacturers of tubes did not seem to keep up with the progress made in the manufacture of other materials entering into boiler construction. Tubes which are used for 150 to 175 pounds pressure to-day, are no thicker and of no better quality than tubes which were formerly used for pressures of from 80 to 100 pounds, consequently tube failures are woefully common. The quality of the tubes may perhaps account for some of the tube failures in locomotive boilers, yet boiler tube manufacturers are perfectly able and willing to furnish the very best quality of tubes, provided the railroads will pay for them, but under the conditions of service which have prevailed during recent years the question of price seems to have been all-important, and tube manufacturers have had to govern themselves accordingly. It would seem to be poor economy, however, for the railroads to buy a poor grade of tubes simply on account of the initial cost, since it is known at the outset that any failures due to the quality of the flue will cause losses far out of proportion to the extra expense involved in buying the best material. Undoubtedly the majority of flue failures to which Mr. Blake alluded has been in water-tube boilers, where the tubes are subject to internal pressure and the danger of overheating, due to deposits of scale and sediment.

In connection with Mr. Kelly's paper on "Flue Failures" we would remind our readers of the recommendations made by Mr. McBain before the New York Railroad Club last May. His recommendations included a method of setting flexible stay-bolts so that a certain amount of expansion was permitted in certain parts of the fire-box, and also the depressing of the tubes at the center, so that they sagged about 1 inch below the normal. These expedients resulted in an exceptionally tight set of flues.

Old Friend Column.

We invite the attention of our readers to the "Old Friend" column which appears in our magazine for the first time this month. Our representatives, who are continually visiting boiler shops throughout the country, receive frequent inquiries regarding boiler makers whose addresses are unknown. Sometimes they are able to give the desired information, but more frequently, on account of changes of location, it is impossible to give a man's latest address. We will, therefore, be glad to have any of our readers who desire such information send us an inquiry, so that we may publish it in our "Old Friend" column, and thus bring it to the attention of the person whose address is desired. No charge will be made for this service, and we hope that this column will prove a benefit to all those who desire to renew old acquaintances either for personal or business reasons.

OLD FRIEND COLUMN.

Inquiries from readers who desire to communicate with a friend whose address is unknown to them will be published in this column free of charge.

JAMES MCQUESTION, foreman boiler maker of the John Baizley Iron Works, Philadelphia, Pa., would like to get in touch with Leon Byram, formerly foreman boiler maker with Theo. Smith & Sons, Jersey City, N. J.

L. C. ZIMMERMAN, superintendent of the Thompson Iron Works, Philadelphia, Pa., would like to communicate with Ed. Starner, whose last-known address was Titusville, Pa.

PERSONAL.

R. R. STURGEON, formerly with the Philadelphia Iron Works, Philadelphia, Pa., has accepted the position of layerout with the Quaker City Iron Works, Philadelphia, Pa.

GEORGE L. BOURNE, who has been connected with the Railway Materials Company, of Chicago, for many years, has resigned to become president of the American Superheater Company, Chicago. This company will make a specialty of superheaters for use on locomotives.

FRANK BRADSHAW, formerly general foreman boiler maker, was promoted Dec. 1 to the position of acting master mechanic at the Tallers F. C. N. de M. Santiago, City of Mexico, vice Mr. Charles Manley, promoted to superintendent of shops, with headquarters at Aguascalientes.

WILLIAM A. KNAPP, treasurer of Satter Bros., Inc., boiler manufacturers, Pottstown, Pa., on Jan. 1 severed his connections with that corporation and retired from the business after a continuous service of almost thirty-two years. Besides the treasurership, the estimating and drafting branch of the work has been very ably and very successfully handled by Mr. Knapp for many years. Mr. Knapp means to enjoy a much needed rest and his plans for the future are undecided.

WE REGRET exceedingly to learn that Mr. John Morgan, head of the boiler department of Baldwin's Locomotive Works, Philadelphia, Pa., recently had the misfortune to fall from the turntable at Twenty-sixth street and break the small bones in both legs. We understand that Mr. Morgan is making a good recovery, but will be obliged to use crutches for some time to come. He now spends from six to seven hours a day in his office at the works. We are sure that his many friends will join us in wishing him speedy recovery.

OBITUARY.

HON. GEORGE F. SEWARD, president of the Fidelity & Casualty Company of New York, died Monday, Nov. 28.

WILLIAM H. BRYAN, announcement of whose appointment as chief engineer of the Chicago Board of Education was made in our December issue, died suddenly before he had hardly assumed the responsibilities of his new position.

WALTER L. PIERCE, who for thirty-two years has been connected with the Lidgerwood Manufacturing Company, and for twenty-nine years its secretary and general manager, died suddenly of heart failure at his winter home in the Hotel St. Andrews, New York City, Dec. 10, 1910. He was known to a wide circle of personal and business associates. He was remarkable as an organizer, and so perfect was his work that no detail of the great business which grew up under his hand was neglected during his long absences from his desk while seeking health. The coherent body which he formed is a monument to the efficiency of his work. Besides his connection with the Lidgerwood Manufacturing Company he was treasurer of the Hayward Company and of the Gorton-Lidgerwood Company.

COMMUNICATIONS.

Comment on a Recent Boiler Explosion.

EDITOR THE BOILER MAKER:

The inclosed newspaper clipping was brought to my attention recently and aroused my interest, since only last spring I visited this plant and tried to sell the proprietor a new boiler. The clipping is as follows:

"FOUR BURNED IN BOILER BLOW UP."

"December 9.—Four men, including the proprietor and three employees, were burned in a boiler explosion which occurred in a planing mill shortly before noon to-day. The accident set fire to the building, the roof and sides were blown out and the building is a wreck."

At the time of my visit the proprietor told me that this boiler had been in constant use for something like twenty-five years. It was, I believe, an iron boiler of lap-seam construction, about 42 inches in diameter.

I told him at that time that he should feel that he had had his money's worth out of the old boiler, and should consider buying a larger one of sufficient size to care for his plant without forcing beyond its maximum pressure, as I felt that his old boiler was. He replied that he was going to get another year's service out of the old boiler and then take up the matter of buying a new one. Consequently, the report which I sent in to my firm was that this man would need a new boiler within a year.

The foregoing instance happened in Massachusetts, where firemen are supposed to pass a very rigid examination.

I have also a case in mind where two 72-inch boilers were installed in a public building this fall, and after they had been in operation two weeks word was received that the boilers were leaking badly. Accordingly a boiler maker was sent to ascertain the cause of the leakage. He found that both boilers were bagged near the girth seam, and had drawn down and elongated the holes so that they were oval shape and the water was coming out in a stream. This was all due to the fact that the man in charge allowed oil to get into his boiler.

I want to say right now that a boiler is not "fool" proof, and there will always be explosions as long as such men are in charge. It seems to me that if the Board of Boiler Rules would get after the men in charge of steam boilers (and not look into such absurd things as having 1-inch clearance around the hand-holes) and put a factor of safety on some of the firemen, there would be greater progress made in eliminating the danger of boiler explosions. F. T. S.

Boston, Mass.

The Hydrostatic Test.

EDITOR THE BOILER MAKER:

While looking over THE BOILER MAKER for November, 1910, I found on page 324 a statement by Mr. James T. Foord, chief inspector of the Hartford Steam Boiler & Insurance Company, to the effect that with materials from 3/8 inch to 3/4 inch thickness a hydrostatic test of 150 percent working pressure is excessive, because it comes so near—in fact, almost meets—the elastic limit of the material. My limited knowledge as to the elastic limit and tensile strength of boiler plates only admits the fact that the elastic limit should not be less than one-half the tensile strength, which is generally understood as the ultimate strength for tension, while the lowest factor of safety allowed on a boiler is 4, and that only when the boiler is built under the most thorough specifications and strictest supervision. Now, then, while the ratio of the bursting pressure to the working pressure of the boiler stands as 4 to 1, and the ratio of the tensile strength to the elastic limit of the material as 2 to 1, I do not see how the elastic limit and the 150 percent hydrostatic test can meet, as their relation being as 2 is to 1½. If the working pressure of the boiler is 200 pounds per square inch the 150 percent hydrostatic test would call for a pressure of 300 pounds per square inch. The lowest assumed bursting pressure will be 800 pounds, and, consequently, the elastic limit will not be reached until there is at least 400 pounds pressure on the boiler. So there is a good hundred pounds margin on the safe side.

On a low-presure boiler carrying 50 pounds, the bursting pressure would be 200 pounds and the pressure corresponding to the elastic limit of the material 100 pounds, while the hydrostatic pressure would be only 75 pounds, thus leaving a margin of 25 pounds on the safe side. No strain can develop in the plate unless the elastic limit is reached, and if for any reason the elastic limit is lowered, due to the crystalization of the plate, corrosion or any other form of weakness, then it would be a very good thing to have it shown up by the hydrostatic test.

Most boiler inspectors depend upon hydrostatic pressure for showing up weakness, as there is no way of getting inside the boiler. Are not enough lives lost and limbs maimed in this country without lessening even the only safeguard that stands between accident and safety? If an excessive stress is feared with a 150 percent hydrostatic test then increase the minimum factor of safety from 4 to 5, and be free from all doubts. The British Board of Trade, British Lloyds and Bureau Veritas, also the German boiler laws, demand a hydrostatic test of 200 percent of the working pressure, and these requirements are all recognized as good practice. X. Y. Z.

Braces.

EDITOR THE BOILER MAKER:

As a party signing himself as "Brace Crank" has raised a question in regard to the rivets in the palm of a brace, and has asked expressions from practical boiler makers, and as I am such, I take the liberty and pleasure of citing to "Brace Crank" some facts which have come under my observation.

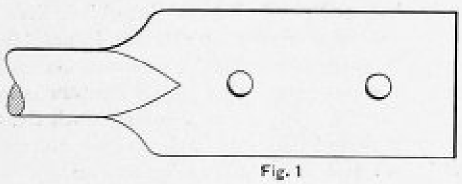


Fig. 1

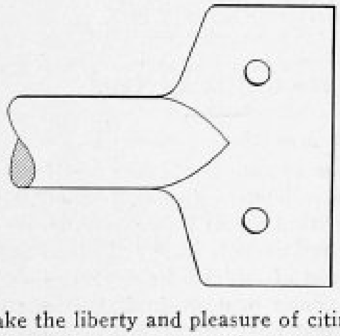


Fig. 2

If the palm of the brace is properly proportioned and its strength considerable beyond the shearing strength of the rivets —and this I recommend—the placing of one rivet back of the other, as shown in Fig. 1, is as good a practice as the arrangement as shown in Fig. 2, or any other arrangement.

This is not a mere opinion arrived at off-hand, for I made a series of tests under conditions as near as possible as would exist within the boiler when subjected to steam pressure.

I have noticed that braces inclined at over 20 degrees break frequently through the net section of plate at the first rivet. Other braces are set aslant—perhaps 20 degrees in one direction and about the same in another—and such braces I have found are liable to break in the manner as described by "Brace Crank." H. S. JEFFERY.

Washington, D. C.

Another Word from Old Mexico.

EDITOR THE BOILER MAKER:

In the November issue of THE BOILER MAKER I described my method for putting in flues in order to get good results in a certain bad-water district. I will now explain how I try to prevent the top flange of the flue sheet from fracturing on these same boilers and what kind of a patch I put on in order to avoid trouble when they have fractured.

When these locomotives first came here for service I examined them carefully to find out what kind of brace, if any, the crown sheet had, and also the flue sheet. I found one tee-iron with palm raised on thimbles 3 inches high with four sets of stays ⅝ inch by 2½ inches, bolted rigid. I left four boilers as they were but on four others I made the following changes: I made sling stays ¾ inch by 2½ inches, with oblong holes at the bottom, giving room for 3/16 inch upward movement. I then took down the tee-iron and took out the thimbles and bolts. The bolts were button-head, and put in in the same manner as old-time crown bolts. I then put in a set of taper bolts, threaded 2 inches, ten for each row; that is, the tee-iron took in two rows of holes. Then I placed my tee-iron on top of a few thimbles, tightened up the nuts and hammered up the bolts at the bottom. I then put on the sling stays and knocked out all the thimbles, leaving the sling stays to hold up the tee-iron.

In the first four boilers that were left rigid the flue holes at the top flanges fractured after about one and one-half years of service. The other four boilers with the improved method of staying, which I have described, have been in service nearly three years, and have showed no fractures to date. The life of these fire-boxes is about four years and six months. They finally fail on account of fractured side sheets and excessive working.

The designer of these flue sheets put the holes along the top flange and down both sides, leaving a space of 3 inches from the edge of the flue holes to the flange. The flange was also given a nice, easy radius with no sharp flange, which I believe is a very good thing, since it allows the flange to double up considerably before showing fractures. The bridges are all spaced 13/16 inch, which I think is good practice, although I should prefer more blank holes for saving the flue sheet. The front heads are ¾ inch thick, and they are good to keep the head from getting out of shape.

When the top flange of the flue sheet fractures from the flue holes I put on the smallest patch possible from the water side, with 13/16-inch patch bolts, spaced 1¾ inches, and rivet the flange at the flue sheet. First I cut out just enough rivets in order to slip in a feather-edge patch by raising up the crown sheet. The patch goes in just far enough to make a full rivet hole. I mark off the rivet holes, get them punched or drilled and then fit up the patch hot. Before fitting the patch I plug the flue hole from the fire side, calking it from both sides with the water side flush and smooth. I drill the holes, spaced 1¾ inches, and then mark all holes and then I am ready to put in the patch bolts. Before putting in the patch bolts, however, I plug the fracture with ½ or ⅝-inch copper plugs from the fire-side and calk from both sides. I then put in my patch bolts and calk from both sides. I have a ⅞-inch lap for the calking edge.

I prefer a small patch, as I do not want too much double thickness around the knuckle. I have put these patches on the fire-side with rivets, plugs and patch bolts with no success, and have put them on from the water-side with plugs and rivets and plugged the fracture with iron plugs and had no success. Iron plugs are too stiff and become loose too easily. In fact, I now plug every fracture with copper. I have plugged fractures from the water-side, putting in plugs in the flue holes from the water-side ,and somehow could not keep them on after the flue sheet began to expand; but when plugging from the fire-side I had no trouble whatever. When renewing flues I just touch up the patch a little, and it is good for another set.

All new locomotives that have come here have had some kind of a dump grate next the flue sheet, with angle-irons 4 inches by 4 inches next the flue sheet and back sheets. The sides of the pan were practically closed up. (Perhaps someone was afraid the flues might catch cold.) I still refer to the wide fire-box class of boiler. These engines would not steam and we got no service from the flues. When the first one was ready to have the flues renewed, I asked the master mechanic to let me try and see what I could do to get better service and more steam out of these boilers. He said, "Go ahead and do something." I threw the dump grates away, took out the side bars and center grate rest bars, and had slots put in for live grates. I then took the angle-irons off and cut them down to 1 inch, and replaced them and connected up the grates. I cut out all the netting in the sides of the ashpan along the mud-ring on both sides, and put in an incline 3 inches wide in place of the nettings. I threw away the old dampers and made new ones with plenty of ½-inch holes punched in them. I also cut out a section of the pan for the rear drivers and so made two ashpans. I then fixed up slides to fit both pans, to be opened with one lever. I then got a pipe fitter to put in a sprinkler the entire length of the pan, so as to keep the fire dead and save the sides of the pan from burning up.

At the same time the petticoat pipes were burned up in about three weeks, and I asked permission to change these. The old pipes were 12 inches diameter with an 18-inch base. I made new ones, 13½ inches diameter with a 26-inch base. The master mechanic was very doubtful about the ability of the boiler to steam, but it gave entire satisfaction. The engine burned less coal, steamed freely and had less leaks than before. I then received orders to change all of the locomotives as soon as possible. These engines will now apparently burn any old thing and steam finely.

D. L. AKERS.

A Question of Efficiency.

EDITOR THE BOILER MAKER:

In your November issue there was published an account of a boiler in the longitudinal seam of which an extra rivet had been inserted to hold the back end of the palm of a stay. In this article it was stated that the inspector for the district in which the boiler was built had taken exception to the extra rivet hole, and ruled that the efficiency of the joint had been reduced from 84 to 68.75 percent. Further, in your issue for December, a number of correspondents agreed with the inspector, quoting the axiom that a chain is no stronger than its weakest link.

Now I wish to place myself upon record as stating that the joint is not reduced to 68.75 percent efficiency, nor can the joint in any way be likened to a chain. I, of course, assume that not more than, say, two braces were fastened in this way on the longitudinal seam.

It seems to me that the inspector and your correspondents make the mistake of looking upon the piece of plate contained in the 6-inch pitch as the joint instead of only a small part of the whole longitudinal joint.

While I acknowledge that putting the rivet hole midway between the rivet holes in the 6-inch pitch does reduce the efficiency of that particular pitch, yet I maintain that the efficiency of the whole joint is reduced barely 2 percent. Look, for instance, at Fig. 1, where a piece of tin is shown. It is 40 inches long, and in it are four 1-inch holes pitched 10 inches between centers. Suppose that this plate is capable of sustaining, before any holes are punched, a total load, equally distributed of 100 pounds hanging from its lower edge; the efficiency of the plate is, of course, 100 percent. After the four holes have been punched the efficiency of the plate has been reduced to 90 percent; so that the plate is now capable of sustaining only 90 pounds total load. Now to come to the point which I wish to make. If I punch another 1-inch hole midway between the two inner ones (see Fig. 2) the inspector would say that the efficiency of the plate was only 80 percent, as there are two 1-inch holes to be deducted from the 10-inch pitch. To continue the inspector's argument it would follow that if I cut a slot from one hole to the other, that is, if I

FIG. No. I
90% EFFIC'Y

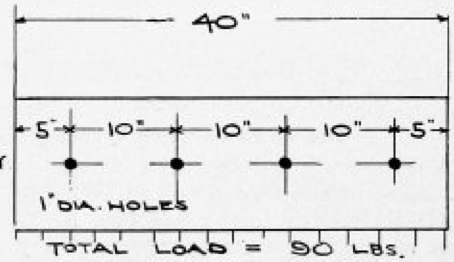


FIG. No. 2
87·5%
TOTAL EFFIC'Y

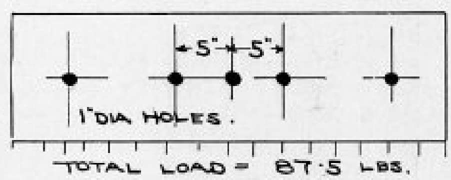
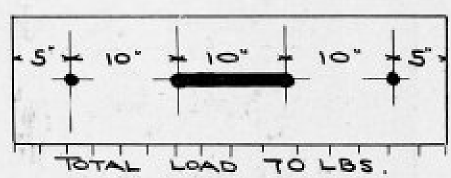


FIG. No. 3
70%
TOTAL. EFFIC'Y



made a slot 10 inches long (see Fig. 3), I would have taken out all the metal in that pitch, and therefore the efficiency of the plate, or joint, as we call it, would be zero. The plate, then, according to his ruling, could not carry any load at all. In other words, it would fall apart. It is not necessary to tell those who have followed me thus far that this is not so, for the plate would still be capable of holding a considerable portion of its former load. What we have really done is to diminish the total length of plate; that is, the length of 40 inches has been reduced by two 1-inch diameter holes and one slot 10 inches long; or, altogether, we have reduced the length 12 inches. By thus taking away 12 inches from 40 inches we have reduced the efficiency of the plate, or chain, to 70 percent, which is a great deal better than zero.

Some one may say that the section where the slot is located would burst apart and thus cause the whole boiler to explode; but I would point out that the plate cannot pull apart at this or any other place unless the plate were to shear in a circumferential direction at the same time, and this, as any one can see, is almost impossible.

While the sketches show simply a tin plate, nevertheless the reasoning applies in the same way to a boiler shell, for the tendency is to pull the whole length of the shell apart.

Of course, if a number of braces were attached, as shown by your correspondent, thus causing an extra hole to be placed on a large number of the sections, the danger from rupture would then be greatly increased, but in the case under discussion I do not think the inspector had any business to cut the efficiency down to 68.75 percent.

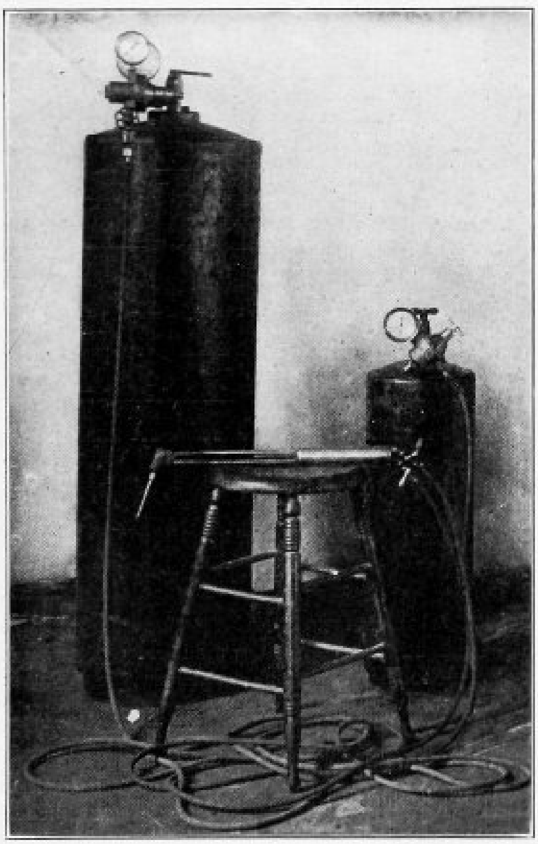
In the December issue, "Brace Crank" takes exception to the two rivets placed one behind the other in the back of the brace. I wondered, after reading his article, if he had ever taken part in a "tug-of-war," and if so why he allowed, say, eight or nine men to pull and hold the rope when, according to "Brace Crank," one man must have done all the work.

Toronto, Ontario, Can. JAMES RUMGAY.

ENGINEERING SPECIALTIES.

The Astra Portable Welding Plant.

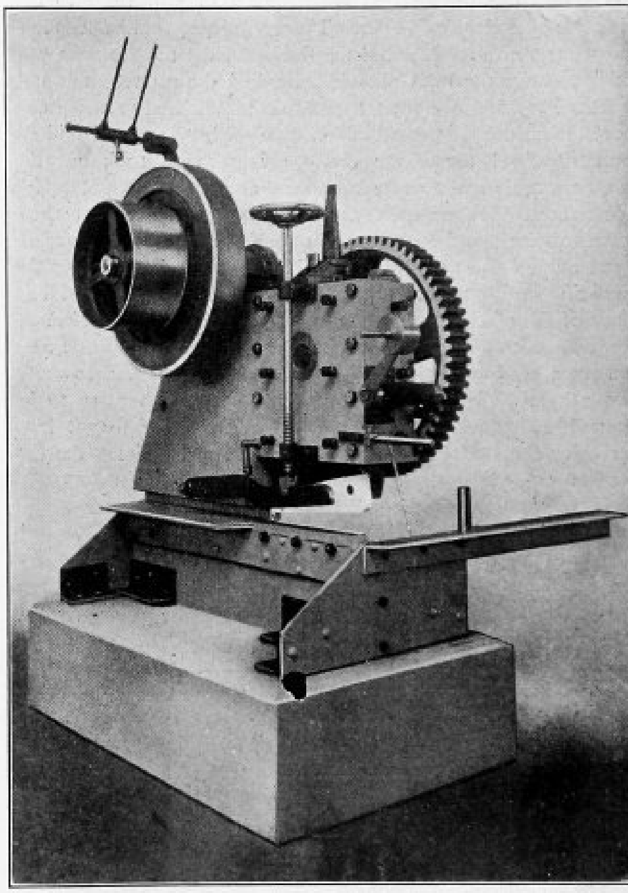
A portable oxy-acetylene welding outfit, which will handle all classes of welding and heating, is manufactured by Alton, Laine & Company, Long Island City, N. Y. The outfit consists of one oxygen storage tank with key and valve; one



acetylene storage tank with key and valve; one oxygen reducing regulator with two gages; one acetylene reducing regulator with two gages; one oxygen safety device; one acetylene safety and purifying device; one welding torch, with ten tips, from No. 1 to 10; 24 feet of high-pressure hose; one pair of "Hallau" chemical ray goggles and two S-wrenches. It is claimed that this apparatus absolutely conforms with the rules and regulations of the National Board of Fire Underwriters for portable welding outfits. Some idea of the capacity of the plant can be gained from the following particulars of repairs which were made to a main bearing of a 4-ton water-jacketed dynamo: This bearing had cracked and was successfully welded with an "Astra" outfit, 45 pounds of cast iron feeding sticks being melted in to fill the crack and complete the weld.

A New Pels Splitting Shear.

Henry Pels & Company, 90 West street, New York, exhibited at the recent Brussels Exposition a splitting shear which has added features of interest, among them being knives of extra length, a patented stripper with a very large bearing surface, and an adjustable gage and guiding pin. These aid materially in reducing the difficulties met with in dealing with



heavy plates of large dimensions, and greatly increase the speed of cutting.

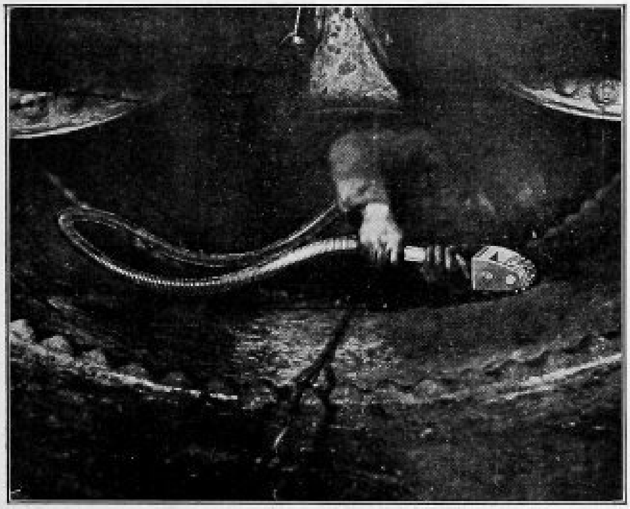
The construction of the product of this concern is well known to the trade. The frame is built of one, very heavy, rolled, open-hearth steel plate, reaching in the largest machines a thickness of 6 inches. The tangent and straight channels are milled out of the frame, and the fact that these channels are smooth and without fillets, it is claimed, makes the passing of the plates through the shear an easy proposition.

The tool is built in eight sizes, the smallest dealing with steel up to 3/8 inch, and the largest taking care of plates 1½ inches in thickness. The illustration shows a machine of medium size, which is capable of cutting plates up to ¾ inch in thickness and of unlimited length and width. The knife is 20 inches long, and it is claimed will shear at a single stroke a ½-inch plate 18 inches wide. The frame is 5¼ inches thick, and is guaranteed to stand up under the severe strains of cutting at the highest capacity continually with ease. Only

6 horsepower is required to drive the machine, and it weighs approximately 6,000 pounds.

Electric Safety Boiler Cleaner.

An electrically-driven tool for removing scale from steam boilers is manufactured by the Electric Safety Boiler Cleaner, Ltd., 6 Lloyds avenue, Fenchurch street, London, E. C. The apparatus is intended to supersede the old method of hand chipping, and it is not only more rapid but is apparently more efficient as regards the complete removal of scale. As can be seen from the illustration, the cleaner consists of several circular cutters about 2½ inches diameter, held in a frame on the same spindle and driven by a shaft which passes through the handle of the apparatus and which receives its motion from a flexible shaft driven by a ½-horsepower



electric motor. The number of cutters can be varied from one to three, according as the tool is to be used in confined narow spaces, or where there is plenty of room. The speed of the cutters may be varied from 1,400 to 4,000 revolutions per minute, but the usual speed is 3,000 revolutions per minute. The handle of the device may be shortened or lengthened as desired to suit the position of the different parts to be scaled, and no particular skill is required by the operator, as the cutters are merely moved over the parts to be cleaned.

Qualifications for a Locomotive Boiler Inspector in New York City.

One of our readers has inquired whether a railroad company in New York State has any right to appoint an inspector for State tests who has never served any apprenticeship. We are informed by the Public Service Commission that no regulations regarding the requirements of boiler inspectors have been formulated by the Commission. Boiler inspectors employed by railroad companies are examined by the Commission, but this is done in an informal way, as there are no specified requirements. It is believed, however, that all boiler inspectors should have served an apprenticeship, or have had work equivalent to same, although it is found that there are a number of men who have not served an apprenticeship but who have had considerable experience inspecting boilers, and it is held that they are as well equipped as though they had served an apprenticeship at the beginning of their career. The Commission states that the greatest difficulty they have with inspectors is that a number of men who are inspecting boilers are accustomed to inspecting stationary boilers only. When these men attempt to inspect locomotive boilers it is found that they are not competent to test stay-bolts. The testing of stay-bolts, of course, is the most important work of the inspector in connection with locomotive boiler inspection.

ENGINEERING SPECIALTIES.

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

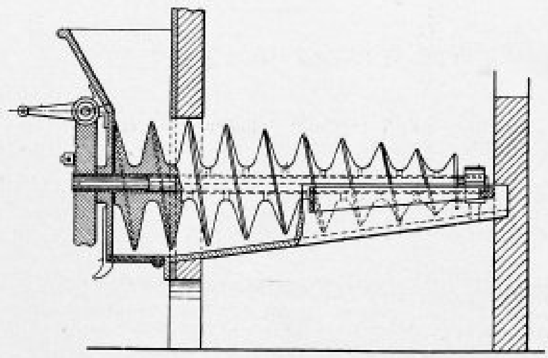
Readers wishing copies of patent papers, or any further information regarding any patent described, should correspond with Mr. Decker.

970,805. FURNACE. JAMES DONALD AND THOMAS F. DOWNEY, OF CHICAGO, ILL.

Claim 1.—A furnace tile construction comprising a tile having a concavity formed in one of its sides, the sides of said tile below said concavity being straight and parallel, the portion of the tile above said concavity being narrower than the portion below said concavity, said portions extending at an angle with each other, a locking tile adapted to lie in contact with the narrow upper portion of the first mentioned tile, and supporting means lying in contact with said concavity and said locking tile, said locking tile being wedged between said narrow portion and a part of said supporting means. Seventeen claims.

970,660. STOKER. WILLIAM H. H. STINEMAN, OF BALTIMORE, MD., ASSIGNOR OF ONE-HALF TO ROBERT A. TAYLOR, OF BALTIMORE, MD.

Claim 3.—In an underfeed furnace, the combination with a fire-box, a screw conveyer leading into said fire-box, a gear-wheel on the conveyer shaft, a power shaft having a worm in mesh with said gear wheel, a



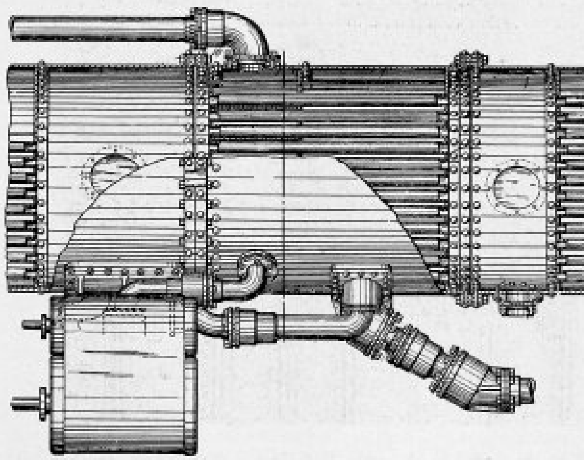
plunger having one end projecting into said conveyer and adapted to move between the flights of the conveyer whereby the fuel is held against any backward movement when the screw rotates, and a link connecting said plunger with said gear-wheel. Four claims.

967,763. STEAM BOILER. EDWARD P. HANAHAN, OF SPRINGFIELD, OHIO.

Claim 1.—The combination with a steam boiler, of a dome arranged on said boiler provided with a longitudinal groove in its bottom, pipe sections communicating said groove with said boiler, pipes connected to said pipe sections having their open ends arranged adjacent the opposite ends of said boiler, and a valve slidably mounted in said groove.

971,522. SUPERHEATER. WILLIAM F. BUCK, OF CHICAGO, ILL., AND HENRY W. JACOBS, OF TOPEKA, KAN.

Claim 1.—A superheater comprising a cylindrical shell or drum having smoke tubes extending in a longitudinal direction therein, said shell being located between two combustion chambers and forming an intermediate



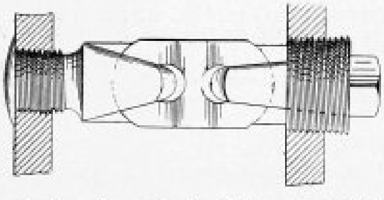
section of the boiler shell, means whereby said section is divided into two compartments to form separate superheating means, and means whereby said section is secured in place to be readily removed. Seven claims.

971,565. GRATE. HORACE H. RUGGLES, OF BOSTON, MASS.

Claim 1.—In a grate, a plurality of rocking sections each comprising a grate-bar and teeth and being independent of the other sections; a dust-proof plate rigidly secured to the outer surface of one of the side walls of the grate; a socket-supporting structure secured to and extending outward from said plate and provided with a chamber having substantially vertical walls at its opposite ends; locking check-beads supported on the upper edges of said walls longitudinally therewith; a rocking shaft extending horizontally through the lower part of said chamber and through corresponding holes in the dust-proof plate and the side wall of the frame of the grate; a series of substantially funnel-shaped vertical socket holders rigidly secured at their lower ends to said rocking shaft, each socket holder being provided with openings in its opposite end walls; latches pivotally hung in said openings and with their iner ends extending into the funnel-shaped sockets and their outer ends extending oppositely from the end walls in the sockets and resting normally on the end walls of the structure supported by the plate, the outer ends of said latches bearing against the check-beads and thereby supporting the sockets centrally in substantially vertical position; sleeves surrounding said shaft and extending from the different socket holders into the grate-frame above the grate, the outer sleeve fitting slidingly in the openings in the dust-proof plate and side wall of the grate-frame; and separate mechanisms connecting said sleeves with corresponding rocking sections. Two claims.

971,805. MANUFACTURE OF STAY-BOLTS. GEORGE S. THOMPSON, OF HOCKESSIN, DEL., ASSIGNOR TO FLEXIBLE BOLT COMPANY, A CORPORATION OF DELAWARE.

Claim 2.—The method herein set forth of manufacturing an articulated stay-bolt which consists in looping a strap of metal into the eye of



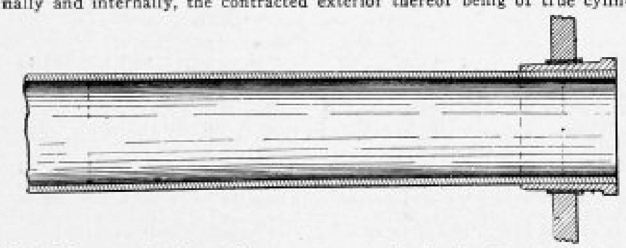
a bolt member, bending the ends of said strap to substantially parallel position upon opposite sides of a grooved filler inserted between them, and welding together such strap ends and filler. Two claims.

971,599. FEED-WATER HEATER. WILLIAM S. FERGUSON, OF LEESVILLE, LA.

Claim 1.—In a bailer furnace, an arch bar composed of parallel curved pipes terminating in straight portions and extending in a direction longitudinal to the boiler, supporting headers into which said straight portions of the pipes enter, one header being adjacent to the boiler and the other remote therefrom, and a brick covering on and supported by said pipe between the headers. Four claims.

972,164. DETACHABLE BOILER FLUE. JOHN M. CROZIER, OF MINNEAPOLIS, MINN.

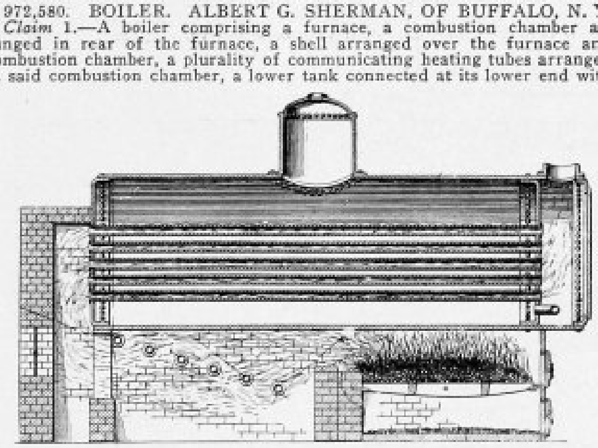
Claim.—A flue having an end portion that is contracted, both externally and internally, the contracted exterior thereof being of true cylin-



drical form and of less diameter than the body of said tube, and an externally tapered sleeve fitting the reduced cylindrical end portion of said flue with a driving steam-tight joint. One claim.

972,580. BOILER. ALBERT G. SHERMAN, OF BUFFALO, N. Y.

Claim 1.—A boiler comprising a furnace, a combustion chamber arranged in rear of the furnace, a shell arranged over the furnace and combustion chamber, a plurality of communicating heating tubes arranged in said combustion chamber, a lower tank connected at its lower end with



the inlet of the heating tubes, a water supply pipe connected with the upper end of the lower tank, and an elevated tank connected at its lower end with the outlet of said heating tubes and with the upper end of said lower tank and also connected at its upper end with said shell. Two claims.

972,583. SPARK-ARRESTER. WILLIAM P. STEELE, OF PALISADE, N. J.

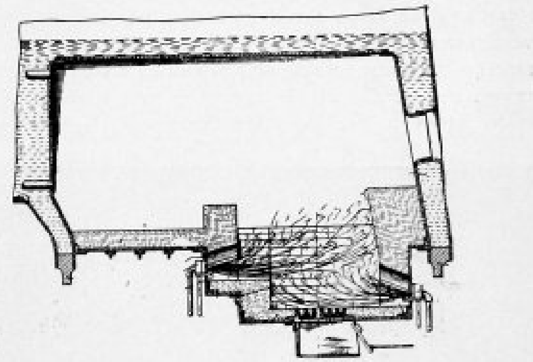
Claim 1.—The combination, with a locomotive smoke box, of an exhaust pipe, inclined deflecting plates extending from the rear of the smoke box to a plane forward of the exhaust pipe, a stack having an inward extension or "penetration," a spark separator interposed between the exhaust pipe and the stack extension, and alternately oppositely inclined baffle plates located, respectively, at the top and bottom of the smoke box front and the top of the smoke box at the rear thereof. Three claims.

973,069. DEVICE FOR CLEANING BOILER CROWN SHEETS. WILLIAM D. RANDALL, OF MONETT, MO.

Claim 2.—In apparatus for removing deposits from a crown sheet of a steam boiler, supports attachable to the boiler shell, members pivotally connected with said supports to swing longitudinally of said crown sheet, a flexible member connecting said first-named members and engaging said crown sheet, and transversely swinging plates having connection with said flexible member. Four claims.

973,112. OIL-BURNING LOCOMOTIVE FURNACE. CHARLES A. HAMMEL, OF LOS ANGELES, CAL.

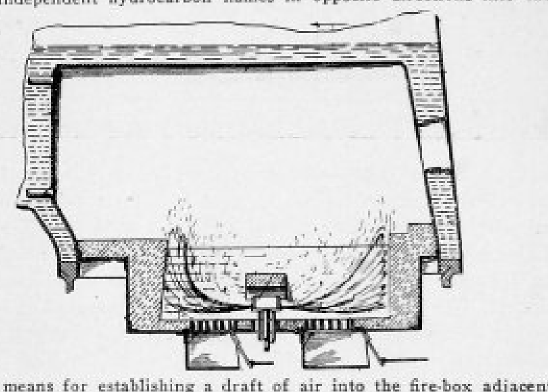
Claim 1.—The combination with a locomotive furnace, of a fire-box provided with a transversely disposed flame deflecting wall, means for delivering hydrocarbon flames from the front and rear of the fire-box toward each other into the fire-box, means for establishing a draft of air



into the fire-box adjacent the flame delivering means, an air admission means in the bottom of the fire-box adjacent to and under the meeting point of the flames, and means located beneath said air admission means for controlling the volume of air admitted therethrough. Two claims.

973,138. OIL-BURNING STEAM BOILER. WILLIAM A. ROGERS, OF LOS ANGELES, CAL., ASSIGNOR TO CHARLES A. HAMMEL, OF LOS ANGELES, CAL.

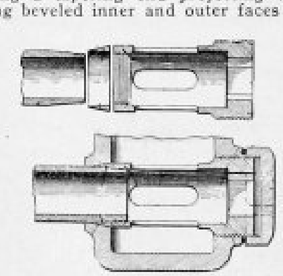
Claim 1.—The combination with a steam boiler having a fire-box, of a double hydrocarbon burner centrally disposed in said fire-box for delivering independent hydrocarbon flames in opposite directions into the



fire-box, means for establishing a draft of air into the fire-box adjacent the flame delivery means, means for admitting air directly into the fire-box adjacent to and under each flame, and a controlling means for each air admission means. Six claims.

973,610. TUBE AND HEADER CONNECTION. JAMES C. ALEXANDER, OF ROSEBURG, ORE.

Claim 3.—In a circulating pipe and header connection the combination of a header provided with alined tapered and threaded openings, a circulating pipe having a tapering end projecting within said header, a packing ring having beveled inner and outer faces associated about said



circulating pipe between the beveled portion thereof and said tapered opening, a screw coupling engaging within said threaded opening to force said packing ring securely in position, and a cap-nut adapted to be screwed upon said coupling outside the header to form a secure joint. Three claims.

973,273. FURNACE. HANNA HAAS, OF NEW YORK, N. Y.

Claim 2.—A furnace for burning semi-liquid fuels, comprising a combustion chamber, oppositely-disposed trays within the said combustion chamber and ranging lengthwise on the sides of the furnace, the said furnace being provided with normally closed inlets extending through the sides thereof for charging the trays with the semi-fluid fuel, pipes in the sides of the furnace for directing a blast into the fuel in each tray in a downward and inward direction to atomize the fuel and to form a mixture passing into the combustion chamber to be burned therein. Nine claims.

THE BOILER MAKER

FEBRUARY, 1911

THE PITTSFIELD BOILER EXPLOSION.

The boiler explosion which occurred at the plant of the Morewood Lake Ice Company, Pittsfield, Mass., Dec. 29, resulting in the death of seventeen men and injury to many more, is the first explosion which has occurred in Massachusetts, where the boiler was inspected by State inspectors, although during the last fifteen years it is said that some 35,000 inspections have been made by the State inspectors. It has so happened that all other boilers which have exploded in Massachusetts have been inspected by insurance companies, whose reports the State laws permit the State police to accept when the inspection has been made by inspectors who have met the requirements of the authorities. Not only did the boiler which exploded at Pittsfield come directly under the supervision of the State boiler inspection department, but it was in charge of a regularly licensed engineer, who, presumably, had satisfied the authorities of his knowledge and ability to operate the boiler in a safe and intelligent manner.

The boiler was of the locomotive type, 36 inches in diameter, built of 3/8-inch plates with double-riveted lap seams. The fire-box sheets were 5/16 inch thick, and the stay-bolts 7/8 inch diameter, spaced 4 7/8 inches between centers. There were fifty-three 2 1/4-inch tubes, 7 feet long, in the boiler. The boiler was bought second-hand by the Morewood Lake Ice Company in 1906. Previous to its use in Pittsfield it had been used in a sawmill working at 125 pounds pressure. At the ice company's plant the boiler was used only during the ice-harvesting season, and consequently was in use only two or three weeks during the year. The remainder of the time it was idle.

FIG. 1—PORTION OF BOILER SHELL, WEIGHING ABOUT 500 POUNDS, BLOWN 500 FEET, CUTTING OFF THREE TREES IN ITS PASSAGE, ONE OF WHICH WAS 8 INCHES IN DIAMETER.

The boiler was inspected by a State inspector last spring, and the working pressure fixed at 70 pounds per square inch. Certain changes were ordered to be made by the inspector, and, after the company had notified the inspector that these changes had been made, the usual certificate was granted. One of the changes ordered by the inspector was the installation of a new safety valve, but it was brought out in the inquest that the inspector's orders relative to the new safety valve were violated in three respects. The order to have a bushing and pipe removed so that there would be a full-sized discharge was not obeyed; the valve was set at a pressure of 80 pounds when only 70 pounds was authorized, and a 3 1/2-inch valve was used when a 2-inch valve had been specified.

The explosion was particularly violent, and the boiler was literally blown into bits. In fact, it seldom happens when a boiler explodes that the shell plate is torn into so many small

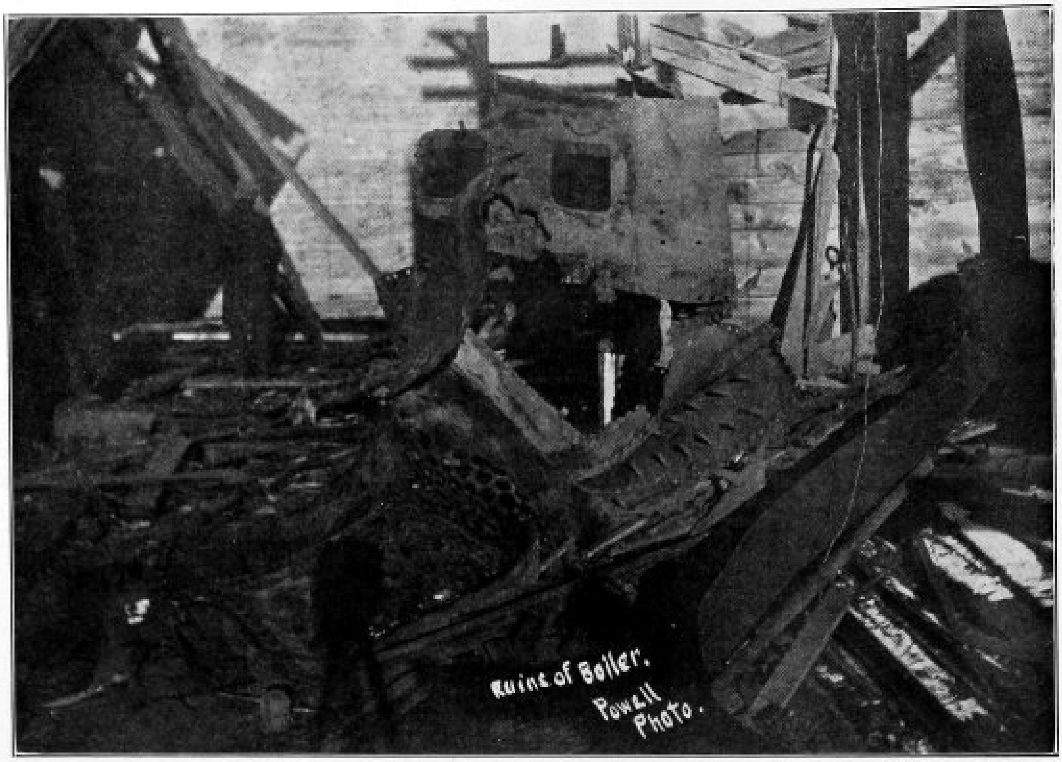


FIG. 2—PARTIAL VIEW OF RUINS, SHOWING TUBE SHEET AND PART OF FIREBOX.

pieces as was the case in this instance. Our illustrations show some of the parts of the exploded boiler, some of the largest of which were hurled several hundred feet from the boiler room. The property loss due to the explosion was small in comparison with the terrible loss of life. The boiler was uninsured, and the total loss, including boiler and buildings, is estimated at about $5,000.

Samples of the boiler plate were tested by Prof. Miller at the Massachusetts Institute of Technology after the explosion, and showed about 47,000 pounds per square inch tensile strength with the grain and about 41,000 pounds per square inch tensile strength across the grain. The elongation with the grain was 6.5 percent in a length of 8 inches and across the grain 8 percent in a length of 5 inches. The specimens showed signs of brittleness when subjected to bending tests.

According to newspaper accounts of the inquest, the testimony of the witnesses showed that on the morning of the explosion the engineer was unable to raise more than 35 or 40

FIG. 3.—FRONT TUBE SHEET AND PORTION OF SHELL.

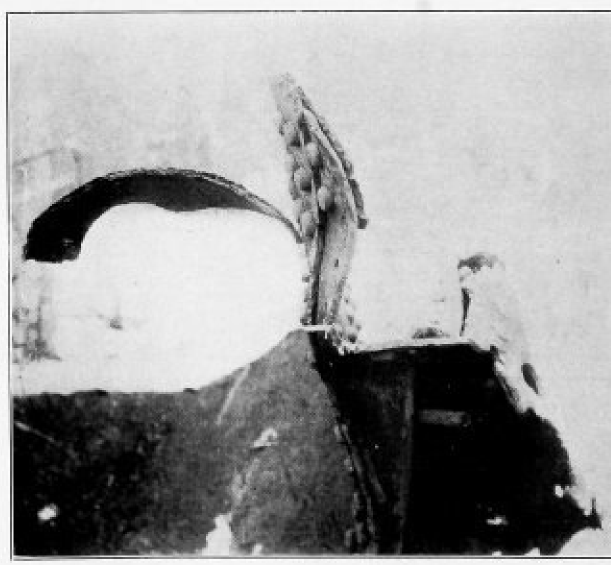


FIG. 4—FRAGMENT, SHOWING HOW SHELL WAS TORN THROUGH THE SOLID METAL.

pounds of steam in the boiler. The steam gage, it was claimed, had been overhauled the day before, and, apparently, relying upon its reading the engineer thought that the safety valve was out of order, as it blew off repeatedly when the steam gage

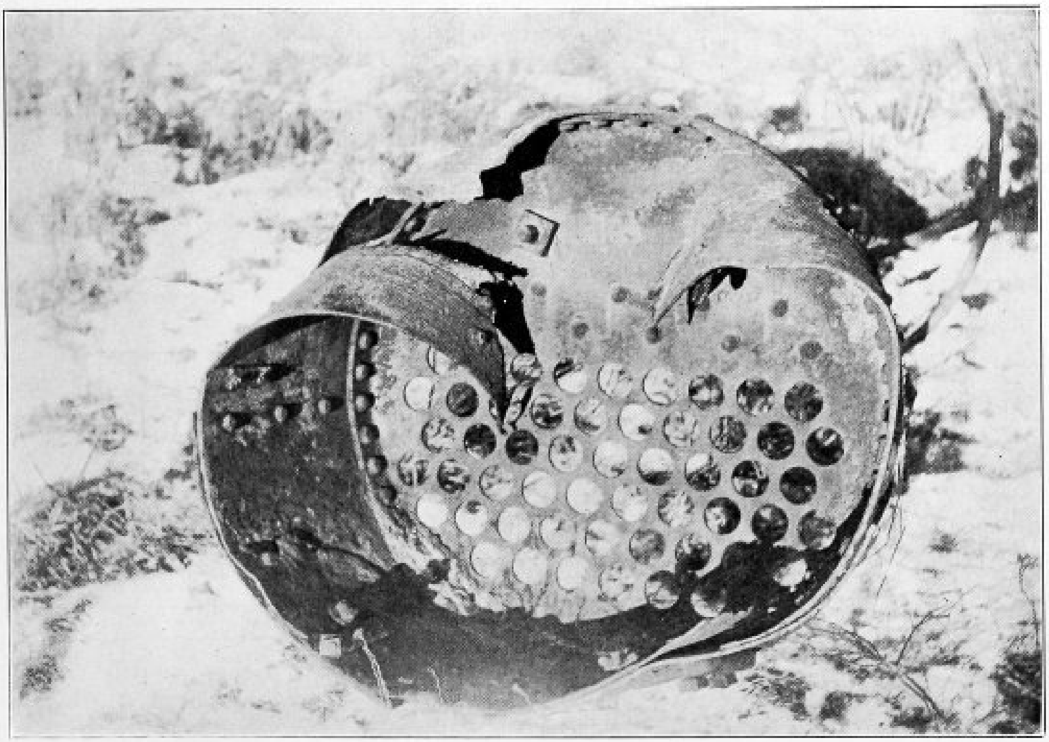


Fig. 5.—Front Head of Boiler, Blown About 250 Feet.

showed a pressure of only 35 or 40 pounds, whereas the valve was supposed to be set for a pressure of 80 pounds. According to the testimony of witnesses, the engineer removed the cap from the safety valve and screwed down the valve several turns. Examination of the valve after the explosion by representatives of the company which manufactured the valve, showed that the setting of the valve had been changed since it was sent out from the factory. Apparently, then, excessive pressure was generated in the boiler which was not shown by the steam gage, due either to some defect in the gage or the plugging up of its fittings, and as the boiler was probably full of water, and working with a hot fire in the furnace, an excessive pressure was soon generated, so that the ultimate strength of the boiler was exceeded, and the explosion occurred. There was no evidence to show that the boiler was unfit to sustain a working pressure of 70 pounds, as allowed by the inspector.

The Survival of the Exhaust Bridge.

The resort to homely and familiar remedies in time of stress or necessity is a natural tendency in mechanics as well as in medicine. There are numerous illustrations of this in locomotive practice, and one of the most recent is the return to the exhaust bridge as a means of making a locomotive steam freely when the ordinary standard appliances fail to produce the desired result. We have referred to standard draft appliances, but find that the Master Mechanics' Association has not adopted the designs and proportions for nozzles and stacks, as recommended in the reports of 1896 and 1906, either as standards or recommended practice. However, those proportions were presented with such a weight of authority, as the result of most elaborate experiments, that they have become generally recognized as standards and are in use on the majority of locomotives. The report of 1896 was concerned principally with the shape and size of exhaust nozzles, and the work included experiments made to ascertain the effect of bars or spreads placed across the nozzle opening; with a 14-inch choke stack, the top of the nozzle was 43 inches from the choke. The bars were made of ⅜-inch and ½-inch round iron; also of brass, triangular in cross section, the apex of the triangle being downward. After repeated tests with these cross bars or bridges on the exhaust nozzle at its outlet, the report concludes that it is not advantageous to increase the enfolding action of the jet at the expense of the induced action, or, in other words, that the more solid the jet of steam, within the limits of the experiments, the more efficient it is as a draft producer. In the general conclusions of the same report, one item states that the efficiency of the jet is reduced by spreading it by means of cross bars in the nozzle, and another item states that cross bars increase the back pressure in proportion to their width. This report was so positive in condemning the bridge in the exhaust nozzle that the subsequent experiments with stacks and nozzles made for the Master Mechanics' Association did not include any reference to it. The exhaust bridge has, for the reasons given, become regarded as bad practice and only to be used as a homely remedy in case of dire necessity.

Notwithstanding this bad reputation, it is interesting to observe the persistence of an effectual appliance and surprising to find that the exhaust bridge is now in general use on the large new locomotives of half a dozen of the principal lines in the West, and, doubtless, in the East, wherever the large diameter smoke-box has compelled the use of a very short outside stack. In its present use it takes the form of a ¾-inch round bolt, which is placed in the nozzle near its top; in some instances the nozzle is given an outside flare at this point, with the apparent idea of giving the exhaust steam a chance to spread immediately on leaving the nozzle, or else to provide an area of opening at the bolt equal to that of an unobstructed nozzle. The action of the bridge in spreading the exhaust is shown in the more rapid wear of the draft pipe and stack at points parallel with the sides of the bolt or bridge. It is this spreading that causes the exhaust jet to fill the stack lower down and thus produce a stronger draft on the fire.—*Railway Age Gazette.*

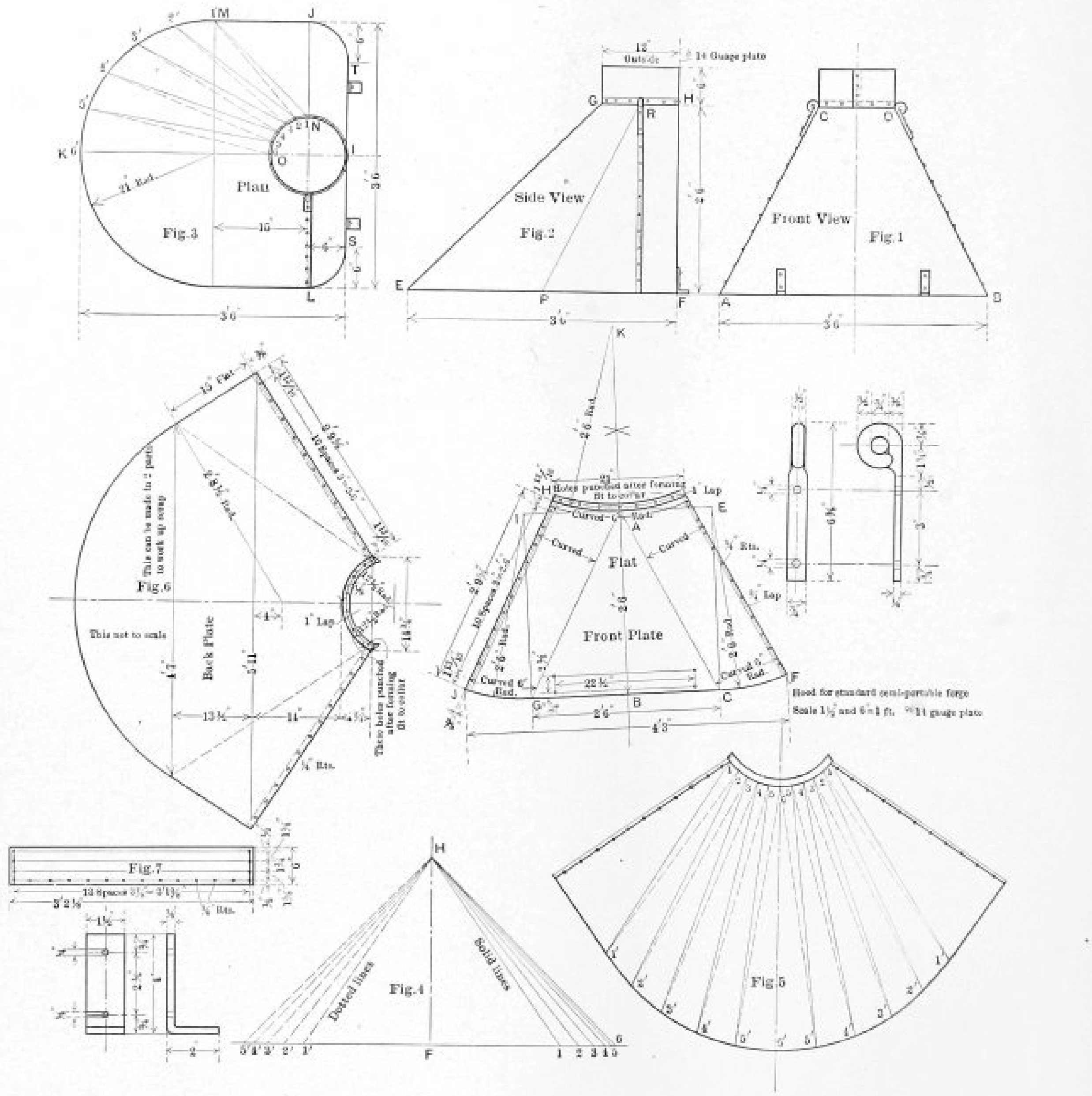
PATTERN FOR A HOOD FOR A SEMI-PORTABLE FORGE.

BY A SUBSCRIBER.

A C D B (Fig. 1) represents the front elevation of a hood, such as is frequently used for a portable forge; *E G H F* (Fig. 2) its side view and *I J K L* (Fig. 3) the plan. As the top is round, divide the quarter circle of the top *N O* into any convenient number of spaces, using the "neutral diameter," also divide the outer curve of the plan *M K* into the same number of equal spaces. Connect points of similar numbers in the two curves by solid lines, as shown 1 to 1′, 2 to 2′ and 3 to 3′, etc. Also connect points in the plan of the top with points of the next highest number in the plan of the base by dotted lines, as 6 to 5′, 5 to 4′, 4 to 3′, etc.

Before the pattern can be begun it will first be necessary to obtain the correct distances represented by the solid and dotted lines across the plan. This is accomplished by means of two diagrams of triangles, as shown in Fig. 4. Draw the vertical line *F-H* in length corresponding to the height of the hood, as shown by *F-H* in the side view; at right angles to *F-H* draw *F*-6 equal to *O-K* or 6-6′ of the solid lines of the plan. From *F* set off also the spaces *F*-5, *F*-4, *F*-3, etc., corresponding to the solid lines 1 1′, 2 2′, 3 3′, etc., of the plan; then connect these points to *H* with solid lines. Then on the other side of *F-H* construct the second diagram of triangles in similar manner. *F*-5′ is set off in length equal to the dotted line 6-5′; then set off the distances *F*-4′, *F*-3′, *F*-2′, *F*-1′ corresponding to the dotted lines 5-4′, 4-3′, 3-2′, 2-1′ in the plan.

To develop the pattern, first draw vertical line 6′-6 (Fig. 5), representing the center line of the back, and make this equal to the solid line 6 *H* (Fig. 4), or *E-G* in side view (Fig. 2). Then with the dividers used in spacing off the outer curve of the plan and from point 6′ as a center describe arcs, and with trams set to the distance 5′-*H* dotted, and with 6 as a center, describe arcs intersecting the arcs previously made with the dividers, which will give points 5′, 5′ in the bottom. Draw dotted lines to these points, then with the dividers used in spacing *N-O* and with 6 as a center describe arcs. Set trams to the distance 5-*H* solid, and with 5′ as centers describe arcs,



LAYOUT OF A CONICAL HOOD FOR A SEMI-PORTABLE FORGE.

intersecting the arcs just made with the dividers, which will give points 5, 5 in the top. Connect 5' and 5 with solid lines, then with the large dividers, and with points 5', 5' as centers describe arcs, and with trams set to 4'-*H* dotted and from 5 as a center describe arcs intersecting the arcs just made with the large dividers, which will give points 4'-4' in the bottom. Proceed in this manner, using alternately the distances shown in the solid and dotted lines in the diagrams of triangles, Fig. 4, until points 1, 1' are reached. Then with distance *J-M*, Fig. 3, and from 1' as a center strike an arc, and with distance *P-R*, Fig. 2, and with 1 as a center describe another arc, intersecting the arc just made; from this point draw lines to 1' and 1, which will give the rivet lines. Then lines drawn through points 1, 2, 3, 4, 5 and 6 at the top and bottom will complete the pattern; material must be added for the lap and flange as required.

It will be seen that Fig. 6 is the same pattern as Fig. 5, but with measurements noted. I noticed in one of your journals an editorial covering this idea of taking measurements, which when followed out, together with notes made of the work, will enable the layerout to duplicate the job at some future time without the necessity of keeping a template for the work. This method is a great help to the layerout and a time-saver to the employer; for, after a job has been laid out by triangulation, as, for instance, this article, and measurements taken, the next one can be laid out in half the time. Of course, there are patterns which it would take as much time to make complete note of as it would to lay out, but one has to determine that himself.

There is no need to lay out the front plate by triangulation, as there is an easier way. First draw line *G C* in the pattern for the front plate equal to *S T*, Fig. 3, which is the straight part of the plate at the base, 2 feet 6 inches long. Bisect this at *B*; then from *G* and *C*, respectively, strike arcs with a convenient radius, then from *B*, through the points where the arcs intersect, draw a line of indefinite length. Set the trams to the distance *F H* (Fig. 2), and from *B*, *G* and *C* strike arcs at *I*, *A* and *E*. The intersection of the arc at *A* with the line *B K* will give point *A*. Set the trams to distance *B C*, and with *A* as center strike arcs intersecting arcs made from *G* and *C*. This will give points *E* and I. From *E* as a center, and with *E-C* as a radius, strike an arc, and from *I* as a center, with the same radius, strike an arc. Then measure off on these arcs one-quarter of 12 inches circumference, which will give points *J* and *F*. Without changing the trams strike an arc from *A* as a center, cutting line *A B*, giving *K*. Then from *K* strike an arc and measure off on the arc each side from *A* a length equal to one-quarter of 12 inches circumference, which will give points *D* and *H*. Draw lines from *H* to *J* and from *D* to *F*, which will be the rivet lines. Draw lines from *A* to *G* and *C*. Inside of these lines the plate must remain flat, outside of them it is rolled to a 6-inch radius. Add a lap to the sides and a flange to the top arc *D H*, then pattern will be completed.

Fig. 7 is the band, developed 12 inches diameter outside 14-gage plate, giving a length of 3 feet 1⅜ inches. It is best to punch the band and mark the holes off from it on to the hood, and punch them with a screw punch.

At the Baldwin Locomotive Works, Philadelphia, the number of locomotives built in 1910 was 1,678. The number of men on the pay roll at the close of 1910 was 16,230, as compared with 16,400 in the late summer months, the latter being the highest figure reached since the panic of 1907. In 1906 these works built 2,666 locomotives; in 1907, 2,663; in 1908, 617, and in 1909, 1,023. The maximum number of men employed in 1906 and 1907 was 19,000. In 1908 the minimum number was 4,400; in 1909 the range was from 5,000 to 11,000, and in 1910 from 11,000 to 16,400.

CARE AND SELECTION OF MACHINE TOOLS AND SHOP EQUIPMENT.

BY W. H. SNYDER.

The care and selection of shop tools is a most important factor in any shop; without the proper tools much valuable time is often wasted in studying and scheming how a job can best be done. The tools used in the average boiler shop, as a rule, show very hard treatment and in many cases the cause of this is misuse. With a little more care on the part of the men the condition and appearance of the tools would be much better. Take, for example, the power punch in a shop where they do not have a regular operator for doing all the punching. You will often see men try to force a 13/16-inch punch through a ¾-inch die; in punching half holes punches and dies may be saved by using a piece of iron the same thickness and holding it against the piece that is being punched. By so doing you actually punch a full hole, and it is much easier on the punch and die. One man should be detailed to do all the punching and shearing. By so doing the cost of maintenance of the punch and dies will be reduced to a minimum.

CARE OF PNEUMATIC TOOLS.

The use of pneumatic tools should receive the most careful attention of all workmen, and especially of the foreman directly in charge. An air hammer should never be put in service without first being well oiled with a good grade of suitable oil; if it continues in service it should be oiled every two hours without fail. Pneumatic tools are like a human being; without the proper nourishment and care they will very soon be a total wreck and useless for service. Never connect an air hose to an air hammer or motor without first blowing the hose out well. There is nothing that will ruin a pneumatic tool quicker than the dirt or grit that is liable to collect in an air hose. At our shop all pneumatic tools have to be delivered to the tool room every evening before the men go home; the hammers are put in a tank containing equal parts of signal oil and kerosene. This keeps them well oiled and prevents them from gumming up. In giving the tools out in the morning the hammers are drained out and given a good oiling with pneumatic tool oil. The motors are also well oiled before they are handed out.

CARE OF MACHINERY.

When installing machines see that they are put on a good foundation, regardless of the size of machine. Level up each machine carefully. The countershaft should not be overlooked; if it is not properly put up, squared, leveled and lined up you will have no end of trouble with the belts. Always keep the machine tools clean and the oil holes open. All revolving parts should be well oiled at all times. Too little attention seems to be given to this important matter.

Never hammer any part of a machine. Never lay anything on the shears or ways. Keep the machine looking neat, as if it was your own personal property. By observing the few points here laid down you will bring credit to yourself and your foreman and keep the cost of machinery and tools to minimum.

CARE AND TREATMENT OF BELTING.

Belts are expensive, and with improper treatment can soon be ruined. Lacing belts with the ordinary rawhide lace seems to receive little consideration. In most of the shops every man has his own way of lacing, and some belts are sure to receive improper treatment, especially those running on cone pulleys. There should be one man in every shop detailed to do all the belt lacing. The lacing giving the best results should be adopted as a standard. The shifting of a cone belt from one cone to another, if the proper care is not exercised, will soon stretch the belt out of shape, and it will have a tendency to creep on the next cone. When it is desired to change the speed of the lathe be careful to have the belt next to the cone it is to be shifted on. If you fail to do this you will soon have the belt stretched on one side, and it will have a tendency to creep. If the creeping is not stopped the belt will soon be ruined. When you notice a belt commencing to creep on the next cone turn it over or turn it end for end. This will oftentimes save it. Never use rosin or any kind of belt dressing that will hang to the pulley or that will have a tendency to collect on the side of a pulley.

SELECTING TOOLS.

In selecting tools and machinery every foreman should be on the lookout for tools and devices that will assist in increasing the output. The foreman must be in position to give satisfactory reasons showing and proving to his employer that the additional equipment and investment will be a paying proposition.—*Railway Age Gazette.*

REPLACING A PORTION OF THE SHELL OF A CYLINDRICAL BOILER.

BY H. S. JEFFERY.

Frequently the shell of a cylindrical boiler becomes deteriorated to the extent that a portion of one course, usually the front course, and a small portion of the other course must

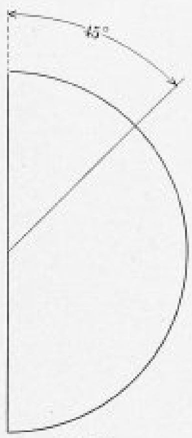


FIG. 1.

be removed and replaced with a new sheet. The new sheet is really a patch, but extending one-half or more around the boiler it is called a half-sheet. This term, however, should not be accepted literally, for the so-called half-sheet usually extends about 75 percent of the circumference of the boiler.

In repairing a boiler, attention must be given to the original design. Just how far around the so-called half sheet will extend will depend greatly upon the location of the longitudinal seam, which is usually placed as near 45 degrees as possible, as shown in Fig. 1. The sheet *A*, Fig. 2, due to defects, may have to be replaced, and, accordingly, the first course will have two longitudinal seams, one on each side of the top center line, and each should be the same distance from the top center line.

With a lap riveted longitudinal seam, either double riveted

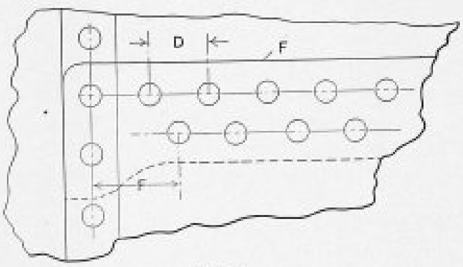


FIG. 3.

or triple riveted, the pitch of the rivet holes should be uniform in the outer row of rivets, marked *B*, Fig. 2. There are numerous tables published by insurance companies, which are reliable enough, but in designing a boiler, lap joint, the pitch of the rivets in the row *B*, Fig. 2, should be uniform, and as the pitch is governed by the overall distance *e*, which may be such that the so-called standard pitch will be a trifle too large

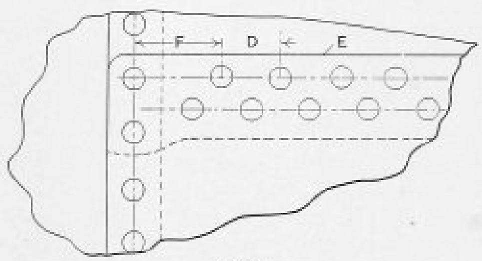


FIG. 4.

or small, it follows that the standard pitch given in various tables will not do in every case.

The riveted joint tables are very misleading, and for the reason that if the pitch *D*, Fig. 2, is 1/16 inch greater than given in the tables, the efficiency of the net section of plate is greater than given in the tables, while if the pitch is 1/16 inch less the efficiency of the net section of plate is less than given in the tables. In addition, there are other considerations; one being that the pitch must not be too excessive for the thickness of plate. The joint may be designed for an efficiency, say 70 percent, the net section of plate being less than the efficiency of the rivets, which would permit increasing the pitch; but this may not be advisable, as the pitch may be so

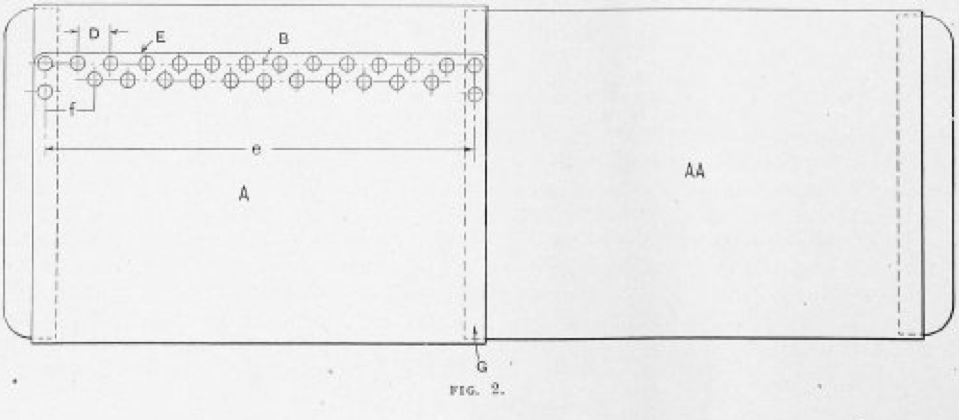


FIG. 2.

great as not to hold the sheets between the rivets together, as they should be in order to have a steam-tight joint.

Therefore, the pitch, whether new or old work, must be within certain limits. In laying off the rivet holes in the longitudinal seam, the uniform pitch, *D*, Fig. 2, should be adjoining the calking edge, *E*, as shown. This makes the large pitch, *f*, in the lower row, as shown in both Figs. 2 and 3. If the pitch was made uniform in the lower row, instead of the upper row, then the layout of the rivet holes would be as

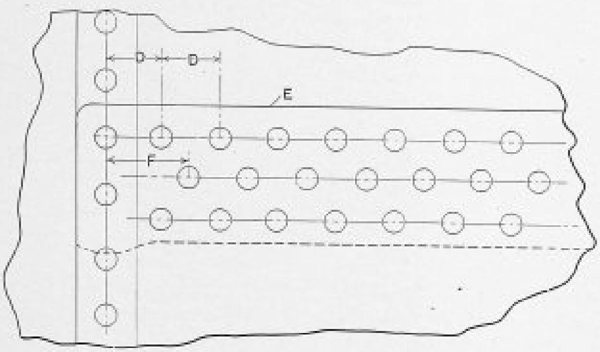


FIG. 5.

shown in Fig. 4, thus making the large pitch, *F* (there being one large pitch, *F*, adjoining each girth seam), next to the calking edge, *E*, which is not good practice, as in calking the plate there will be a tendency to lift the plate between the rivets if the plate is calked too heavy, or the rivets are spaced with too large a pitch. In Fig. 5 is shown the arrangement of the rivets for a triple riveted lap joint, the letters *D*, *E* and *F* serving for the same parts as the corresponding letters of Fig. 2.

If the sheet *A*, Fig. 2, is defective and no portion of sheet *AA* is removed for repairs, the new so-called half sheet can

FIG. 6.

readily be laid out and practically all the rivet holes be installed before the sheet is rolled. However, in most of the contract shops it is not the practice to install the rivet holes before rolling the sheet; the usual practise being to roll the sheet, installing a few tack holes, and by means of same the sheet is bolted in place to permit the other holes to be marked from the holes in the head and the holes in the girth seam of the sheet *AA*. The principal object of this practice is to secure fair holes, for, in addition to some of the holes in that portion of the shell sheet removed being more or less unfair, the boiler is liable to shift or adjust itself when a large portion of the first course is removed. If the holes are laid off from

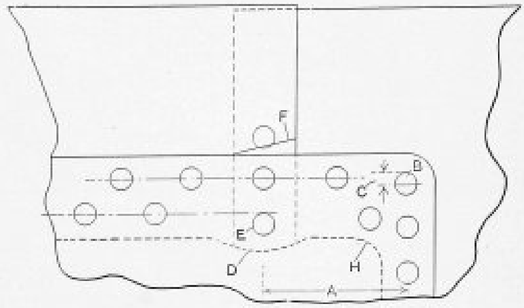


FIG. 8.

measurements taken from the old sheet, or if the old sheet is straightened and the holes in the new sheet marked from it, the boiler might shift sufficiently so as to make the holes partly unfair, causing heavy drifting in fitting up the new plate; also in riveting. For this reason many shops mark off the so-called half sheet, the same first being bolted in place by means of the tack holes. Before the holes in the sheet are marked, the sheet is laid-up at all points, or, in other words, fitted to the adjoining sheets. Then the holes are marked off, the usual practise being to use a marker, one type of which is shown in Fig. 6.

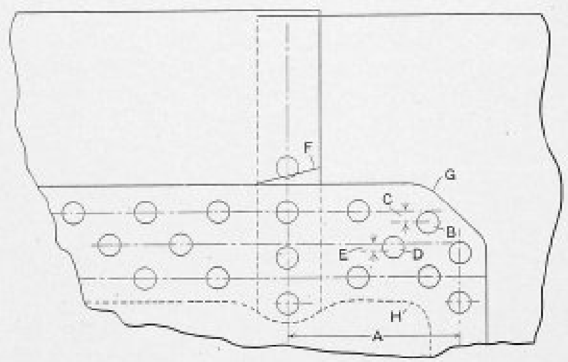


FIG. 9.

The marker should fit the holes neatly, thus causing the center punch mark on the new sheet to be correctly located.

Following the marking of the holes, the sheet is removed and the holes installed, the surplus material removed, and the sheet beveled for the calking edge, and then replaced and riveted in place. If riveted by hand, hammer driven rivets, or by hand, snap driven rivets, or by hand, air hammer driven rivets, the plate should be well laid-up before the rivets are driven.

It very frequently happens that the sheet *AA*, Fig. 2, is defective at the girth seam, *G*, or the sheet just back of the girth seam has corroded away; therefore, when applying the

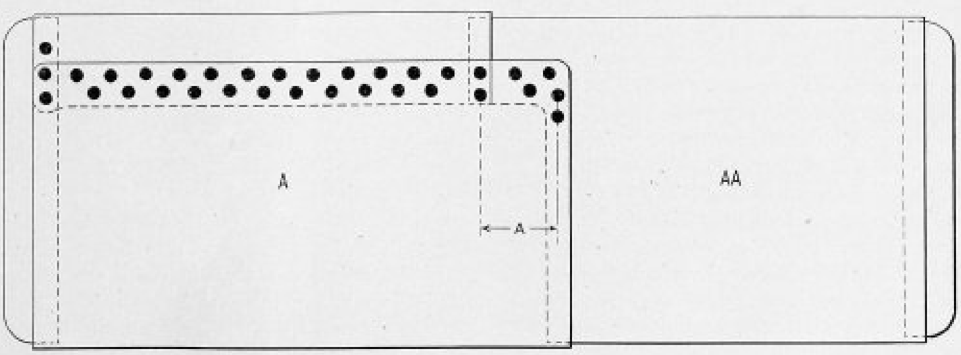


FIG. 7.

so-called half sheet, the practice is to extend the sheet over on the course *AA*, as shown in Fig. 7. This also removes the girth seam from being directly above the fire, where it is located with a three course tubular boiler, and many times with a two-course tubular boiler. The distance *A*, Fig. 7, is no stated amount, but should be sufficient to enable a good connection to be made at the riveted longitudinal seam on the course *AA*.

The arrangement of the connection from the longitudinal seam to the girth seam for a double riveted lap joint is shown in Fig. 8, and the arrangement for a triple riveted lap joint is shown in Fig. 9. With the double riveted lap joint, the rivet *B* is usually dropped down, as shown, the distance *C* ranging from ¼ to ½ inch. The shell sheet is also allowed at *D* to extend down, as shown, giving sufficient lap for the rivet *E*. At the girth seam there will be three thicknesses of plate, necessitating the outer course, the front course, to which the half sheet is attached, to be scarfed at the girth seam, the line *F*, indicating that the sheet has been scarfed beyond the half sheet, which is necessary in order to have no abrupt joint at the girth seam.

With a triple riveted lap joint, as shown in Fig. 9, the rivet *B* is dropped the distance *C*, as in Fig. 8, and the rivet *D* is also dropped, making the distance *E* about two-thirds of the distance *C*. The shell sheet is scarfed as described in connection with Fig. 8, the line *F* representing the same part in both illustrations. With a triple riveted joint, the half sheet is rounded off at *G*, as shown, this being the principal reason for dropping the rivets *B* and *D*. The shell sheet should be cut so as to have a large size radius at *G*; the least radius should be 2 inches. The object of so cutting the sheet is to prevent a crack from starting, which it might do if the sheet were cut with a sharp corner, due to the panting of the boiler.

STEAM BOILER DESIGN.

BY CHARLES ERITH.

Mr. Michael Longridge's annual report for the British Engine, Boiler & Electrical Insurance Company contains highly interesting tests of Dr. Nicolson's experimental high-velocity boiler and economizer, designed to test a theory (mistakenly called a "law") that heat transfer is nearly proportional to the speed of flow of gases.

This velocity theory is in direct contradiction to the general experience that heat transfer is proportional to the difference between the temperature of the gas on the one side of the plate or tube and of the water on the other side.

Dr. Nicolson's boiler and economizer carry his velocity theory to its logical conclusion. According to his lecture to the Junior Institution of Engineers his design was to artificially accelerate the flow of gases through boilers, both by dispensing with skilled firing and admitting a large excess of air to the furnace, and also by employing a fan to draw the gases through small channels of remarkably small total area, quite inadequate for their natural flow, in the belief that the high-velocity gases would have a scrubbing effect on a cool film of gases which was supposed to retard heat transfer. In this way Dr. Nicolson proposed both to enormously increase the steaming duty of the boiler plant and also to attain an efficiency of 95 percent for boiler and economizer together, in place of the 60 to 80 percent efficiency of actual practice. As recorded in the *Journal* of the Junior Institution of Engineers, February, 1909, pages 254 to 257, both the velocity theory and all the proposed changes in boiler design were promptly challenged by the writer, while the evidence given in the paper was questioned by other speakers also; and subsequently similar criticisms and questions appeared in the engineering papers, to which Dr. Nicolson responded.

As originally made the boiler had a 39-inch diameter water-drum placed in the rear end of a 41-inch furnace flue, so that gases were drawn through a 1-inch annular space; and under these conditions Dr. Nicolson claimed to have burnt 1,200 pounds hourly of small and dusty coal on the 41-inch furnace; but in Mr. Longridge's tests this 39-inch water-drum was replaced by a 37-inch diameter fireclay plug, making the annular gas flue 2 inches instead of only 1 inch wide.

Part of the boiler consists of a shell 6½ feet in diameter and 24 feet long, with the above 41-inch diameter internal furnace, followed by a brick-lined chamber wherein the partial combustion in the furnace proper was to be completed before the gases reached the annular flue, the other part of the boiler consisted in a nest of very small watertubes, placed in a vertical drum, only 16 inches in diameter, through which the gases pass immediately on leaving the annular flue; finally, the gases traversed a small tube economizer in a similar 16-inch diameter vertical shell. A 40-horsepower, induced-draft fan and a 4-horsepower water circulating pump were necessary for this one small boiler.

We now have Mr. Longridge's series of six exhaustive tests, carried out with his usual thoroughness and impartiality, and giving ample information to judge whether Dr. Nicolson's theory was correct or mistaken. The one omission is the moisture in the steam; while the unaccounted heat losses for the six tests are as high as 22.6, 15, 11.3, 13.2, 16 and 13.3 percent, respectively.

A practical comparison of the high-velocity experimental boiler and economizer, with ordinary mill boilers and economizers, is tabulated. The hand-fired, low-duty test was reported by Mr. Hiller, of the National Boiler Insurance Company, to the Institution of Mechanical Engineers; the stoker-fired, high-duty test is typical of many in the possession of the writer; it was made on an old plant in ordinary working conditions by the users, and a new plant under expert testing conditions would show a higher result.

On the question of boiler capacity there is nothing to approach Dr. Nicolson's claim of burning 1,200 pounds of small and dusty coal hourly on the 41-inch furnace with 1-inch annular gas flue; with the actual 2-inch annular gas flue, and with good fuels, the duty was quite ordinary for capacity tests of standard boilers with clean coals and fan draft, viz.: with Manvers Main coal, 13,166 British thermal units per pound, the three tests show 685 pounds, 688 pounds and 413 pounds hourly; while with best Welsh, 14,929 British thermal units per pound the 41-inch furnace burnt 478 pounds, 740 pounds and 737 pounds of coal hourly, which is nothing remarkable.

Dr. Nicolson's proposal to dispense with skilled firing, and to admit a large excess of air to the furnace, was, of course, found fatal to efficiency; it is clearly stated that on these tests "the air supply was carefully curtailed in order to reduce the chimney loss," and the fuel was fired at very frequent intervals. With this highly skilled firing the estimated combustion temperature of 3,000 degrees F. was reached, though the large unaccounted heat losses already referred to make it doubtful if this high temperature was constant.

The efficiency of the boiler and economizer together is no better and no worse than any ordinary type of boiler with ordinary large tube economizer would give with similar conditions of combustion temperature and burning the same fuel, viz.: combined efficiency from 73.8 to 79.1 percent; but these apparent efficiencies were reduced to 64.4 to 69.1 percent after deducting the enormous working cost for fan power and for water circulating pump, these net efficiencies being much below the test efficiencies of ordinary boiler plants.

As regards space occupied, the economizer should be excluded, as, wherever space is limited, an ordinary economizer is placed above the boiler. The 16-inch diameter vertical drum, with watertubes, adds but little to the floor space occu-

DR. NICOLSON'S EXPERIMENTAL BOILER COMPARED WITH ORDINARY LANCASHIRE BOILERS.

Test made by	Mr. Longridge	Mr. Hiller	Users
At	Adamson's, Hyde	Irish Mill	Yorkshire Mill
Date of test	Oct. 13, 1909	June 11, 1903	April 8, 1910
Duration of test	9 hours	4 hours	13 hrs. 50 min.
Boilers	Experimental shell and water small tube economiser	Two each, 30 ft. by 8 ft. plain flue Lancashire 224-tube economiser	One each, 28 ft. by 7½ ft. and 8 ft. plain flue Lancashire 192-tube economiser
Boiler-heating surface per furnace, sq. ft.	363	460	433
Economiser heating surface per furnace, sq. ft.	293	560	480
Furnace diameter, average, ins.	41	38	37
Grate surface or combustion area, average, sq. ft.	18.1	19	18½
Firing method	Hand	Hand	Erith's stokers
Average coal per furnace per hour, lbs.	688	352	583
Coal used	Manvers Main	Welsh	Grimethorpe slack
B. T. U. per pound of coal	13,166	14,040	12,870
B. T. U. per furnace per hour	9,058,208	4,942,280	7,503,210
B. T. U. per furnace transmitted per hour to boiler only	5,652,321	3,098,850	5,049,660
Ash and clinker, p.c.	5.04	4	8.27
Feed-water to economiser, degrees Fahr.	73	61	105
Feed-water to boiler, degrees Fahr.	280	245	215
Hourly water evaporation per furnace, lbs.	5,810	2,741	5 040
Equivalent hourly water evaporation per furnace from and at 212 degrees Fahr., lbs.	6,903	2,974	5,806
Actual water per pound of coal as fired, lbs.	8.445	7.781	8.65
Equivalent actual water per pound of coal as fired from and at 212 degrees Fahr., lbs.	10.030	8.450	9.96
CO_2, average, p.c.	12.07	8.28	14.2
Temperature of gases leaving boilers, degrees Fahr.	814	635	790
Temperature of gases leaving economiser, degrees Fahr.	279	299	497
Average steam pressure by gage, lbs.	120	159	103
Steam temperature, degrees Fahr.	350	370	340
Superheat, degrees Fahr.	None	112	None
Boiler efficiency, p.c.	62.3	62.7	67.3
Add economiser efficiency, p.c.	14.5	10.99	7.5
Total gross efficiency, p.c.	76.8	73.69	74.8
Deduct working cost.			
Horsepower for fan per furnace, h. p.	37.4	None	3
Percentage for fan, p.c.	10.0	None	0.9
Percentage for stoker ram, p.c.	None	None	1.1
Total net plant efficiency, p.c.	66.8 High duty	73.69 Low duty	72.8 High duty
Average heat transmission per square foot boiler heating surface	15,040	6,736	11,666

pied by the other part of the boiler, which was 6½ feet in diameter and 24 feet long; but as there were no bottom or side flues, the width was somewhat less than required for any brick-set cylindrical boiler of the same diameter and length.

As compared, therefore, with standard Cornish or Lancashire boilers for the same duty, Dr. Nicolson's boiler occupies slightly more length, but slightly less width; but it requires considerably more length than the well-known "Economic" boiler for the same duty, which would be only 15 feet long; while marine boilers for the same duty are even shorter. The comparison for single-furnace boilers, of course, applies equally to cylindrical boilers with two or more internal furnaces.

Watertube boilers are easily made so that no more space is used than required for the furnace; so, on the question of ground space for a given steaming duty, certain types of both watertube and cylindrical boilers of standard makes compare very favorably with the experimental boiler.

As the velocity theory, which Dr. Nicolson's experimental boiler was built to test, has been refuted by these trials, it is only necessary, before discussing correct boiler designs, to mention a few of the practical objections to the complications of the experimental boiler, viz.:

Nine-tenths of the fan power used was wasted in drawing gases through areas totally inadequate for their natural flow.

The water-circulating pump is totally useless in brick-set cylindrical boilers, as the heat transferred through boiler shells circulates the water below the furnace flues sufficiently to ensure a temperature corresponding to the steam pressure. It is never required in watertube boilers with normal water areas; if the water areas in Dr. Nicolson's small tubes involved pump circulation the remedy was obviously to increase such water areas.

The partial combustion in the furnace was the sole justification for lining the center part of the furnace flue with firebrick; combustion ought to have been completed in the furnace itself.

The partial combustion in the furnace, and the lining of the central part of the flue, merely prevented the normal heat transfer at the right place, and so caused an abnormal heat transfer at the rear or wrong end of the 41-inch flue.

The proposed cooling of the exit gases to 100 degrees F. was not approached; it could only be done by pumping through the economizer much water that the boiler could not use, and then the unduly cooled gases would deposit moisture and corrode the economizer.

The proposed admission of excess air to the furnace, and the proposed dispensing with skilled firing, was an obvious confusion between completing combustion at the expense of efficiency and correct combustion due to a proper mixture of a minimum excess of air with the combustible gases.

Such practical objections were mentioned by the writer at the close of Dr. Nicolson's lecture, and further observations by the writer on heat transmission in boilers are recorded in the *Proceedings of the Institution of Mechanical Engineers*, October, 1909, pages 1054 to 1058.

Perhaps the one definite point made clear by the tests of the experimental boiler is that the time required for heat transfer is only a small fraction of the time ordinary boilers give; in other words, and contrary to Dr. Nicolson's theory, it is proved that gas velocity is of extremely small importance, at any rate when the combustion is as efficient as during these tests. The experimental boiler gave abnormally high gas velocity, viz.: abnormally short time for heat transfers, without either better or worse effect than normal practice gives. But there can be no objection to allowing longer time for heat transfer than is strictly necessary, and therefore avoiding the prohibitive working cost involved in artificially high gas speeds.

It has long been recognized that where the gas travel is short the volume of gases should be divided by using numerous small flues or gas passages. The locomotive, marine, economic, return-tubular and most watertube boilers involve a short gas travel, but split up the volume of gases, just as the regular vertical-pipe economizer does, to compensate for the short gas travel; whereas the standard 30-foot brick-set Lancashire boiler, giving about 100 feet length of gas travel, has very large unobstructed flue areas, much in excess of the gas areas at furnace bridges; and yet Lancashire boilers cool the escaping gases down to much the same temperature as small flue boilers with short gas travel.

This division of gas volume over small flues of ample total area is, however, a totally different matter from accelerating the velocity of gases by drawing them through areas inadequate for their natural flow, as proposed by Dr. Nicolson. Even when the flue areas are normal there are many objections to using a strong suction draft, which draws unburnt fuel and grit into the flues, and causes cold air to enter at the wrong places, a suction fan is only a makeshift substitute for a suitable chimney.

The best method is to supply to the furnace by positive fan draft the correct proportion of air to combustible, leaving the gases free to flow naturally through the flues to the chimney, which then becomes a mere outlet. If the air and fuel are supplied with mechanical regularity, and if the mixture of air and combustible gases is efficient, the gas volume will be only about half as great per pound of coal as with ordinary hand firing, and therefore the rate of combustion can be doubled without any increase of gas volume and velocity, so that normal gas areas suffice for forced duty with this correct firing method.

The writer is no advocate for forcing boilers or for overloading any kind of plant whatever, but experience shows that boilers can be heavily forced when needed, consistently with natural outflow of gases, through ordinary flues.

But the above method, though often confused with "forced draft," is just as efficient at ordinary as at high rates of combustion, and is properly called "positive draft." The writer has applied it to boilers of all types and sizes, burning all kinds of coals, in connection with grateless stokers; both air and fuel responding automatically in correct proportion to load variations, and combustion is smokelessly completed with minimum excess of air within the thick bed of burning fuel, thus attaining maximum temperature in the furnace itself and free outflow of gases through the boiler. The simplicity of this method is obvious, and boilers of all standard types so fired leave no margin for improvement in efficiency, as it reduces the volume and temperature of exit gases to the minimum, and is quite free from smoke and grit nuisance.

It is quite practicable to approach maximum efficiency with highly skilled hand firing, which closely approximates to mechanical regularity of firing; but such skilled tests are simply misleading, as in actual practice hand firing is intermittent, and so involves the use of a large excess of air, with consequent heat loss in exit gases. Correct mechanical firing, with positive draft and correct mixing method, can alone ensure in commercial working a good boiler efficiency.

Leaving aside all test results, the writer's experience of the same firing method on the most varying types and sizes of boilers, with all grades of fuels, shows that there is no appreciable difference in efficiency of standard types of boilers, that the only reason for any boiler giving a low efficiency is a defective firing method, and that with a correct firing method any type of ordinary boiler design is consistent with the maximum efficiency commercially practicable being sustained.

The choice of the type of boiler is a matter of convenience; whatever the type its steaming capacity will depend on the furnace area and the quality of the fuel used, since the same correct firing method will give all boilers the same efficiency.

Most boiler ratings are based on forcing tests with good, clean coals; so, if inferior and dirty fuels are to be used, a large margin should be allowed. It is far easier to force the rate of combustion with good fuels than with inferior ones; but forced rates of combustion are never necessary if boilers have adequate furnace areas for the class of fuel available.

Boiler ratings based on total heating surface should be ignored; for the same total heating surface, one boiler may have a furnace occupying its entire ground area, while another may have a very much smaller furnace area; it is ridiculous to suppose the capacity can be the same.

No one has succeeded in finding the actual rate of heat transfer at various parts of boilers; but the practicable limit has not been reached, even in high-temperature forcing tests. The great bulk of the total heat is transferred by the front heating surface, so that total heating surface is no guide to capacity; the rear heating surface never receives more than a small fraction of the initial heat. Lancashire boilers have been made 100 feet long without any result beyond adding to the water capacity or thermal storage of the normal 30-foot length; and, similarly, watertube boilers can be built with abnormally long tubes or with abnormally deep banks of tubes without any advantage beyond increasing water capacity; and in the same way rear heating surface can be cut out, and abnormally high average heat transfer per square foot of total heating surface can then be calculated without any real advantage whatever over standard practice, which mainly represents the survival of the fittest.

The following table gives approximate figures for various types of standard boilers, as generally used, for about 1,000 gallons actual evaporation hourly when using best Welsh coal, and for proportionately lower duty with inferior fuels; in each case the furnace is about 42 square feet in area, suited for the normal combustion of about half a ton of coal. All weights are for 160 pounds working pressure.

The wide range of choice in regard to total heating surface, water capacity, weight and ground space for identical steaming duty is very marked. The figures are approximate, as all boilers can be varied within wide limits when required:

STANDARD BOILERS, ALL FOR 1000 GALLONS HOURLY, WITH BEST COAL.

Type of Boilers.	Total Heating Surface.	Water Capacity.	Weight of Boiler and Mountings for 160 Lbs.	Total Ground Space, Including Usual Settings.		
				Width.	Depth.	Area.
	Sq. Ft.	Gals.	Tons.	Ft.	Ft.	Sq. Ft.
Fire Tube.						
Two Cornish, each 6 ft. x 30 ft.	1,500	5,500	34	16	35	560
Lancashire, 8¼ ft. x 30 ft.	1,100	5,500	34	12	35	420
"Economic," 10¼ ft. x 15 ft.	2,500	3,500	30	14	20	280
Under-fired, 6 ft. x 15 ft.	1,300	1,500	14	10	18	180
Scotch marine, 11 ft. x 11 ft.	2,000	3,000	27	11	11	131
Vertical, with fire-box	1,400	1,600	15	10	10	100
Water Tube.						
Standard inclined tube	3,000	2,700	25	10	23	230
Shorter, inclined tube	2,500	1,800	20	10	18	180
Small diameter, inclined tube	2,000	750	15	10	12	120
Standard, vertical tube	2,200	2,100	23	10	20	200
Cylindrical, vertical tube	2,000	2,000	20	10	16	160

The "large water-space boiler," as the Lancashire boiler is aptly termed in Germany, is exceedingly simple and accessible; its first cost is low, and its large water capacity or thermal storage is valuable.

The "Economic" type of boiler, internally fired but with return tubes, is half the length, but larger in diameter than the Lancashire, with similar size furnaces; it is similarly set, and is naturally quicker in raising steam. The marine type of boiler is still more compact, but unless brick-set there is no heat transfer through shell plates to assist water circulation when raising steam. Under-fired multi-tubular boilers are cheap and compact. They are chiefly used in America and the Colonies, and are open to objections for modern high-pressure work unless the water is very good. Vertical shell boilers are very compact, but are little used. All cylindrical boilers are limited to medium-sized units; but a number of medium-sized units involve no loss of efficiency, and when one is cut out for cleaning or repair no occasion arises for undue spare boilers or for heavily overloading the others in a battery.

Watertube boilers have no limit as to size per unit, and their sectional construction makes them very easy to transport; their relatively small water capacity or thermal storage makes them quick to raise steam, but liable to prime or deliver wet steam if unduly forced. The average watertube boiler involves considerable saving in ground space over Lancashire, but not much over "Economic" boilers; but where space is valuable the short-tube type of watertube boiler is unapproachable, as its total ground space need be no larger than its furnace area.

A high-capacity boiler of any type does not therefore need forced rates of combustion, but merely a large furnace area and a good arrangement of plate or tube-heating surface.

An efficient boiler can be of any type, and the simpler and more accessible the better. All that is needed for efficiency is a correct firing method, viz.: mechanical regularity of fuel supply, positive delivery of air into the fuel, and a good mixing method, so that the mixture of the right proportion of air to combustible is completed and maximum temperature attained within the furnace itself.

The steaming duty of any boiler is considerably increased when the feed-water is first heated to 210 degrees by exhaust or waste steam, thus recovering latent heat from pumps and other auxiliaries; and then further heated to about 300 degrees F. by an economizer, using waste heat which the boiler itself is incapable of absorbing, because the water in the boiler is at the temperature corresponding to the steam pressure.

Wherever the water is hard or scale-forming the solids are easily arrested in a heater softener, viz.: an exhaust-steam direct-contact heater combined with appliances for feeding soda and for sedimentation and filtration.—*Engineering.*

CUTTING WITH THE OXY-ACETYLENE TORCH.

BY J. F. SPRINGER.

Those who read the writer's article in the November issue dealing with the methods of welding by means of the oxy-acetylene flame will remember perhaps the remarks on combustion. In welding and putting on metal in general it is combustion that furnishes part of the heat necessary to bring the metal to the desired temperature. This combustion occurs between gases. We have now to consider an operation where the production of heat is only a secondary matter. We are now going to use combustion as a means of *removing* metal.

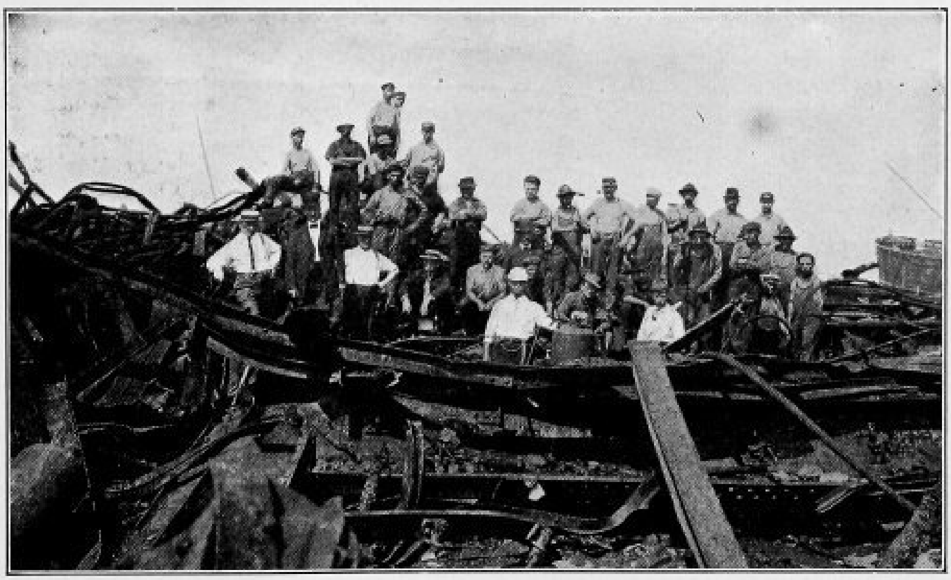
Steel, as is well known, is composed of iron and carbon. But so also is gray cast iron. The difference between the two is largely this: In steel all the carbon exists in a combined form; in gray cast iron this is not the case. The carbon in steel is chemically united with iron, the combination being known as carbide of iron or cementite. This substance is ordinarily intermingled with layers or films of pure iron. No carbon exists in the form of carbon uncombined. In cast iron there is such carbon. Now it has been found very practicable to consume away rapidly—or "burn," so it would seem—the metal steel, but not cast iron. No doubt it is the presence of free carbon that hinders the operation in the one case.

Briefly and typically stated, the procedure of cutting with an oxy-acetylene cutting torch is as follows: The metal is first highly heated by the use of the *welding* flame at the point where the cut is to begin. A second jet, located in the immediate vicinity of the heating nozzle, discharges a stream of oxygen upon the highly heated metal, and this results in a removal of the metal by a process which appears to be combustion in part or in whole. Moving the double nozzle along, the metal will be cut just as a handsaw will cut a board in two.

If the action is really confined to combustion, we are prepared to understand that the *conditions* of combustion must be met. However, it may seem incredible to some that steel can be burnt. Of this, there can be no doubt. Combustion, as ordinarily understood, means the chemical combination of a substance with oxygen. The chief components of steel—iron and carbon—are both capable of uniting with oxygen. Thus carbon forms two oxides—carbon monoxide (CO) and carbon dioxide (CO_2). So, also, iron forms several oxides. In fact, pretty nearly all substances will unite with oxygen under certain conditions. Asbestos is somewhat of an exception to this, the reason seeming to be that it is formed principally of oxides. That is to say, asbestos consists for the most part of substances that have already been oxidized or burnt. Silica, or sand, is burnt silicon; alumina, or clay, is burnt aluminum. In fact, nature is very well aware of a burning process which affects minerals and metals. Ordinary iron rust is the result of burning iron to one of its oxides. The processes of nature are, however, rather slow. No doubt a steel bar could, conceivably, be rusted through in such a way as to restrict the combustion to a narrow cut. But it is too slow a method. A great many things will yield to the effects of the oxygen in the air, given time enough. What we have to consider, then, are the conditions of a *rapid* combustion.

A fundamental condition of all combustion is oxygen. Consider, for example, what takes place when coal is burnt. The principal ingredient is carbon. This unites with the oxygen of the air to form one or other of the two oxides. Which oxide will result depends largely upon the amount of oxygen immediately available. To burn a pound of carbon to the monoxide requires 1⅓ pounds of oxygen; to burn it to the dioxide, twice as much.

Now, no furnace can be operated in disregard of this. For example, if oxygen in the ratio 1⅓ :1 is not supplied, the combustion will only take place for part of the carbon. There is no way of dodging this requirement. Extra heat will not do it; preheating the air will not do it. The right amount of oxygen must be supplied. Consider now what this means, on the assumption that all the iron and carbon involved in cutting through a piece of steel is chemically combined with oxygen. The oxide of iron formed seems to be Fe_3O_4. The carbon occurs in such a minute proportion that we shall err in only a



WRECKED STEEL WORK OF BURNED STEAMSHIP PIER REMOVED IN RAPID TIME WITH SAVING IN LABOR BY USE OF OXY-ACETYLENE CUTTING TORCHES.

very small way if we assume the whole product of combustion to be the oxide of iron. Since the atomic weights of iron and oxygen are 56 and 16, we readily see that the ratio of iron and oxygen in $Fe_3 O_4$ is 168:64. This is equal to 21:8. For 21 pounds of steel, then, we shall have to supply 8 pounds of oxygen; or, for 1 pound of steel, 0.38 pound of oxygen. As 1 pound of oxygen at the standard temperature and pressure occupies 11.21 cubic feet of space, the combustion of 1 pound of steel would therefore require 4.26 cubic feet of oxygen. Suppose, for example, that we wish to cut a 6-inch square bar of steel, consuming a layer of steel 1/8 inch thick. This 4½ cubic inches of steel weighs about 20 ounces, so that the oxygen requirement would be about 5⅓ cubic feet. This supply must come practically altogether from the special oxygen jet. The oxygen coming through the welding tip is consumed in the heating flame. Further, an excess of oxygen is no doubt necessary, because of the probability of a portion escaping off without combination. In actual practice, a cut of the character of the one mentioned, involving perhaps a very little more steel, consumed 10 cubic feet of oxygen from the auxiliary nozzle.

But oxygen is not the only requirement of combustion. Another essential of rapid combustion is temperature. It would seem as if every substance had a peculiar temperature to which it is necessary to raise it in order to accomplish combustion. Iron has one temperature; carbon another. It is very essential that these temperatures be attained in order that burning may result. It has been found quite possible to cut steel with its minute quantity of combined carbon, and practically impossible to cut gray cast iron with the somewhat greater amount in an uncombined form. It would seem as if the free carbon somehow clogged the action, perhaps by reducing the temperature through the considerable amount coming suddenly into the scene. I am not sure that the exact reason has been thoroughly searched out as yet. Wrought iron, with its almost negligible quantity of carbon, can be cut, too. From this it would appear that carbon is not the thing which facilitates cutting. As to steel, pretty much every kind can be cut—high-speed steel, machine steel, structural steel, nickel steel, manganese steel, chrome steel, and so on. It seems to make little or no difference whether it is forged, rolled or cast. However, in all cases a high temperature must be reached.

In operating a boiler, much advantage, in respect to combustion, is lost by neglecting this requirement of temperature. Thus, gases distilled from the coal may reach the boiler surface before they have combined with the oxygen of the air. They are accordingly chilled by the comparatively cool boiler, and so combination may not take place at all. Great waste results. So with the cutting of metal. There is little or no use operating the oxygen cutting jet, if the temperature of the metal is insufficient. The heating jet can be advantageously supplied by the oxy-acetylene flame which has an enormously high temperature, rising as high as 6,000 degrees F., so it is said. It is very true that this temperature will not be reached by the metal. Condensation and radiation operate too effectively for that. Nor is such a temperature desired, at least with steel and wrought iron. But, in order that the metal shall attain the high temperature actually essential, it is necessary that the flame shall have an excessively high one. Further, it is advantageous that this temperature shall be confined to a very narrow flame in order to give sharpness to the cut. It is very essential that the cutting jet be suitably arranged to follow the heating jet. The various requirements, it is claimed, are well provided for by the apparatus of the Davis-Bournonville Company, 104 West street, New York City.*

Now it may, in exceptional cases, prove unnecessary to continue the heating jet once the cutting is fairly started. Thus, a hole may be bored through a piece of steel by first heating the site, then turning on the oxygen jet, and, when action has fairly started, turning off the heating jet. It must not be sup-

DEMOLITION OF FOUR SCOTCH MARINE BOILERS BY THE USE OF OXY-ACETYLENE CUTTING TORCHES.

* For details of the cutting torches supplied by Walter McLeod & Co., Cincinnati, O.; the Industrial Oxygen Co., Hanover Bank building, Pine street, New York; the Linde Air Products Co., Buffalo, N. Y.; the F. C. Sanford Manufacturing Co., Bridgeport, Conn.; the Oxy-Carbi Co., New Haven, Conn., and other prominent manufacturers of oxy-acetylene welding and cutting apparatus, readers are referred to articles on this subject published in previous issues of THE BOILER MAKER, or to the manufacturers themselves.—EDITOR.

posed from this that the high temperature does not have to be maintained at every point where combustion or cutting is to take place. The heat needed for this comes, we must suppose, from the heat developed when iron, and carbon, too, unite with oxygen. This is the way a flame spreads from one part of a piece of paper to another. We light one corner with a match. Combustion is thus started, and continues from the heat developed by itself. It is quite true that paper is a very poor conductor of heat, and this, no doubt, militates against the propagation of the flame. But the ignition temperature is low, very low, and this, it would seem, compensates for poor conduction from point to point. It seems probable that much of the heat necessary to secure ignition during the cutting operation is supplied by the heat generated by combustion itself, and not merely from the heating flame. It would seem that we may, perchance, have here the controlling reason for the inability to cut cast iron. Pure iron and carbon both have high points of ignition, but they differ in heat conductivity. When the carbon is chemically combined, as in steel, its negative action is perhaps obscured. In cast iron there is more of it and it is uncombined. All this seems to be confirmed by the fact that a carbon electrode cannot be cut by the oxy-acetylene process, but a wrought iron or steel rod can.

It might be thought that an auxiliary jet of air would be effective in cutting. We can soon see that this is not the case, when we come to consider the total amount of oxygen that must be supplied. We calculated that over 5⅛ cubic feet would be required for cutting through the square bar, 6 inches on a side. Ten cubic feet were actually used. This was supplied at a pressure of 75 pounds per square inch. Now the oxygen in the air is excessively diluted, so that the pressure would have to be enormous to get enough oxygen on the spot in the time employed. It might be thought that by operating more slowly a less excessive pressure could be used and the requisite amount of oxygen supplied. But another difficulty is present. This concerns the cooling effect of the great amount of nitrogen present in the air. No; the way to accomplish results is to use oxygen itself undiluted with anything else.

In cutting through metal, whether thick or thin, the cut is made all the way at one time. Thus, in cutting 6-inch metal, the cut is not made part of the way through upon one passage of the jets across and then finished by another passage. The cut is made just as with a handsaw. Indeed, the jets are directed downward and with the upper portion leaning in the direction of movement. The cut is thus made in a very similar manner to that made by the saw. However, the profile is perhaps steeper. Further, it is not precisely straight, but has a slight curvature.

Now the little inner flame of the heating torch is quite short, usually having a length of about three times its diameter. It will readily be seen, then, that this flame often does not extend to the full depth of the cut. This seems to show that dependence for the ignition temperature must frequently be put upon the heat of combustion for the lower part of the cut. Some heat is carried to this point, no doubt, by the oxygen jet subsequent to contact with the heating flame. But this is surely insufficient to bring the temperature to the ignition point. It must be largely from the heat of combustion that the necessary temperature is obtained.

The oxygen supplied for the cutting jet comes from a separate tank than that which supplies the heating tip. In fact, it is generally advisable that the cutting oxygen be under a higher pressure. As a rule, the thicker the metal cut the higher this pressure must be. For very thin metal the pressure need be no more than, say, 18 or 20 pounds. The pressure of both supplies of oxygen may, in this case, be nearly the same. In the case, however, of the 6-inch metal already referred to a pressure of 75 pounds was employed. It would seem to the writer that the rapid rise of the advisable pressure for increasing depth of cut is due to the necessity to get the temperature in the lower part of the cut to a high point. The combustion of an ounce of steel will result, no doubt, in the generation of the same number of thermal units, whether the combustion be rapid or slow. But temperature is another thing. Rapid combustion will generate a high temperature because of the concentration of the quanity of heat. A great deal of heat is generated in a confined space in a short interval of time—hence a high temperature.

Of course, it is the practical application of a process which interests the industrial world. At the same time it should be remembered that a knowledge of the underlying principles of the process can hardly fail of proving useful, especially where variations from established practice have to be made. It is recommended that the foregoing account be well digested.

The cutting of sheet steel is a matter which has been pretty well attended to. The practice varies somewhat in respect to the pressures to be used. However, the following may be taken as typical: If the steel is ½ inch or less in thickness, then the oxygen of the heating tip is kept at 14 to 18 pounds and of the cutting jet at 20 pounds. For heavier steel, but not thicker than 1½ inches, the two pressures are 14 to 18 and 30 pounds. For sheets thicker the pressure may be kept at 18 to 22 and 45 to 75 pounds. Where a factory has a great deal of cutting to do of a few sizes, a little experimentation should be made to determine the most economical pressures. These may very well vary with the character of the steel itself. The consumption of oxygen is, at times, an important point. It is more expensive than the acetylene and much more is used. However, when the high pressures are employed the cutting can be rather quickly performed, so that the total amount will be reduced for that reason, although increased because of the pressure.

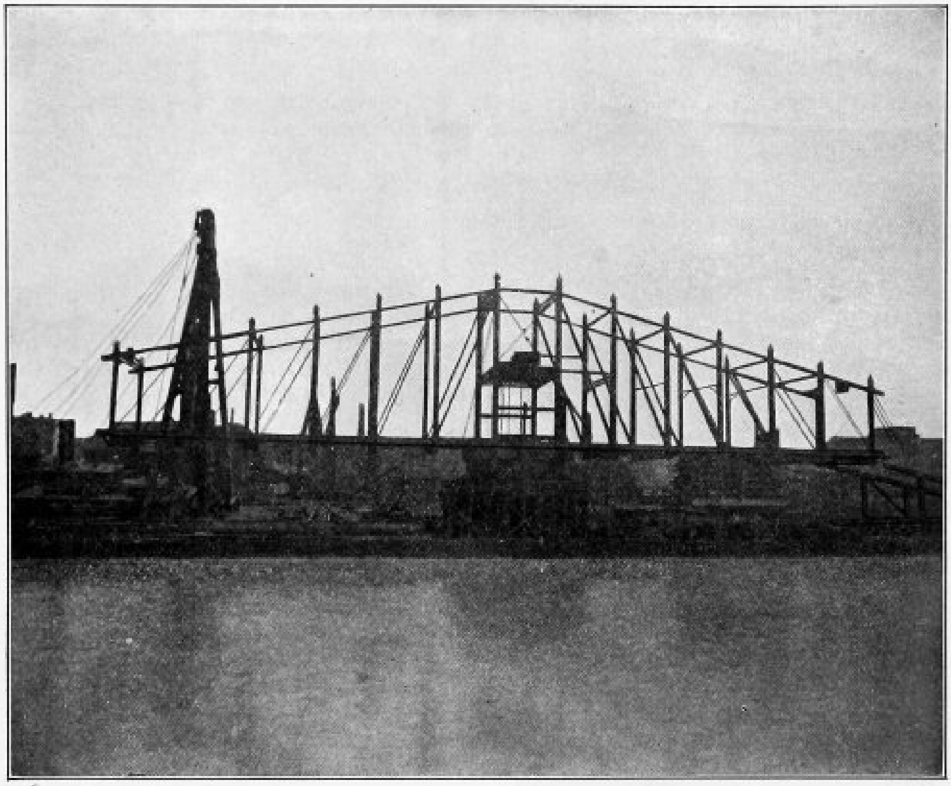
A mechanical means of cutting sheet metal has been devised. The apparatus is carried across the sheet with precision and regularity. This is probably the best way to cut sheets. Further, a device has been gotten up for the purpose of cutting steel tubes when in the vertical position. It is in use for the cutting off of shells forming the envelope of a certain kind of bearing piles. This is suggestive of a good deal of cutting where the work is immovable. For example, steel sheet piles are driven into the soil. It is very difficult to get the heads even when driving. So here the oxy-acetylene cutting tool is brought into requisition and the heads trimmed off to a definite level. It may be necessary to cut circular holes, to cite another example, in the hull of a steel ship. Thus 125 port holes were required to be cut in steel plate 15/16 inch thick. As the steel was a nickel alloy, the job would have been rather a difficult one by ordinary means. But nickel steel was no especially difficult thing to the oxy-acetylene cutting torch. Each hole was cut, in fact, upon an average in six minutes.

Again, take the matter of cutting up immovable scrap into manageable pieces. A notable example of this occurred not long ago in New York City. Where 136th street crosses the Harlem River was a large steel structure forming a swinging span. This was rotated upon a pier in the middle of the river. The span itself was 330 feet long. It was made up of a network of I-beams and riveted I-beam sections, or the like, and weighed upwards of 450 tons. As it was desired to remove this bridge, a considerable problem presented itself. By ordinary methods it is said it would have taken six weeks to two months to accomplish the work. With the aid of the oxy-acetylene cutting apparatus the job was done in one week. Only about 1,500 cubic feet of oxygen and 450 of acetylene were used. With oxygen at 2½ cents and acetylene at 1 cent, the total cost for all gas would be $42. Two outfits were employed, and the whole was cut into seven manageable sections. Thus the first two sections totaled about 50 tons. The next two weighed about 66 tons apiece. The method employed was, briefly, about as follows: A floating derrick would be gotten into position to take the weight. The torch would then cut the section free, when it would be lowered onto the grillage of the fender. The week's time was occupied not so much with cutting as with getting ready for it. Thus it was necessary before removing a section on one side of the central support to block up the other side. It seems that this part of the undertaking required very careful work. Oxy-acetylene cutting is itself not a slow thing at all.

It sometimes becomes necessary to cut off steel girders extending through a wall. The work may have to be done from a scaffold or similar support. But the process is quite equal to meet the difficulties of such cases. An example is the case of a four-story building whose girders had to be trimmed. In all there were 242 feet of cutting. The steel was 3/16 inch thick. The contractor who did the work says that they know of no other method except the portable emery wheel. If it had been used the expense would have been considerably more.

Take another case. At 95 William street, New York, it was desired to cut up and remove a large steel tank made of ½-inch sheets. Its dimensions were 8 by 10 by 4 feet, and working space was but 1 foot. A sledge could not be swung for the purpose of cutting rivets. It was possible to draw the tank out a short distance, cut off a section, and then repeat. In this way the problem could have been solved. But this solution was, apparently, not attractive. With the oxy-acetylene torch all difficulty disappeared, as is shown by the fact that in one day's time the whole was cut into thirteen pieces. It is thought that a week or ten days would have been required by any other procedure.

The cutting of steel plate, when it is accessible, is fast being standardized. A mechanical method controls the operation of the torch by means of a hand-screw. Thus by using the mechanical method, ½-inch plate can be cut at the rate of 1½ feet per minute, with the cutting oxygen at 15 pounds pressure. Under the same conditions 9/16-inch plate can be cut at 1¼ feet per minute. For ¾-inch plate 1 foot can be cut per minute with the pressure at 25 pounds. The same speed can be maintained with 1-inch plate by increasing the pressure to 32 pounds. If the pressure is raised to 42 pounds, 1 foot per minute can be cut of 1¼-inch plate. In making these cuts about ⅛ inch of the metal is cut away. Ordinarily, the important thing is not the waste of metal but the waste of gases when a wider cut is made than is necessary. Six-inch steel can be cut with the narrow kerf of only ⅛ inch or thereabouts. If the pressure is raised to 125 pounds it seems possible to cut it at the rate of 1 lineal foot in about three minutes.



MADISON AVENUE BRIDGE, NEW YORK, REMOVED BY CUTTING INTO SECTIONS WITH OXY-ACETYLENE TORCHES AND REMOVING THE SECTIONS ON LIGHTERS TO BE SCRAPPED.

The question of expense is governed by the total amount of gases used and the labor cost. Ordinarily, 30 cents per hour, or even less, is to be counted for labor. Perhaps the fairest thing to do as to gas consumption calculation is to estimate on the basis of the cubic inches of metal removed. A test was made in connection with cutting off the risers of steel castings By the use of the cold saw 181.69 cubic inches were cut in the space of 405 minutes. Apparently, however, this was the day's work. Estimating the labor at $1.90, and the grinding of the saw at $0.86, we have a total of $2.76, exclusive of expense for power. This gives a cost of $0.0152 per cubic inch. With the oxy-acetylene torch, 135 cubic inches were cut per hour. If we put the labor at 25 cents, oxygen at 2 cents and acetylene at 1 cent, it is calculated that the new process enables the work to be done at a cost of but $0.0080 per cubic inch.

Again, a series of sixteen miscellaneous cuts were made, the areas ranging from 5 to 21 square inches. The total area amounted to 187.46 square inches. The oxygen used amounted to 42.5 cubic feet. We thus get 0.228 cubic foot of oxygen per square inch cut. At 2½ cents the cost is $0.00670 for oxygen per square inch. The acetylene used per square inch is taken 0.048 cubic foot, having a value at 1 cent per cubic foot of $0.00048. The labor at 25 cents per hour is estimated at

$0.00107 per square inch cut. Adding, we get for total expense of cutting an area of 1 square inch of steel, $0.00825. These results are to be regarded as those obtainable by an expert. It would seem safe, however, to take 1 cent as a fair commercial expense for cutting an area of 1 square inch. Another series of tests, thirty-eight in all, in which the areas ranged from 1.56 to 75.60 square inches, has been tabulated. The total area cut was 615.56 square inches, and the total amount of oxygen used was 195 cubic feet. The average per square inch was, accordingly, 0.3168 cubic foot, having a value of $0.00792, with oxygen at 2½ cents. Adding the acetylene and labor expense, using the values of the former example, we get for the total cost per square inch of area $0.00947. The time actually consumed in making these thirty-eight cuts was eighty-three minutes.

Not long ago it was required to remove two boilers from a ferryboat running across the North River at New York. The metal to be cut was ⅞ inch thick, and there was 160 lineal feet. It is said, in effect, that the labor cost at $2.50 per day, which would have resulted by following the old method, would have been $480. By means of the oxy-acetylene process the whole job was done by one man in eleven hours. The scale was removed in advance. The pressure on the cutting oxygen used was 45 pounds.

LEGAL DECISIONS OF INTEREST TO BOILER MAKERS

INJURY FROM DEFECTIVE STEAM PIPE—CONTRIBUTORY NEGLIGENCE.

The engineer of a manufacturing company was scalded and burned as a result of the breaking of a defective steam pipe attached to the boiler, which was used to clean the boiler by "blowing-off," and ejecting through the pipe, by means of steam, the sediment and dirt that, from time to time, accumulated in the boiler. He sued his employer for damages. He had been in charge of the boiler, as engineer, for three weeks prior to the accident. The apparatus that caused the injury consisted of a 2½-inch pipe running from the boiler through the wall to a "Homestead valve" on the outside of the building, to which valve were affixed other pipes connecting with a horizontal pipe about six feet long running just above the surface of the ground to a terminal point where the steam and sediment were discharged. For several years, while acting as night watchman and assistant to the engineer, the plaintiff used this, or a like appliance, almost every night for the purpose of blowing out the sediment. The pipe, outside of the wall, was in three sections, and they were put in position only when the work of blowing-off was to be done. These sections were screwed together when in use, and unscrewed and put away when not in use. When not in use they were always stored under an arch of the chimney, in a place exposed to the weather. When the plaintiff hired as engineer it became his duty to keep the boiler clean, and, in such work, to use this or a like appliance of pipes. During the prior three weeks he had used the appliance several times. On the day of the accident he procured and screwed the pipes together and turned on the steam, when, by reason of the threads being "rusty and insecure," due to disintegration through exposure to the elements, the threads "stripped," allowing the pipes to part, whereby he was scalded. Immediately after the accident it was seen that several threads of the horizontal section of pipe which had been screwed into the other section had been "stripped or pulled off," and that two threads which had not been entered were "rusty and insecure, and had been decreased from their original size by rust." The company maintained a machine shop next to the boiler room, where were kept an adequate supply of 2½-inch pipes and fittings and tools to cut a thread, and the plaintiff frequently cut pipe there.

Under these circumstances, the court held that the condition of the threads was an obvious defect and one which the plaintiff, by exercising a reasonable degree of caution, would have discovered, and that he failed in his duty to use due care to observe the danger and to avoid it by substituting new pipe from the adequate supply at hand. Three justices dissented. In his dissenting opinion, Garrison, J, said: "The notion that, because the unsafe condition of an appliance would have been discovered by the master, if he had not been negligent, it was obvious to the servant, is fallacious in the extreme; yet not more so than the opinion that because, after an accident has happened, its cause is apparent to those whose attention, is then concentrated upon its discovery, it was, therefore, before the accident, a danger that was obvious to the ordinary observation of one whose attention, by the terms of his calling, was concentrated upon the performance of the work he was set to do."—*Weatherby v. Newfield Smyrna Rug Company. New Jersey Court of Errors and Appeals.*

INJURY FROM BURSTING OF CYLINDER IN STEAM FEED.

An employee of a manufacturing company sustained injuries from the bursting of a cylinder in a steam feed, for which he sued his employers. They contended that the accident was caused by a sand hole in the cylinder, for which, as a latent defect, they were not liable. The evidence showed that the cylinder was of cast iron, had been in use for 20 years, and had been re-bored at least twice since its construction. This re-boring had rendered the shell much lighter and weaker. In some places it was only five-sixteenths of an inch, while the evidence showed that it should have been three-fourths of an inch to be safe. In affirming a judgment for the plaintiff, it was held that the jury would have been justified in finding, upon this evidence, that the shell of the cylinder was not thick enough to stand the pressure, or that the employer's tests were not sufficient or proper to determine the defects. These tests consisted merely of inspection made by looking at the cylinder and making the "hammer test."—*Suess v. J. S. Stearns Lumber Company. Wisconsin Supreme Court.*

DELAY IN PROSECUTING ACTION FOR INJURIES BY BURSTING CYLINDER RELIEVES DELINQUENT.

A complaint in an action for damages caused by the bursting of the cylinder of a boiler was served in 1905, and thereafter no proceedings were taken until 1910. In the meantime, one of the defendant's witnesses, whose work was about the boiler, and who was thoroughly familiar with its condition at the time of the accident, had died. Another employee who was preseint when the accident happened and his former foreman, who was familiar with the facts, could not be found. It was not the fault of the plaintiff that the delay had taken place, but of her former attorney. But it would be unjust to the defendant, after the lapse of time for which he was not responsible, to bring him into court, deprived of several important witnesses. The case was therefore dismissed.—*Burns v. Meister. New York, Appellate Division.*

MEASURE OF DAMAGES FOR BREACH OF WARRANTY OF ENGINE.

An engine was sold under an implied warranty that it was sound and merchantable, and reasonably fit to operate a sawmill. The price was $288, and the buyer subsequently sued the seller for $1,000 damages for breach of warranty. A defense was that the plaintiff knew and assented to the terms of defendant's catalogue, that, under no circumstances, would the latter be responsible for any damages beyond the value of the goods. It was held that the measure of damages for breach of the warranty was governed by South Dakota Civil

Code, Section 2,300, providing that the damages are the excess, if any, of the value which the property would have had at the time to which the warranty referred, if it had been complied with, over its actual value at that time. Therefore, it was error to admit evidence of loss of profits by the plaintiff, and to charge the jury that, if he did not know of the terms of the catalogue, he might recover such amount as he was damaged by the defects in the engine. —*Christiernson v. Hendrie & Bolthoff Manufacturing & Supply Company. South Dakota Supreme Court.*

SUGGESTIONS FOR MAKING DIMENSIONS OF BOILERS STANDARD.*

To-day there is an increasing demand for higher steam pressure in boilers, and also a tendency to the centralization of steam boiler plants.

The number of boiler explosions which occur day after day, with their horrible train of victims, demands that we, as a society and as individual members of the American Institute of Steam Boiler Inspectors, should earnestly endeavor to minimize the danger of explosions.

The important factor in the world's work of to-day is a strict attention and close investigation of small, seemingly unimportant details. We all feel the need of making measurements of boilers standard. The object of this paper is to be just to the manufacturers, to the purchasers and to the inspectors of steam boilers, for "when inspectors disagree, who will then decide?" Different individuals may have different methods of measuring boilers, and both may be reasonably correct. We will apply our suggested standard of measurements to common types of boilers.

When considering the length over all of the shell or drum of a boiler, we will suppose the boiler to be without fittings and out of its setting. The usual and suggested method of measuring the length of a horizontal cylindrical tubular boiler with flush heads is from the outside flat surface of the front tube sheet to the outside flat surface of the rear tube sheet, or the distance between two perpendicular lines which touch the outer surfaces of tube sheets at their respective centers, the depth of nuts on through bracing and rivets heads being neglected, to avoid confusion. This method could also be followed out in measuring water-tube boilers of the Babcock & Wilcox, Heine, Geary, Herreshoff, Hazelton, Climax and Worthington type; the upper and lower drums of the Cahall & Wicks vertical water-tube boilers, the perpendicular lines touching the outer centers of the bumped heads. You well understand that. Hazelton, Climax, Cahall & Wicks vertical boilers are supposed to be in a horizontal position, and the perpendicular lines are at right angles to the axis of the shells or drums of these boilers.

In measuring the length of the locomotive type of boiler with inclined fire-box, this same method could be followed, the perpendicular lines touching the bottom of the water leg at the front end, and the end of the extension sheet at the rear end. It may be said, and with reason, that this extension sheet is not the boiler, but the smoke box or part of the same. We have this same question brought into the horizontal tubular boiler, with the overhanging front, and vertical boilers, with the hanging of upper tube sheets, convex to pressure. The method of measuring boilers of these types has been to consider the smoke connection as part of the boiler, and in giving "length over all" this extension sheet has been included. This has been the practice for so long that it would be advisable to have it remain as it is.

In measuring boilers of the Robb Mumford and Robb-Brady type, it is suggested that the length of the upper and lower drums be given separately.

The length of vertical boilers is usually taken from the bottom of the base ring to the outer flat surface of the upper tube sheet; when the flanging of the tube sheet is concave to pressure and when the flanging is convex to pressure, as in the Manning vertical type of boiler, the extension of the shell plate is included in the length of the boiler.

The question is now brought to our notice as to what is the correct length of Corliss vertical, vertical boilers with submerged heads, and Scotch or Continental boilers with furnace-tube extension. We consider that it is reasonable to include the manhole frame on Corliss vertical, the flanging of submerged head and the furnace-tube extension of the Scotch boiler when "length over all" is taken.

You will remember that in the first portion of this paper the length of the shell or drum was being considered. In giving the "length over all" of the Cahall & Wicks, etc., vertical types of boilers, with all tubes fitted and boilers supposed to be in a horizontal position, we suggest that the length be taken in the same manner as in the Heine, Babcock & Wilcox water-tube type, the perpendicular lines touching the outer centers of the upper and lower bumped heads.

In measuring the length of cast iron sectional boilers, we suggest that, when the boilers are fitted with steam or mud drums, the extreme length of the longest drum (when these drums exceed the length of all the sections combined) be taken.

While considering the length of boilers, your attention is called to Babcock & Wilcox marine, the Robb Mumford water-tube, the Sterling water-tube, etc., types of boiler. When "length over all" is asked, it is correct to give the length as required. You will see, then, without further remark, that the length of the drum may be the width of the boiler.

The question has been brought to our notice as to whether length of boilers should be given in feet and fractions of a foot, or in feet, inches and fractions of an inch.

While the safety of a boiler may not be affected by a reasonable length of shell, it is considered proper to give length in feet, inches and fractions of an inch. Take the horizontal tubular boiler with flush heads. We may have the length of shell given as 15 feet 11 inches, and length of tubes 16 feet. Then, again, many boilers are built for specification, in which fractions of an inch in length are required.

While the question of length is being considered, we deal with length of tubes and furnaces.

Many boiler rooms have the certificate of annual inspection posted in the engine or boiler rooms. Would it be safe for the owner or user of such boilers to order a new set of tubes, giving the length of tubes as written on the certificate? Or is it understood that the sender of the tubes is guided by his judgment?

In taking the length of plain or corrugated furnaces, we take the distance from center of rivets in the mud ring or extension sheet to center of rivets in the tube sheet. In calculating the collapsing pressure of a plain cylindrical furnace, the length is an important item. This opens discussion as to what is the proper length or unit of length in furnaces fitted with Adamson's rings." Seeing that 3 inches are allowed on flanging as self-bracing, it is reasonable to suppose that the length or unit of length of such furnaces should be taken from the center of rivets in the plain cylindrical part of the furnace to the commencement of the curvature of the flange when the furnace is fitted with one ring, and when fitted with two or more rings, center units of length to be measured from the commencement of curvature to commencement of curvature of flangings.

* Address by Inspector Geo. R. Richardson, before the American Institute of Steam Boiler Inspectors.

Neglecting the wear incident to age and service, can we not apply this rule also to vertical boilers fitted with reverse flange at the base of furnace sheets?

We sometimes find plain cylindrical furnaces of Scotch or Continental boilers made up with two or three courses. It has been suggested that the girth or circumferential seams of these furnaces act as stiffening rings, and that unit of length be taken from center of rivets to center of rivets in circumferential seams.

In measuring the pitch of rivets in longitudinal seams of boiler shells or drums, it is suggested that the shortest pitch of the weakest ligament be taken. By this is meant that it seems inconsistent to measure the length of a course and then divide spacing equally by the number of rivets in the said course. You will perhaps get a clearer conception of this when you imagine the length of a sheet being made up by a number of concentric rings, each individual ring being the width of and depending upon the strength and pitch of its rivets or the strength of the ligament.

This question brings to our notice the proper pitch of holes and the strength of ligament in boilers of the Sterling, Hazelton, Herreshoff, Yarrow, etc., water-tube type of boilers. We may have boiler shell plates drilled for receiving tubes 1⅛ inches, 3 inches, 3½ inches and 4 inches in diameter, as the case may be. Take, for instance, a tube 4 inches in diameter. The hole in the shell or drum may be drilled 4-1/32 inches to 4-1/16 inches in diameter, and not 4 inches in diameter, as is sometimes assumed. We could readily find this in a boiler not yet assembled, and this extra diameter of tube hole would materially affect the strength of the ligament, and consequently the safe working pressure of the boiler.

It is suggested that in building Babcock & Wilcox water-tube type of boilers a standard length be made for mud-drum nipples, so that a free examination could be made of the area exposed to the products of combustion, the length of this exposed section to be not less than 1 inch.

In measuring the diameter of a shell or drum of a boiler, our measurements should be absolutely correct to the fraction of an inch. You will find this clearly defined when measuring horizontal tubular, Manning vertical and vertical boilers with straight shells, wherein boilers are made up of three courses, and the middle or center course is an outside sheet and the inside diameter of the inside sheet is an even figure in inches.

The question should be determined as to what is the proper diameter of a conical sheet when fitted into a shell. Shall we take a mean of the large and small diameters, or is it more correct to consider the diameter of such cones in units of length per pitch of rivets? It is suggested that the latter method be followed when estimating the safe working pressure.

The question as to what is the outside and inside diameter of a plain cylindrical flue or furnace may be made clear by considering such flues or furnaces as one unit, and not fitted into the shell of a boiler.

The diameter of a corrugated furnace is usually measured by taking the smallest inside diameter plus 2 inches, giving a mean diameter of the furnace. A horizontal and vertical point or male gage made to furnaces of this type when new may be of interest to operators and useful to inspectors of boilers when making regular internal inspections. By using such gages we could readily and accurately see any distortion of surfaces.

It is suggested that the pitch of stay-bolts be measured in thirty-seconds of an inch when necessary. This is an important fraction when furnace sheets are ⅜ inch in thickness and less than 38 inches in diameter; and when thickness of furnace sheets is given in thirty-seconds of an inch, the horizontal or circumferential pitch of stay-bolts should be taken at the curved surface of the sheet. You will readily see that if the pitch is taken in a straight line, or the shortest distance between the centers of the stay bolts, the former method is correct.

In calculating the pressure allowed on surface supported by stay-bolting, it seems reasonable to deduct the area of the stay-bolts; and why not carry this further, and permit the area of through bracing to be deducted from the area supported? Would it not also be reasonable to allow a maximum unbraced area of flat surfaces? If this area is governed by a specified number of square inches, direct preference would not be given to braces of large diameters, which it is reasonable to suppose have a sponginess or deterioration of fiber at their centers; although such braces, when unwelded and over 1¼ inches in diameter, are sometimes allowed a greater value than through braces of smaller diameter, and this greater value of large braces is given regardless of how the load is distributed on the flat surfaces. There is some variation in the commercial sizes of diagonal braces. It is suggested that the actual size of the brace be taken, without reference to commercial size.

In diagonal bracing the length of the brace is important. It is suggested that a minimum length of such braces be established, as you will see that the greater the angle which a diagonal brace is to the shell of a boiler, its relative value is reduced.

In computing the safe working pressure per square inch on the bottom or water drums of the Sterling water-tube, Cahall & Wicks vertical water-tube and similar types of boilers, and the pressure per square inch allowed on the stay-bolts of vertical boilers, would it not be advisable to consider the extra pressure per square inch due to the weight of the water when boilers are in operation? Thus, where the average water level is from 15 feet to 24 feet above the center of the lower drum or the bottom row of stay-bolts, means that there is at these points a pressure per square inch of from 6.9 pounds to 10.4 pounds per square inch over and above the pressure in the steam space of such boilers.

In conclusion, I would say a word on tubes. Each tube in a boiler acts as a brace or stay. We have nothing to govern the thickness or quality of such tubes. In view of this fact, and the number of disastrous tube explosions which have occurred, it is suggested that a specified gage and quality of tube be made standard for power boilers.

Large Boiler Plates Successfully Used by Scotch Boiler Makers.

That progress has been made in recent years in boiler making and in the manufacture and handling of heavy plates is shown by contrasting a number of boilers which are being made by Messrs. James Neilson & Son, Ltd., Alma Boiler Works, Crownpoint Road, Glasgow, with boilers made previously. Within the memory of men who are not very much past middle age, the ordinary plates used in the shells of boilers ran from three to four feet wide by seven or eight feet long, and weighed some four or five hundredweights at most. A number of shell plates for boilers now being built by Messrs. Neilson measure 31 feet 7 inches long by 12 feet 5¼ inches wide, and are believed to be the largest plates ever seen in Glasgow. They have a superficial area of no less than 393 square feet, and weigh between nine and ten tons each.

The cost of these plates is very great, for whereas the price for ordinary plates (i. e., not over four tons weight and not over eight feet wide) runs about $34.07 per ton, the extras on these large plates run to $62.05 per ton, giving a total of $96.11 per ton. These great extras are not incurred on account of increased cost of making the plates, but to cover the cost of the heavy and expensive machinery required in their manufacture, and the risk of breakages, which is considerable.

The large plates can be handled and bent and riveted with as great or even greater facility with modern tools as the smaller plates of 30 or 40 years ago could be with the machinery then in vogue.—*Glasgow Herald.*

BOILER SHOP DEVICES.

Many methods of setting up for different classes of work generally practiced before the introduction of pneumatic tools into railway shops are now considered inadequate, and are being replaced by others more adaptable to high speed tools. The accompanying illustrations, Figs. 1 and 2, show two methods of setting up for this work, and by the employment of either the drill can be run almost continually. Fig. 1 shows a scaffold used at the Brewster shops of the Wheeling & Lake Erie Railway, which is attached to the firebox near the mud ring, and at the top. It is made of 3 by 3 by 3/8-inch angles, one at the front and one at the rear end of the firebox. One side of these angles contains notches spaced 6 inches apart to receive U-bolts, which support a plank extending uprights support a cross-bar, *C*, which is adjustable and contains centers 2 inches apart to accommodate the air motor center. The adjustable cross-bar is held in the desired position by the nut, *D*. The rack is also provided with a platform support, *E*, which, like the cross-bar, can be adjusted to any height.

Fig. 3 shows a method in use at the Collinwood shops of the Lake Shore & Michigan Southern for supporting boilers during their construction or while they are being repaired. The trestles are made of wood, the detail dimensions of which are given in the illustration, and are held together by 5/8-inch bolts throughout. These trestles each support the mountings for two rollers which turn on trunnions set in recesses in the mountings, and so arranged that they may be varied to three spacings for boiler shells of different diameters. These trestles furnish a very convenient addition to a boiler-shop equipment, inasmuch as a boiler placed upon them can be readily rolled to any desired position with very little effort.

Two air motor supports are shown in Figs. 4 and 5. That shown in Fig. 4 is used at the Collinwood shops of the Lake Shore & Michigan Southern Railway in connection with work on the outside of the boiler, such as drilling out staybolts and tapping side sheets. It consists of a base of 1/2-inch iron formed to fit the top of the boiler, and into this base a 2-inch

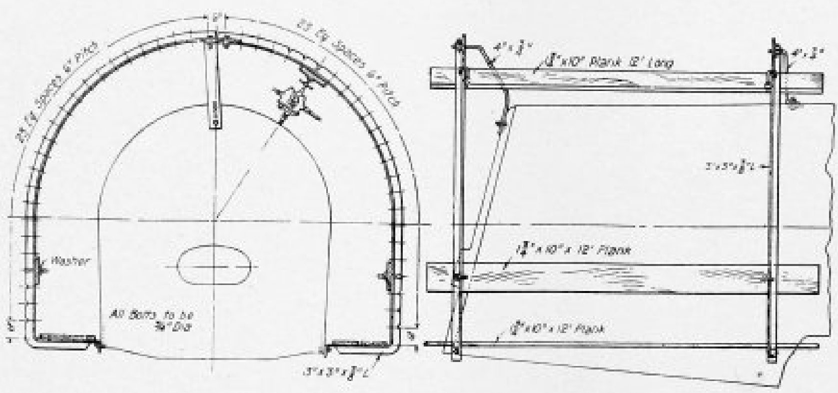


FIG. 1.—SCAFFOLD USED FOR DRILLING STAY-BOLTS, WHEELING & LAKE ERIE RAILROAD, BREWSTER, OHIO.

from one angle to the other, furnishing a means of holding the air motor center. As each row of holes is completed the plank is shifted to the next with very little delay. Another rack for accomplishing the same purpose, shown in Fig. 2, is in use at the Collinwood shops of the Lake Shore & Michigan Southern Railway. This rack, instead of being attached to the boiler, as in the previous case, is set upon the floor beside the pit. The rack is held at the base by a hook, *A*, which is fastened to the rail and is stiffened by the brace, *B*, riveted to the top of the rack and secured to the floor by lag screws. The flue is expanded, which serves as an upright or mast upon which the arm swings. This upright is stiffened by a U-shaped brace riveted to the base. The arm of the crane, which is 5 feet long, swings upon the upright and carries the traveler from which the motor and its counterweight are suspended. This device greatly facilitates the use of an air motor. The other support shown in Fig. 5, used by the Chicago, Burlington & Quincy at the Aurora shops, is for service on the inside of the firebox, principally for supporting an air hammer while expanding the flues in the flue sheet. The construction of this

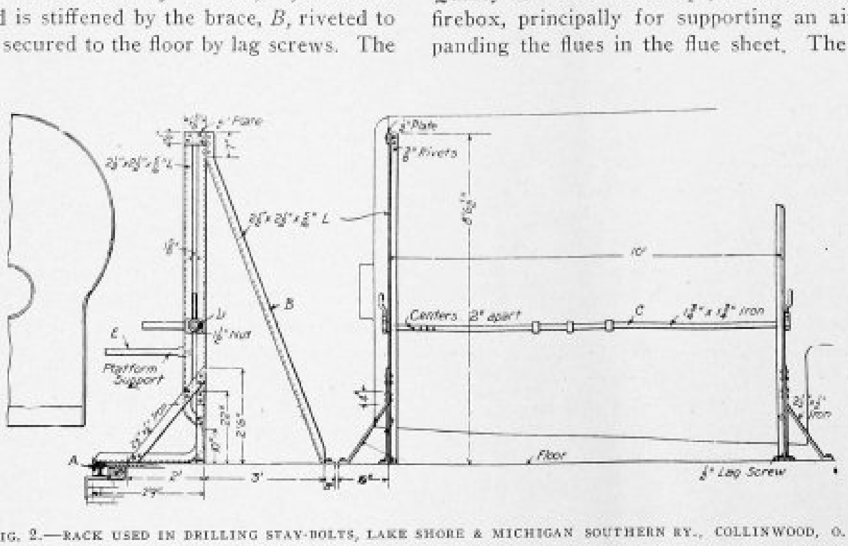


FIG. 2.—RACK USED IN DRILLING STAY-BOLTS, LAKE SHORE & MICHIGAN SOUTHERN RY., COLLINWOOD, O.

device is very simple. It consists of a 1-inch pipe cut to the right length for the firebox in which it is to be used, which serves as a way for a traveler. A ⅞-inch rod, threaded nearly the entire length, pointed at the outer ends and carrying a ⅞-inch nut, is placed in each end of the pipe. One of these rods has an eye, *A*, which makes it possible to turn it with a bar, the eye being flattened to accommodate a wrench, which may be used, instead of a bar, in turning the point. The traveler contains a pulley over which a rope is passed, the ends of the rope carrying the air hammer or motor, and the counter weight.—*The Railway and Engineering Review.*

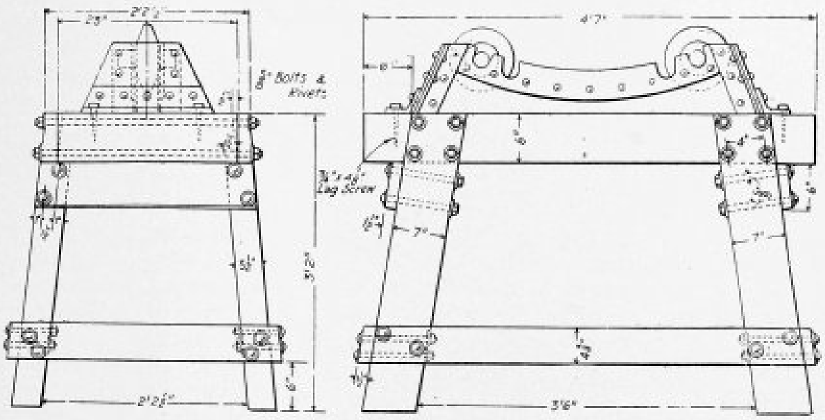


FIG. 3.—TRESTLES FOR SUPPORTING BOILERS, LAKE SHORE & MICHIGAN SOUTHERN RY., COLLINGWOOD, O.

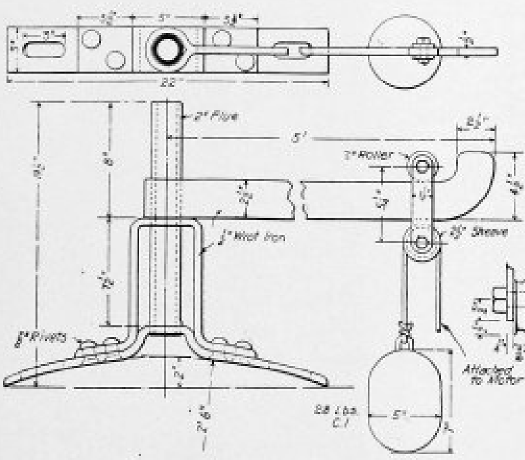


FIG. 4.—AIR-MOTOR CRANE, LAKE SHORE & MICHIGAN SOUTHERN RY., COLLINWOOD, O.

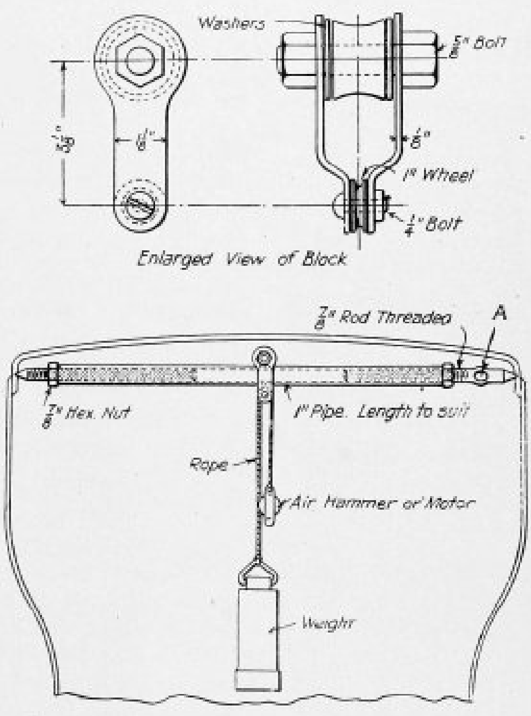


FIG. 5.—DEVICE FOR SUPPORTING AIR HAMMER IN FIRE-BOX, CHICAGO, BURLINGTON & QUINCY RAILROAD, AURORA, ILL.

Rules Governing Oxy-Acetylene Apparatus.

The large increase in the number of shops that are using the oxyacetylene welding apparatus for manufacturing and repairing their various products, has caused the National Board of Fire Underwriters to recognize this industry and pass a set of rules and requirements for the safeguarding of the apparatus and the property on which it is located. This has been due largely to the fact that a number of accidents of a more or less serious nature have occurred in the recent past. These, in turn, have been due to the fact that the industry is a new one, and the design of the apparatus has not always been that most conducive to safety.

When the apparatus is properly designed, and the necessary safeguards used, there is little more danger in handling the oxygen and acetylene gases than there is in handling the illuminating gas or electricity with which shops are lighted, or the kerosene oil which has been so largely used in the past. Without the proper knowledge of these gases, however, and the necessary apparatus for their use, they become very dangerous elements.

The rules and regulations that have been laid down for the construction and installation of the apparatus, the control and use of the gases for heating and welding purposes, are printed in a 3½ by 5½-inch booklet of 30 pages, and we would strongly advise those who have welding apparatus of this kind, or those who are contemplating putting it in, to send to the National Board of Fire Underwriters, New York, for one of these booklets. The rules cover the construction of the apparatus in every essential detail, from the foundation to the torch that applies the heat to the work.

These rules are simple in their nature and easily applied at small cost to any apparatus that may be in use. It will enable those who are contemplating putting in apparatus of this kind to see that the builder has complied with the necessary rules. When they have been complied with, there will be little danger of loss of life from explosions, or of losses by fire, as they place practical safeguards around the apparatus that enable it to be safely used when the ordinary amount of care is exercised.—*The American Machinist.*

THE STRENGTH OF OXY-ACETYLENE WELDS IN STEEL.

A knowledge of the strength of welds which have been made by the oxy-acetylene process is of the utmost importance where this method of welding is used in boilers, tanks, or other work where the metal is subject to tensile stress. A careful investigation of this point has been made by Mr. Herbert L. Whittemore, now Director of Tests, U. S. Arsenal, Watertown, Mass. The work was done as a thesis submitted to the University of Wisconsin for the degree of mechanical engineer. The experimental work upon which the thesis is based was performed at the University of Illinois. A comprehensive abstract of this thesis was published in a recent issue of the "Wisconsin Engineer," from which the following information is taken:

Steel was chosen as the material for the investigation because of its importance in commercial construction. Circumstances limited the work to a small range of thickness of steel plates, but, nevertheless, an attempt was made to determine the effect of other variables which might influence the strength of the weld. Three series of tests were made. The first to determine, if possible, the variables affecting the strength of the welds. The second was a continuation of the first, under somewhat altered conditions. The third was made to investigate the proportion of the acetylene in the discharged gas and the effects upon the former due to variations of the proportion.

In the first series, ¼-inch plates were used and specimens were taken, some with their axis perpendicular to the direction of rolling and some parallel to that direction. The average efficiency of the welds for the sections perpendicular to rolling was found to be 70 percent, which compares favorably with that for the sections parallel to rolling, which is 67 percent. Due to the many variables of this series of tests, it was concluded that this slight difference in efficiency is entirely accidental, and that the direction of rolling, so far as these tests permit an opinion to be formed, has no influence upon the efficiency of the welds. In specimens where the welding was performed by causing fusion of the metal on one side only of the seam and causing the metal to flow together by the blast of the flame as it swung back and forth, the metal was melted as deeply as possible and left rough, with no attempt to add metal or grind the weld. Upon breaking the specimens of this section, the fracture clearly showed that the welds only extend to about 1/16 inch below the surface of the plates. The metal which had been melted showed a coarse crystaline fracture. Below that was a strip of white which probably became pasty in welding but did not fuse thoroughly. This metal appeared to unite to a slight extent, but the weld there was weaker than through the molten metal. These sections were lower in efficiency. Considering the small areas actually fused and welded, the efficiencies seem quite remarkable.

In specimens which were welded from both sides without the addition of filling material, the welds invariably showed high efficiency, due, possibly, to the fact that the blow-pipe flame was confined almost entirely to the surface of the weld, so that the metal did not suffer the deterioration which occurred in beveled welds in fusing in the filling material. Since the rough surface of the weld was not ground off, some of the efficiencies ran over 100 percent.

In the second series of tests, ⅛-inch plates were used. All sections were beveled 45 degrees. In one specimen the molten metal was hammered frequently as it was put into place. The results for this section tend to show that hammering the weld during blow-pipe operation is laborious and detrimental, rather than beneficial. Pre-heating the beveled edges of the plates was tried in one section, but apparently had little effect on the strength of the weld. It merely increased the welding rate and so lowered the cost. Some of the specimens were heated in a forge and drawn down on an anvil to a uniform cross section. Forging apparently produced a decided increase in the strength of the welds and also in the ductility of the fused metal. Apparently, this increase in efficiency is about 10 percent. The highest efficiencies were obtained where the edges of the beveled plates were drawn down so that they projected below the surface of the plate. The filling matrial was then added and the hump ground off. One section was welded with an excess of oxygen and another with an excess of acetylene. The decrease in efficiency due to the excess of oxygen was only 1.9, and for the excess of acetylene, 3.5 percent. There seems to be no excuse for greater variation in commercial work, due to improper flame regulation.

As varying flame regulation seems to have little effect upon the welds, interest was renewed in the proportion of acetylene in the discharged gas and the variation in this amount for a visible change in the flame. This effect was studied in the third series of tests, with the result that it seems safe to conclude that a change in the amount of acetylene of one percent in the gas could be detected by a change in the appearance of the flame, providing this change occurs near normal regulation.

As a result of this investigation the author concludes that only forging and thorough fusing of the material in the weld result in any noticeable increase in the efficiency of the welds. He states that the average technical article on this process apparently lays too much emphasis upon the necessity for very careful flame regulation, pure oxygen and acetylene, as well as the value of pre-heating, and hammering the weld in securing high efficiency. Certainly they are in error when 100 percent efficiency is claimed. About 85 percent appears more probable.

BOILER INSPECTION.*

The foundation stone of boiler inspection regulations is the safeguarding of human life. A boiler inspector's work begins with the design of a boiler, and the next step is an examination during construction and boiler-shop inspection upon completion. A short time ago the question was asked as to what I considered boiler-shop inspection amounted to; and in answering I may have gone more into detail than might by some be considered necessary; but in speaking of that branch of our work, I have in mind the position an inspector would be in, in the event of the explosion of a boiler the construction and workmanship of which he had certified to. When a man in a responsible position vouches for certain details of workmanship of a boiler, he should be in a position at any time to show the reason why he vouched for the construction of that boiler, by having actual knowledge of its construction. Regulations in connection with the United States Government inspection of marine boilers include the identification of plates and examination of boilers during construction, and the same surely applies to boiler-shop inspection of Massachusetts standard boilers; that is to say, an actual examination during the different periods of the process of construction, not merely measuring up the boiler after it is completed and ready for hydrostatic pressure test. We have

* Address by Chief Inspector Joseph H. McNeill of Boiler Inspection Department, Commonwealth of Massachusetts, before the American Institute of Steam Boiler Inspectors.

had some cases of boilers built in this State and boilers built in other States where the fact that the inspector had not examined the boiler during construction fully warranted him in not vouching for its being constructed in accordance with the Massachusetts regulations. Some people may think that that is rather a rigid view-point to take; but an inspector who holds a commission from the Governor of the Commonwealth of Massachusetts must be in a position at any minute of the day or night to show that any act of his in vouching for the construction of a boiler is warranted by his actual knowledge of that boiler, and that his action is not based on statements made by some other person; and the same surely applies to any inspector holding a certificate of competency as an inspector of steam boilers.

The object of the Massachusetts law for the construction, installation and inspection of steam boilers is to have every steam boiler which comes within the provisions of this law under the constant care and supervision of a properly qualified man throughout the period of the boiler's service. A strong feature in connection with this continuous supervision is the fact that a certificate of inspection is required to be posted in the boiler or engine room of the plant where the boiler is located, except that the certificate of inspection for a portable boiler shall be kept on the premises and shall be accessible at all times; said certificate giving name of inspector, date of inspection and the maximum allowable working pressure allowed on the boiler. The value of the certificate of inspection is being understood more thoroughly, and owners and users of steam boilers are paying more attention to complying with this requirement of the boiler inspection law. When all is said and done, the man who owns the boiler pays the bills; and in enforcing the provisions of the boiler inspection law we come in daily contact with the owners of steam plants in this State and are in a position to speak encouragingly regarding the results of the rules formulated by the Board of Boiler Rules, which were not drafted from the view-point of any individual steam plant owner, but rather from what we believe to be the best boiler engineering practice.

One part of the engineers' and firemen's license law which is of importance in connection with the work of boiler inspection, is the engineer's record book. The law states that:

The person in charge of a stationary steam boiler upon which the safety valve is set to blow off at more than 25 pounds pressure to the square inch, except boilers upon locomotives, motor road vehicles, boilers in private residences, boilers in apartment houses of less than five flats, boilers under the jurisdiction of the United States, boilers used for agricultural purposes exclusively and boilers of less than eight horsepower, shall keep a daily record of the boiler, its condition when under steam and all repairs made and work done on it, upon forms to be obtained upon application from the boiler inspection department. These records shall be kept on file, and shall be accessible at all times to the members of the boiler inspection department.

I fully believe that the conditions of our work in Massachusetts are such that an amendment to this wording of the law is advisable, so as to extend this authority regarding accessibility of record books to inspectors holding certificates of competency as inspectors of steam boilers; as the records kept by the engineer in charge are of importance to any inspector who has made an internal and external inspection and issued a certificate permitting the operation of a steam boiler at a pressure not to exceed that stated in the certificate. This provision of the engineers' and firemen's license law took effect Sept. 1, 1907. At first we found a certain amount of opposition, especially from the older men, who had been in charge of steam boilers for many years, and who felt that keeping records was a clerical task which they didn't think they should be called upon to do. It is pleasing to state, at this time, that there is a better understanding now, and engineers are taking pride in keeping these records and appreciate the protection the record book gives them. I am also pleased to state that we have never had a case brought to our attention when an engineer has positively refused to show his engineer's record book to an inspector holding a certificate of competency as an inspector of steam boilers, and employed by the insurance company insuring the boiler. If such a case should arise, we would be warranted in detailing a State inspector to make an investigation, and ascertain the reason why such records should not be shown to any authorized inspector whose visit to the steam plant and desire to examine the engineer's records is in the interest of public safety. The owners or users of steam boilers also appreciate the value of the engineer's record book, recognizing the fact that it means better care of boilers and appendages, definite statements regarding washing boilers out and repairs to boilers, settings and appendages.

There is another part of our work of which I would like to speak for a moment or two. When the rules governing the construction of boilers were being drafted, we felt assured that boilers would be constructed that would not comply in every detail with regulations, and therefore could not be accepted as Massachusetts standard boilers; and provision was made for the inspection and installation of such boilers; that is to say, Paragraph 1, Section 6, Part III. of the Rules, makes provision for the installation of boilers which have not the Massachusetts standard stamp, or were not within the Commonwealth on May 14, 1909. Every inspector should understand that when he is detailed to inspect a boiler, and on reaching the premises finds that the boiler to be installed is not Massachusetts standard, he should immediately notify the owner or user that the first step for him to take, if he still desires to install the boiler, is to apply to the Board of Boiler Rules for permission to install a boiler not Massachusetts standard; it of course being distinctly understood that if the diameter of shell or drum exceeds 36 inches, the longitudinal joint must be of butt and double-strap construction. We want it understood that we are not advocating the installation of these boilers, nor holding out any special inducements; but such cases warrant prompt action, especially where a person has ordered a Massachusetts standard boiler and the inspector finds that it is not. That information is valuable to the purchaser, and tends to show that we are all working together in the carrying out of this work. Considering the large number of boilers installed in Massachusetts since May 1, 1908, comparatively few have taken advantage of this special provision in the rules. In fact, in many cases, owners have merely installed these boilers temporarily, while the manufacturers were constructing Massachusetts standard boilers to replace them.

The first convention of the American Boiler Manufacturers' Association of the United States and Canada which I had the privilege and pleasure of attending was held at Detroit, Mich., Aug. 10 to 12 inclusive, in the year 1909. Many prominent boiler manufacturers from various parts of the country, especially from the Middle West, attended this convention, at which resolutions were passed endorsing the Massachusetts Rules for adoption in the City of Detroit. At that time various forms of legislation were being advanced for Detroit, and since then they have adopted the Massachusetts regulations. The greater part of the Massachusetts rules have also been adopted by the City of Manila, P. I.; and we are in communication continuously with various parts of the country that have under consideration steam boiler regulations.

I do not think that there is another State in the Union that would have taken up this work as thoroughly as Massachusetts has done and have been able to carry it out with as little opposition. We had the advantage of having had for a number of years boiler inspection and engineers' license laws and a department for their enforcement also, the advantage of the large amount of educational work done by engineers' organizations, by boiler insurance companies, mechanical engineers and institutions of learning along mechanical lines, all these having greatly facilitated progression in steam boiler construction, installation and inspection. All these interests helped out wonderfully and we aimed, in formulating the rules, to draft from the best information procurable. Information was sought from all sources, and I can state without hesitation that there is not a man present who has not had something to do with the making of these rules. Therefore, we all are naturally desirous to see them successful. It would be very unwise to state that the rules are perfect. We can see, reading between lines, many details that can be improved upon; and the policy of the Board is to take up everything that is progressive and to be at all times in a receptive mood for ideas, the aim of which is along the line of advancement and betterment of the service. In addition to seeking for knowledge, information is brought to us continuously. It is one of the pleasant features, for men feel free to come and discuss all phases of our work.

When the boiler inspection law of 1907 was enacted, calling for the appointment of five members of a Board of Boiler Rules, many thought that feature over carefully and felt that there would be little or nothing done: that it would be a difficult matter to get four on a board representing different interests, which some considered to have entirely different view-points, and be able to get anything done that would be progressive. It is a pleasure to state that the work of this Board has been done as a unit. It meant straightening out differences of opinion at the meetings; discussing vexed questions, and, if necessary, letting matters rest until more information was gained; looking into the matter at issue carefully and fairly before arriving at a conclusion. We made many errors—the changes in the rules have shown that; and these errors were brought to the surface more especially by the work of the inspectors in the field. A man sitting in an office may look at a thing from one point of view and feel fully assured that he is right; while the inspector in the field, who is in contact with the actual work of carrying out the regulations, is the one who is most valuable to show the various rules which require modification.

In Chicago the inspection of boilers comes under one department and the examination of engineers under another. That is an ill-advised condition, as these two branches should be carried out under the jurisdiction of one department, as in Massachusetts.

In New York city and Chicago, every boiler is under city inspection. In Massachusetts, boilers that are under the periodically guaranteed inspection of boiler insurance companies, authorized to insure boilers in this Commonwealth, are exempt from State inspection, which is a much more advisable method, as subdividing responsibility does not tend toward getting the best results. An inspector who inspects a boiler and issues a certificate over his signature, allowing a maximum pressure per square inch, takes a greater responsibility than one who goes out and inspects a boiler, reports to the office, and then a certificate is issued, but not over the signature of the inspector who made the inspection. The former method applies to Massachusetts; the latter, to Chicago.

Through the Middle West boiler manufacturers and representative men feel that there should be some standard boiler regulations for the United States. The boiler manufacturer says that, if he builds a boiler for one section, he must follow certain regulations; and if for another section, he must build in accordance with other regulations, and, with no guarantee that a boiler will be accepted until it reaches its destination and passes through the hands of the local authorities. They say there is one thing they can figure on for Massachusetts; when they build a boiler strictly in accordance with the rules, and it has been passed at the works by an inspector holding a certificate of competency, they have not the slightest fear that it will not be accepted when it reaches its destination in this State; and they feel that this is the only proper solution. When asked regarding standard regulations for the whole country, I stated that the first step should be a United States law, specifying quality of material and fundamental details of construction. We know there is the law regarding State rights; each State has the right to enact legislation according to its own needs; but men who have given this matter of steam boiler regulations a great deal of thought have come to the conclusion that, human life being just as valuable in the North as in the South, in the East as in the West, the United States Government should take some action to safeguard the lives of its citizens, as we are being looked at as a country carrying too many risks in connection with steam boilers.

To look at the area of Massachusetts in comparison with the extent of the whole country, we see that this State covers a very small part; but the fact that various parts of the country are taking interest and talking about legislation along the lines of Massachusetts law is encouraging, and emphasizes the fact that progress is being made, so that eventually what is required in one section of the country will also be required in another.

A matter has been brought to my attention within twenty-four hours about which I think a word should be spoken. It has been said (I do not desire to state the authority, or how much stress to lay on the statement) that Massachusetts standard boilers of the horizontal return tubular and vertical fire-tube types will be subject to a reduction of pressure, whereas boilers of the water-tube type will not be subject to such reduction of pressure within the same number of years. This statement is entirely in error, as in these regulations we have established a uniform factor of safety of five on shells and drums of Massachusetts standard construction, and any reduction in steam pressure on Massachusetts standard boilers will depend entirely on the condition of the boilers and their service, not necessarily on account of their being of any particular type.

Two parts of our work have been criticised; namely, requiring a manhole under the tubes of horizontal return tubular boilers 60 inches in diameter and over; also that the Board does not recommend the use of externally-fired boilers over 84 inches in diameter. We candidly believe, in looking at it fairly and after consultation with the best engineers, that these two details will do more to retain in general use the horizontal return tubular type of boiler than anything else the advocates of this type of boiler could do.

There is one matter that I look more strongly upon than may be thought necessary, and that is accuracy in boiler measurements. We daily come in contact with each other in this part of our work, and sometimes accuracy in details looks like a hair-splitting proposition. The policy of the department is that, when a boiler has once been accurately measured, all future measurements should check without any variation. When accurate measurements are made by an inspector of an insurance company, there is no reason why that vessel should be again measured while under the inspection of that company; and the same applies to measurements taken by State inspectors. It is safe to say that former records show considerable variation in measurements, whereas now we feel assured that our records will stand close criticism; and that is a valuable asset to have in departmental affairs.

This work has increased the responsibility of the inspectors of steam boilers and the responsibility of the engineers and firemen in charge of and operating steam boilers. In former years many mishaps have taken place and investigations have been made, but there was a question as to placing the responsibility. From now on, if any disaster should take place, the public will want to know the reason why, and who is to blame; and inspectors, engineers and firemen are realizing more and more the importance of the inspection and care in operation of steam boilers. That is a great step in advance. We are also finding that the owners and users are in a much more receptive mood, ever ready to receive suggestions regarding the care of their boilers, feeling, as they do, that Massachusetts is being looked at by other States as one to take pattern by.

It is surprising to know how this work has broadened, especially regarding inspectors holding certificates of competency. The total number of inspectors holding such certificates is 79; and, in addition to Massachusetts, we have inspectors located at Portland, Me.; Manchester, N. H.; Providence, R. I.; Bridgeport, Hartford and New Haven, Conn.; Brooklyn, Buffalo, New York city, Oswego and Rochester, N. Y.; Erie, Pittsburg, Philadelphia and Reading, Pa.; Cleveland and Dayton, O.; Detroit, Mich.; Chicago, Ill.; and Minneapolis, Minn. —showing the gradual spreading out of men who are carrying this work into every section that they visit. We also find representative men in steam-engineering circles in various parts of the country who are using the regulations of Massachusetts to get better conditions, and applying the rules for maximum allowable working pressures on boilers where there is no law to regulate such pressures. In addition to the inspectors of the State Department and of insurance companies authorized to inspect and insure steam boilers in this Commonwealth, we have steam boiler insurance companies throughout this country in constant touch with the boiler rules, and their representatives all over the country are receiving our literature. Over 10,000 copies of these rules have been distributed since August, 1909. Interest in the study of steam engineering is on the increase, and classes for the instruction of engineers having care of steam boilers is a sign of the times. Communications, asking for copies of the engineers' and firemen's license law, boiler inspection law and rules formulated by the Board of Boiler Rules of this Commonwealth show the widespread interest taken by those who are directly and indirectly connected with steam engineering.

The bill that was presented in the Legislature of Ohio last winter called for the appointment of a certain number of boiler inspectors, one-half to be appointed from one political party, and the other half from the other. Inquiry was made regarding the general features of this bill, and in reply to this part about appointment of inspectors we stated that politics should never enter into the appointment of any man to carry out such responsible work as the inspection of steam boilers, and that the Massachusetts method was the best; namely, all appointments to be made by civil service competitive examinations.

Oil Replaces Coal on the Great Northern.

After a thorough investigation by an expert for more than a year, the Great Northern has decided to utilize oil for fuel on practically all of its locomotives west of Leavenworth, Wash., in the Cascade Mountains. It will take an immense amount of money to equip the locomotives with new burners and install the tank facilities along the system, but it has been figured that a big saving can be accomplished in the long run. Much economy can be realized in fuel alone, while the dirt and smoke incident to coal consumption will be eliminated.

The grates on 115 locomotives are to be removed and replaced with oil burners, involving considerable labor in the shops at the west end.

FEDERAL LOCOMOTIVE BOILER INSPECTION BILL.

The bill providing for Federal inspection of locomotive boilers passed the Senate January 10, and is now in the hands of the House Committee with a fair chance of becoming a law at the present session of Congress. The principal features of the bill are as follows:

Section 1.—Defines the application of the measure.

Section 2.—Provides that no locomotive boiler shall be used by any common carrier which does not conform to the requirements of this act; that is, the boiler must be well made and provided with the proper equipment, so that it may be safely employed without unnecessary peril to life or limb. The boiler must meet the tests prescribed by the Rules and Regulations provided for by the bill.

Section 3.—The President, by and with the advice and consent of the Senate, shall appoint one Inspector-General (salary $4,000) and two Assistant Inspector-Generals (salary $3,000 each). Traveling and office expenses of these officers are to be paid, in addition to the salaries.

Section 4.—Upon appointment, the Inspector-General shall divide the country into fifty inspection districts and one inspector shall be appointed for each district by the Inter-State Commerce Commission, after a competitive examination according to the law and the rules of the Civil Service Commission governing the classified service. Each district inspector will receive a salary of $1,800 a year, with traveling expenses and $600 office rent. The list of questions for the Civil Service examination will be prepared by the Inspector-General and approved by the Inter-State Commerce Commission.

Section 5.—Each carrier subject to this act shall file its rules and instructions for the inspection of locomotive boilers with the inspector-general, and, if approved by the Inter-State Commerce Commission, they shall become obligatory upon such carrier. If the carrier fails to file its rules, the inspector-general shall prepare suitable rules and instructions, to which the carrier must conform.

Section 6.—Each inspector shall become familiar, so far as practicable, with the condition of each locomotive boiler ordinarily housed or repaired in his district, and shall make such personal inspection of the locomotive boilers under his care as may be necessary, but shall not be required to make inspections at stated times or at regular intervals. His first duty is to see that the carriers make inspections in accordance with the rules and regulations established, or approved, by the Inter-State Commerce Commission, and that carriers promptly repair the defects which such inspections disclose. Each carrier subject to this act shall file with the inspector in charge, under oath of the proper officer or employee, a duplicate of the report of each inspection required by the rules and regulations and also a duplicate report under oath showing the repair of the defects disclosed by the inspection. If the inspector finds a boiler out of repair he shall so report it, and order it to be placed in proper condition by the carrier and thereafter the boiler shall not be used until in serviceable condition and so certified to the inspector.

Section 7.—The inspector-general shall make an annual report to the Inter-State Commerce Commission.

Section 8.—In case of a boiler explosion, or failure resulting in serious injury or death to one or more persons, a statement of the facts shall be made to the district inspector by the carrier and the explosion shall be investigated by the inspector or inspector-general. Parts of the disabled locomotive shall be preserved intact as far as possible until after such inspection. The inspectors shall make a thorough report of the explosion, which shall be published in the annual report of the inspector-general.

Section 9.—Penalty for violation, $100.

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Steam Boiler Design.

Radical departures in steam boiler design invariably meet with strong opposition until their merits have been proved in a practical way. The entire history of steam boiler development shows that the process of trial and error is the determining feature in practically all new developments.

Dr. Nicholson, an English professor, has designed and experimented with a new type of what is called a high-velocity boiler and economizer, with which he has tried to prove the theory that heat transfer is nearly proportional to the speed of flow of gases. In this boiler the heating surface is very finely divided by the use of small diameter watertubes, and the speed of the gases through the boiler is accelerated by means of induced draft. Naturally, too, the high rates of evaporation per square foot of heating surface have called for positive circulation of the water in the boiler, and this has been provided for by the use of circulating pumps. Although many claims have been made for this type of boiler by its inventor, these claims do not as yet seem to have been verified. An experimental boiler, built according to these designs, was thoroughly tested by Mr. Michael Longridge, who is recognized as one of the foremost boiler experts in England, with the result that the efficiency of the boiler and economizer together was found to be no better or worse than that which any ordinary type of boiler with an ordinary large tube economizer would give with similar conditions of combustion temperature and burning the same fuel, the combined efficiencies being from 73.8 to 79.1 percent. These apparent efficiencies, however, were reduced to from 64.4 to 69.1 percent after deducting the working costs for fan power and for the water circulating pumps. These net efficiencies, it will be seen, are considerably lower than the test efficiencies of ordinarily well-designed boiler plants.

Incidentally in connection with the report of this test, which we publish elsewhere in this issue, some sound observations are made regarding boiler performance. It is pointed out that while continual forcing of a boiler plant, or, in fact, any other kind of power plant, is bad practice, yet experience shows that boilers can be heavily forced when necessary without interfering with the natural outflow of gases through ordinary flues, and the conclusion is drawn that correct mechanical firing with positive draft and correct mixing methods can alone insure in commercial working a good boiler efficiency. It is also very properly pointed out that it makes little difference what the type of boiler is, provided it is built in accordance with what has been shown to be good practice. The principal factor which determines the rating of a boiler is not the total heating surface but the furnace area, quality of fuel used and rate of combustion. It is evident that with the same total heating surface one boiler may have a large furnace, and without forcing combustion can produce a large quantity of steam, while another boiler, exactly similar except with a smaller furnace, would have a less capacity with the same rate of combustion, or for the same capacity it would require a higher rate of combustion.

The matter of heat transfer from hot gases on one side of a boiler tube or plate to the water on the other side is something about which very little is really known. No exact determination of the actual rate of heat transfer at various parts of boilers has ever been made. In fire-tube boilers the great bulk of the total heat is transferred by the heating surface nearest the fire. The length of boiler tubes can, of course, be increased to the limit imposed by practical considerations, and the result on the design of the boiler will simply be increased heating surface, but it is doubtful whether any increased efficiency will result from the increase in the heating surface. The principal result would be that the water capacity and, consequently, the thermal storage capacity of the boiler would be increased. In the same way it is a very simple matter to increase the heating surface of sectional watertube boilers by adding more sections; but, again, there does not seem to be any reason for carrying this process beyond certain practical limits. Decreasing the heating surface and keeping the furnace conditions the same will result in a higher average rate of heat transfer per square foot of total heating surface, but it yet remains to be proved what the most economical rate is. So far as our present knowledge extends, then, it is probably better to reply upon what is known as standard practice, which really covers the results which have been obtained by the natural law of the survival of the fittest.

LAYING OUT CONTEST.

We are authorized by Mr. F. H. Cahoon, of Lick Run, Va., to offer a prize of $5 for the best solutions of the three following problems:

Problem 1.—The layout of one section of the pipe shown in Fig. 1. Each section of this pipe is made from one sheet of $\frac{1}{4}$-inch plate with large and small ends, the rivets to be $\frac{5}{8}$ inch diameter and spaced about $2\frac{1}{8}$ inches pitch.

Problem 2.—The layout of a course for a hot-blast stove of the dimensions shown in Fig. 2. The course is to be made of four sheets of $\frac{3}{8}$-inch plate, with rivets pitched about $2\frac{1}{4}$ inches. The plates are to have large and small ends; that is, the course fits outside the adjacent course on one side and inside the adjacent course on the other side. The width of sheets for this course is 4 feet.

Problem 3.—The layout of the frustum of a cone of the dimensions shown in Fig. 3. The cone is to be made first of one sheet of $\frac{1}{4}$-inch plate and second from four equal pieces.

In judging the solution of the above problems, particular importance will be attached to the practical and accurate layout of the camber of the sheets in each case. All the sketches for the plates must show all the detail work of getting out the sheets as well as the rivet spacing, etc. In other words, the sheets should be shown fully dimensioned, with all the various steps used in laying out the work indicated.

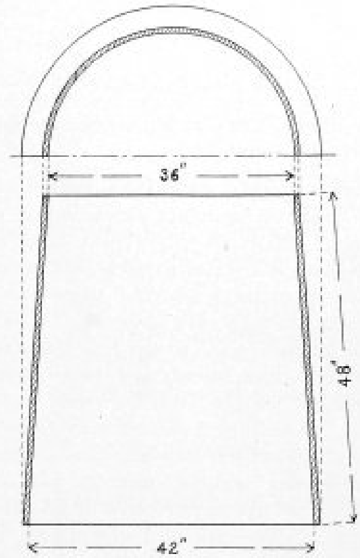


Fig. 3.

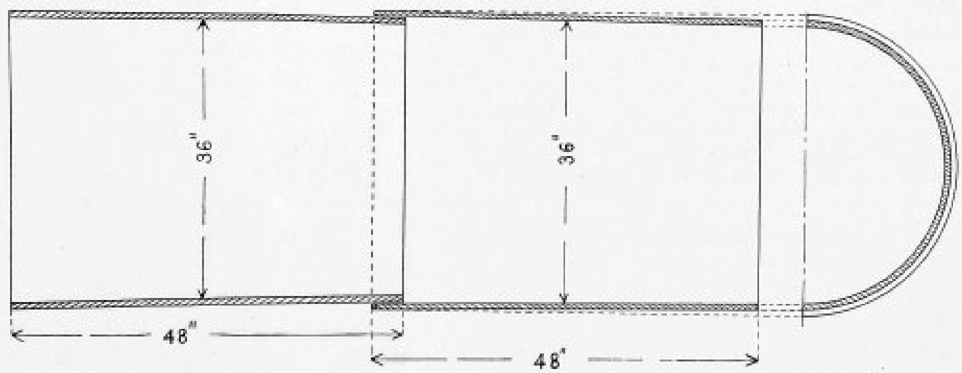


Fig. 1.

This competition is open to any of our readers.

All solutions to these problems should be sent us, accompanied by the name and address of the competitor, inclosed in a sealed envelope, on which is some *nom de plume* or sign which must also appear on the drawings and manuscript. Thus each solution will be judged solely on its merits without any knowledge of who the competitor may be.

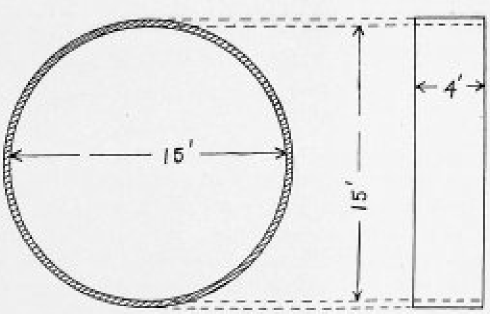


Fig. 2.

All solutions must reach the office of The Boiler Maker, 17 Battery Place, New York, not later than March 1, 1911.

Announcement of the prize winner and the best solutions of these problems will be published in the April issue of The Boiler Maker.

PERSONAL.

J. H. King, formerly of Boyne City, Mich., has been appointed general foreman of the Cincinnati, Hamilton & Dayton Railway Company's boiler shop at Lima, Ohio.

P. S. Hursh has resigned his position as manager of works with the Blaw Collapsible Steel Centering Company, Reynoldsville, Pa., and has haken the position of general foreman boiler maker and inspector for the Buffalo, Rochester & Pittsburg Railway Company, with headquarters at Dubois, Pa.

W. P. Pressinger, formerly vice-president of the Keller Manufacturing Company, Philadelphia, Pa., has again become associated with the Chicago Pneumatic Tool Company, and will hereafter be manager of the compressor department of that company, with headquarters in New York City.

J. F. Doolittle, president of the Cleveland Steel Tool Company, Cleveland, Ohio, has started on an extended vacation trip of four months. As his time will be spent entirely in recreation, he will tour by easy stages through the Isthmian Canal district, Old Mexico, Southern California and the Yellow Stone National Park, returning to business about May 1.

Jeremiah J. Keenan, founder and owner of the Lake Erie Boiler Works, Cleveland, Ohio, died at his home in Cleveland, Jan. 27. Mr. Keenan at the time of his death was 72 years old, and was well known to the boiler making and shipbuilding trades on the Great Lakes. For twenty-five years he was foreman of the Globe Iron Works, Cleveland.

TECHNICAL PUBLICATIONS.

The Mechanical World Pocket Diary and Year Book for 1911. Size, 4 by 6 inches. Pages, 422. Figures, 94. London, 1910: Emmott & Company, Ltd., 20 Bedford street, W. C. Price, 6d. net.

This is the twenty-fourth year of publication of this pocket book and each year the contents are enlarged and brought up to date. Some thirty-two pages have been added to the present volume and, by careful revision and condensation of some of the more permanent contents, space has been afforded for the introduction of a very large amount of new matter. Particular attention is directed by the publishers to an important chapter on the shapes, speeds and feeds of cutting tools, with supplementary sections dealing with milling cutters and twist drills. Additions have been made to the section on wheel gearing and entirely new sections on standard screw threads, high-speed steel and its treatment, annealing, hardening and tempering, and the constructive details of gas engines, have been added. There are also new tables and data on marine boilers, riveted joints, etc., and a table of steam fittings has been included, together with several additions to the tables of weights and measures. Taken all in all, this book provides a convenient and valuable reference book for marine engineers.

The Mechanical World Electrical Pocketbook for 1911. Size, 4 by 6 inches. Pages, 270. Figures, 68. London, 1910: Emmott & Company, Ltd., 20 Bedford street, W. C. Price, 6d. net.

This book is a companion volume to the "Mechanical World Pocket Diary and Year Book" which is reviewed in this issue. As has been the custom in previous years, the book has been thoroughly revised and brought up to date by the addition of new material. Among the important additions to the book this year are tables of current densities; permissible temperature rise; percentage losses in electrical machinery; units of illumination; current consumed by incandescent lamps; life of glow lamps; depreciation allowance; etc. Some of the sections which are briefly treated in this book are considered more fully in the Pocket Diary and Year Book and readers are referred to that volume for information on such subjects.

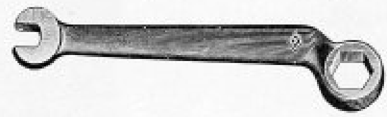
Applied Thermodynamics for Engineers. By Professor William D. Ennis, M. E. Size, 6¼ by 9¼ inches. Pages, 438. Figures, 316. New York, 1910: D. Van Nostrand Company. Price, $4.00 net.

Thermodynamics is a subject which has been so thoroughly treated in various text-books that any new book can hardly do more than re-present the subject. This, in fact, is all that is claimed by the author, and his method of treating the subject is clearly outlined in the preface, where he says that the book takes a middle ground between those text-books which replace all theory by empiricisms and the other class of treatises which are to apt to ignore the engineering significance of their vocabulary of differential equations. He states that it is his aim to present ideal operations, to show how they are modified in practice, to amplify underlying principles and to stop when the further advocation of those principles becomes a matter of machine design. The book includes chapters on compressed air, hot-air engines, gas power, the steam engine, the steam turbine, the steam power plant, distillation and mechanical refrigeration. A large number of problems has been included which will serve to test the student's grasp of the subject.

ENGINEERING SPECIALTIES.

Williams Spark Plug Wrench.

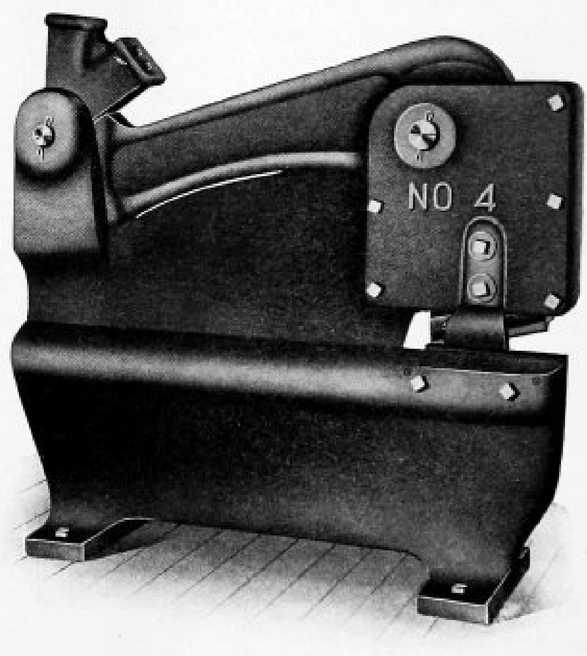
J. H. Williams & Company, 150 Hamilton avenue, Brooklyn, N. Y., have just placed on the market a ½-inch spark plug wrench which involves a concentration of service, in that the tool has a "box" end adapted for use as a ½-inch spark plug



wrench and an "open" end suitable for tire lugs, ⅜-inch United States standard cap screws, ⅜-inch A. L. A. M. standard nut and cap screws and 9/16-inch set screws. The tool is drop-forged from steel, and has been designed for convenience and reliable service about automobiles, motor boats, internal-combustion engines, etc.

Beloit Lever Splitting Shears.

Slater, Marsden & Whittemore Company, Beloit, Wis., have on the market a line of splitting shears designed for cutting plates from ¼ inch to ½ inch thick by hand. The shears are operated by a lever, but the lever works from the back of the machine, so that the operator is out of the way when cutting large sheets. The bodies are offset so that when splitting



large sheets the metal will pass through freely. The knives are adjustable and reversible, giving four cutting edges. They are also easily removed for sharpening. In the machines designed for cutting ¼-inch and ⅜-inch plate the knives are 6½ inches long, and for cutting ½-inch plate the knives are 7 inches long.

The "Ideal" Automatic Pressure Controllers.

The "Ideal" Automatic Pressure Controller is an oil controlled piston actuated, pressure controlling valve for the reduction of hydraulic pressures, in boiler shops for testing boilers, or in places where it is necessary to reduce high pressure down to the pressure required for any particular work. These pressure controllers are manufactured by the

"Ideal" Automatic Manufacturing Company, 125 Watts street, New York City, and the Style "C" Controller (Fig. 1) is one especially adapted for the above purpose. The controllers and valves are made of the best bronze metal for higher pressures, and cast iron for the low or intermediate pressures. No diaphragms or cup leathers are used and the body of oil in the trap and pressure cylinder on top of the water or other liquid of which the pressure is reduced follows the piston in both its upward and downward strokes, thus thoroughly lubricating and protecting the wearing surface of the cylinder walls and piston from all liability to corrode and stick fast when the controller is called upon to act. It is claimed that this piston, working in oil at all times, makes the controller very sensitive and quick acting, as the slightest break in the

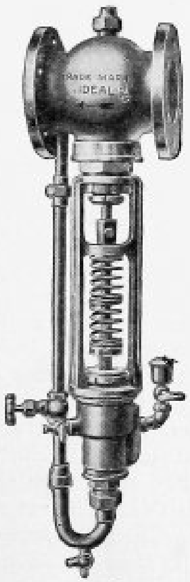


FIG. 1.

FIG. 2.

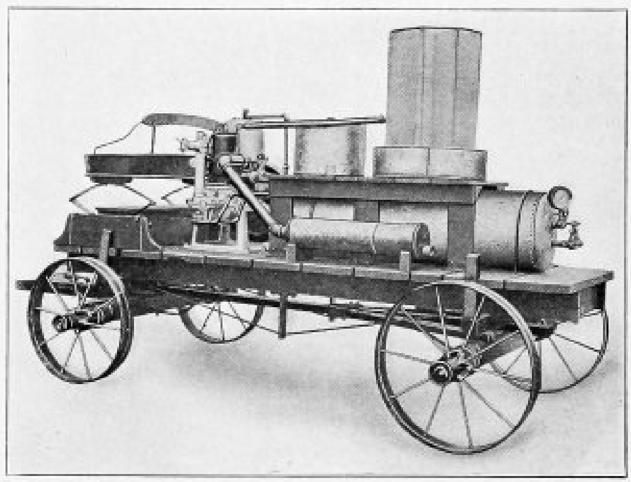
pressure will set the controller in operation. At the bottom of each controller is a petcock, so that any dirt or sediment collecting may be readily blown off without affecting the working of the controller. For this reason it is claimed that the Ideal controllers are not affected by salt water or other liquids that might corrode or leave a deposit.

Fig. 2 shows the "Ideal" compound pressure pump governor, style "B." This governor has been designed for special work on boiler feed pumps and gives a better range of pressure than is possible with the ordinary pump governor. The special feature for boiler feed and other pumps where varying pressures are required is that by simply shifting the levers on the quadrant up or down the working pressure desired is easily obtained. If a low pressure is needed, the low-pressure spring is in action, and if a high pressure is needed the high-pressure spring is brought into action by means of the lever tension on the high-pressure spring compounding or bringing into action both springs until the desired pressure to do the work is obtained. Should, for any cause whatever, the steam line be required to be shut off entirely, this governor can be used as a hand-operated stop valve by bringing the lever to an upward position on the quadrant, bringing the lever in contact with the flanged nut on the valve stem proper, thus shutting the valve off tightly and stopping the pump. The pump stands in this position until the lever is shifted to the low pressure or central position on the quadrant when the low-pressure spring is in operation or by shifting the lever in a downward movement on the quadrant to any desired position for an intermediate pressure by bringing into operation the high-pressure spring. This method of adjustment allows the engineer to control the pump from a low to a high pressure or any intermediate pressure which he might desire. The "Ideal Automatic Manufacturing Company further advise that they have their Style C controller in one of the largest boiler shops in this country, reducing the hydraulic pressure from 1,600 pounds per square inch down to 400 pounds per square inch for testing boilers. This control has been in operation a long time and has never been repaired in any manner, doinng the work to-day as well as when it was installed.

Owing to the fact that their controllers and pump governors are constructed with an oil actuated piston, they are able to control the highest pressures, as they have no diaphragms or cup leathers in the manufacture of their devices, therefore, no weak points.

Roberts Portable Motor Air Compressor.

Portable air compressors are practically a necessity in the erection of boiler, tank and stack work, where the riveting is to be done by pneumatic hammers. It is seldom that the place where this work is to be done is equipped with a stationary plant, and as one job occupies only a comparatively short time, it is necessary to move the outfit around from place to place. For this purpose the type of air compressor illustrated, which is manufactured by the Roberts Motor Company, Sandusky, Ohio, will be found useful. The compressor shown has a capacity of 30 cubic feet of free air per minute



at 80 pounds pressure. It is equipped with a heavy galvanized steel tank of 8 cubic feet capacity, tested to 500 pounds pressure, which, it is claimed, can be filled with air at 100 pounds pressure within less than three minutes after starting the motor.

The use of a gasoline motor in connection with an air compressor is a somewhat new development and is the result of an exhaustive series of experiments to determine the proper design of compressor that could be direct connected to a high speed motor and yet be efficient. The solution of the problem, as incorporated in a Roberts compressor, lies principally in the following points. In the construction of the compressor proper, the intake valve has been abandoned and in its place the air drawn through ports in the wall of the cylinder, which are uncovered by the piston at the end of the downward stroke. The compressor is of the two-stage type and is, therefore, efficient at high-pressure In order to pump efficiently, it is necessary to cool the air in its passage from the low to the high-pressure cylinder. Both the high-pressure cylinder and the upper portion of the low-pressure cylinder must be cooled. In the Roberts compressor a big advance in compactness has been achieved by incorporating the intercooler in the water space surrounding the cylinder. The intercooler is in the shape of a horseshoe, which gives a large cooling surface and, at the same time, large capacity. The motor is a valveless high-speed two-cycle engine of the very latest automobile type and its construction conforms to the highest grade of automobile construction, both in materials and workmanship. The motor has jump spark ignition and the timer is driven by a helical gear which also drives the gear pump just below it. The pump is of ample capacity to keep the compressor cooled and has been designed to operate in any kind of water. The outfit is mounted on a truck with an open platform, the sills being trussed to prevent warping. The gasoline tank is of 6 gallons capacity, which is sufficient for a ten-hours' run. The motor is 4½ inches bore, 5 inches stroke, and running at 600 revolutions per minute develops 6 horsepower. The air compressor, with iron base, weight 400 pounds, and with aluminum base, 350 pounds; the pressure can be varied from 80 to 150 pounds per square inch.

New Offices for The Boiler Maker.

The increased demands put upon us for office facilities have necessitated our moving into much more spacious quarters,

THE NEW WHITEHALL BUILDING, WHERE THE BOILER MAKER IS PUBLISHED.

and, beginning Feb. 1, our offices in the "Whitehall Building," 17 Battery Place, New York, will be in the recently-completed addition to the building in rooms 934 and 935. We shall have considerably more floor area and better facilities in every way for expediting business. On the picture shown herewith the four office windows facing the west have been marked to locate the new offices. The rooms extend back across the greater part of the north end of the building. As we command a view of New York harbor, the Statue of Liberty, and all of the shipping passing in and out, we invite our friends to call and not only inspect our spacious new offices but also enjoy the view from our windows.

COMMUNICATION.

A Question of Efficiency.

EDITOR THE BOILER MAKER:

The remarks of Mr. James Rumgay, on pages 29 and 30 of your January issue, regarding a riveted joint, are not well taken, for I cannot subscribe to his idea of computing a riveted joint. The essential point to consider is that the efficiency of the riveted joint is determined by the lowest percent of the several parts. It is not practical to strike a general average from the efficiency of the several parts, for this would mean an over-load on the weaker parts. A boiler rupture starts at one point, and the method of computing the longitudinal riveted joint is to consider that the weakest point will be the point of rupture. The problem taken up in the December issue of the BOILER MAKER indicated that the efficiency of the riveted joint was 84 percent, except at one point, which was 68.75 percent. Then the weakest part of the riveted joint, according to the calculations, is the net section of plate having a percent of 68.75. It matters not how many such sections exist in the riveted joint, the point is this: The net section of plate at the aforesaid point is below the percentage of the maximum net section of plate, and therefore its efficiency is the efficiency of the riveted joint in this case.

Your correspondent's views are correct when considering the load on a suspended body; but we are not dealing with a suspended body in the least, we are dealing with a vessel which is subjected to a given force per square inch the entire length of the longitudinal seam, which seam must be steam-tight, or at least should be.

Your correspondent's calculations are right in regard to certain bridge work, etc., but they are not applicable to boiler work.

H. S. JEFFERY.

Washington, D. C.

QUERIES AND ANSWERS.

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

Q.—I am running a 12-foot hydraulic riveter, the top end of the stake is 9½ inches by 4½ inches; the space between the driver and stake is 17 inches. I have a great many flanged heads to be riveted into 8-inch pipe. The heads are backed in and riveted with ⅝-inch rivets. I would be glad to know how your readers would do this work?

I would also like to know how to make a good rivet heating furnace to use either coke or coal?

BULL DRIVER.

Q.—Having recently given the matter of beveling plates before calking some consideration, and knowing that this is customary at the present time, I should be glad to have some of the readers of THE BOILER MAKER give their opinions as to whether this is really necessary or not.

QUIZZ.

SELECTED BOILER PATENTS.

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

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

973,468. STEAM BOILER. CLAUDE A. BETTINGTON, OF JOHANNESBURG, TRANSVAAL.

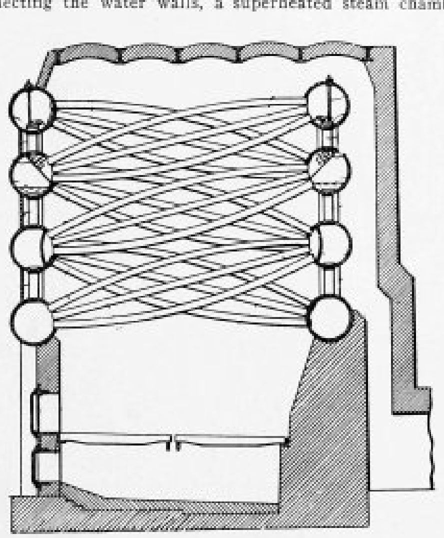
Claim 4.—In a boiler, a combination of steam and water chambers, forming with their connections a combustion chamber, closed except at or near the bottom whereby all the products of combustion are caused to double back upon themselves, a passage for the products of combustion, an escape for the products of combustion, and an inlet for combustibles located at or near the open part of said combustion chamber. Twenty claims.

973,481. FURNACE GRATE. JOHN F. CUNNEEN, OF CHICAGO, ILL.

Claim 1.—A traveling grate comprising rows of pivotally supported fuel supporting clips, a cam integral with each clip curved on the forward faces and means for simultaneously contacting all the curved faces of the cams of a row of clips for swinging the same on their pivots and said cams having flat rear faces adapting the clips to drop abruptly to jar the clips. Nine claims.

973,541. WATERTUBE BOILER. JIRO MIYABARA, OF TOKIO, JAPAN.

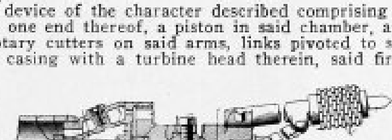
Claim.—A watertube boiler having, in combination, two water walls on opposite sides of the combustion space of the boiler inclined water tubes connecting the water walls, a superheated steam chamber located



above each water wall, inclined superheating tubes connecting each water wall with the opposite superheated steam chamber, and steam separators located at the lower ends of the superheating tubes to prevent the entrance of water. One claim.

973,740. TUBE-CLEANER. THOMAS ANDREWS, OF ROCKAWAY, N. J.

Claim.—A device of the character described comprising a head having a chamber in one end thereof, a piston in said chamber, arms pivoted to said head, rotary cutters on said arms, links pivoted to said piston and said arms, a casing with a turbine head therein, said first-named head



and said turbine head each having lugs thereon, and each having a socket formed in their adjacent ends and a ball pivoted to each of said heads, said ball and each of said heads having openings forming a communicating passage to said chamber. One claim.

973,652. FURNACE. GILBERT R. HAIGH AND JOHN R. FORTUNE, OF DETROIT, MICH., ASSIGNORS TO MURPHY IRON WORKS, OF DETROIT, MICH., A CORPORATION OF MICHIGAN.

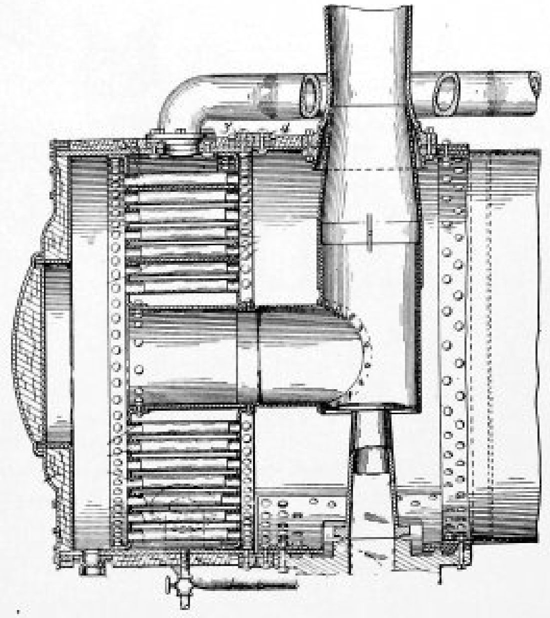
Claim 1.—A furnace comprising an inner and an outer arch extending over a fire chamber with an air space between said arches, a wall to close one end of said air space with an expansion space between said wall and said inner arch, and means extending across the air space adjacent to said wall to close the expansion space and carried by the inner arch to move therewith upon expansion of said arch. Two claims.

973,947. SMOKE-CONSUMING APPARATUS FOR LOCOMOTIVES. JOHN LOFTUS, OF ALBANY, N. Y., ASSIGNOR OF ONE-HALF TO ANTHONY HUGHES, OF PHILADELPHIA, PA.

Claim 1.—A smoke-consuming device comprising, in combination with the fire-box of a locomotive having an inclined arch with openings therethrough, flues positioned above and at the sides of said arch and having exit apertures adapted to discharge air transversely of the arch between the openings in the latter, and means for automatically introducing air into said flue. Eight claims.

973,662. STEAM SUPERHEATER. HENRY W. JACOBS, OF TOPEKA, KAN.

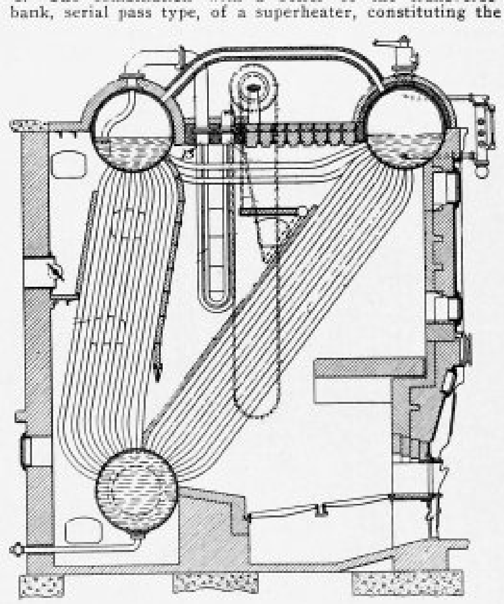
Claim 1.—The combination in a locomotive, of the boiler, the smoke-box, and the cylinders, with a superheater, the superheater being composed of one or more compartments arranged in the smoke-box, with the shell of the superheater forming a continuation of the boiler shell and removably secured thereto, said superheater being formed with flues



arranged to convey the gases of combustion forward to the front end of the locomotive and an enlarged flue for conveying the said gases rearward for delivery to the smokestack of the locomotive, and means located to the outside of the shell whereby communication between the boiler, the superheater and the cylinders is established. Three claims.

973,717. SUPERHEATER BOILER. JAMES P. SNEDDON, OF BARBERTON, OHIO, ASSIGNOR TO THE BABCOCK & WILCOX COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW JERSEY.

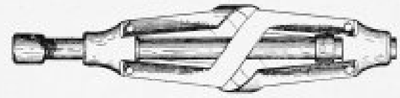
Claim 1.—The combination with a boiler of the transverse drum, multiple bank, serial pass type, of a superheater, constituting the entire



heating surface of the second pass, and an adjustable baffle shelf adjacent the bottom of the entrance to the pass arranged to vary the flow of the gases over the superheater; substantially as described. Five claims.

974,041. TUBE CLEANER. PARMER DORSEY, OF HUTCHINSON, KAN., ASSIGNOR TO THE STANDARD SUPPLY & MANUFACTURING COMPANY, OF HUTCHINSON, KAN., A CORPORATION OF KANSAS.

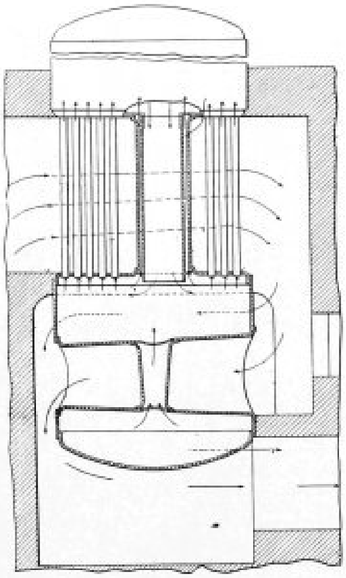
Claim 1.—In a tube cleaner, a shaft, a pair of heads movable on the



shaft, separate blades connecting said heads, said blades being bowed longitudinally and having offset central portions provided with cutting edges, and means on said shaft for engaging said heads. Three claims.

973,720. VERTICAL BOILER. TOZABURO SUZUKI, OF SUNAMURA, JAPAN.

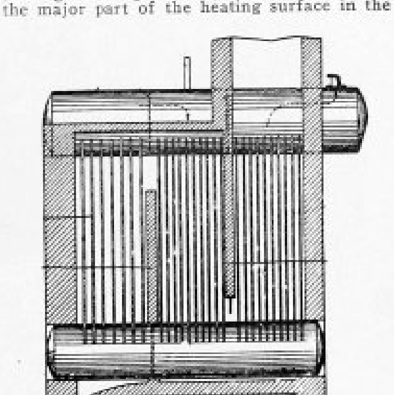
Claim.—A vertical boiler comprising in combination, a boiler setting provided with a main passage for the products of combustion, a steam chamber intersecting the upper wall of said passage, a water chamber intersecting the lower wall of said passage and being provided with a combustion flue below said passage having an enlarged intake end and a



relatively reduced outlet end; watertubes connecting said chambers and extending across and into the path of the products of combustion traveling through said main passage, a downwardly directed extension passage connecting said main passage with said combustion flue, an egress passage for the delivery end of said combustion flue, and an auxiliary passage connecting said extension passage with said egress passage. One claim.

973,743. INDEPENDENTLY-FIRED SUPERHEATER. JOHN E. BELL, OF NEW YORK, N. Y., ASSIGNOR TO THE BABCOCK & WILCOX COPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW JERSEY.

Claim 2.—An independently fired superheater having upper and lower longitudinally drums or receptacles baffles arranged to cause back and forth passes to the gases longitudinally of the drums, water heating surface forming the major part of the heating surface in the first pass, the



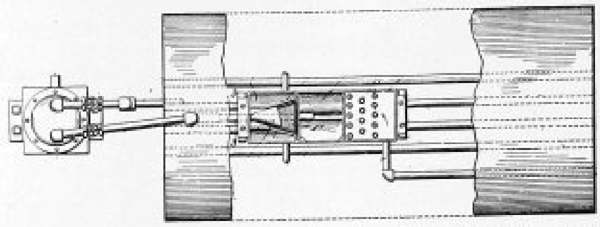
superheating tubes being located in the succeeding pass or passes, and constituting the major part of the heating surface, the superheater having an inlet arranged to supply steam thereto from a separate boiler and being arranged to receive water and itself act as a steam generator. Three claims.

979,121. HAMMER FLUE-CLEANER. WILLIAM J. BAKER, OF OSWEGO, N. Y., ASSIGNOR OF ONE-HALF TO LEWIS G. GRIDLEY, OF OSWEGO, N. Y.

Claim 2.—A flue cleaner comprising a tubular frame having an opening in one side, a transversely disposed partition arranged in said frame, a lever fulcrumed in said frame and arranged below the partition, a laminated spring arranged above the partition and having one end engaging the hammer end of the lever for forcing the latter outwardly through said opening, hold-fast devices for securing one end of the spring to the inner face of the frame, actuating means for operating said lever against the action of said spring, and operating means for said actuating means. Two claims.

973,989. SCALE PREVENTER FOR BOILERS. JOHN W. STEPHENS, OF STAUNTON, VA.

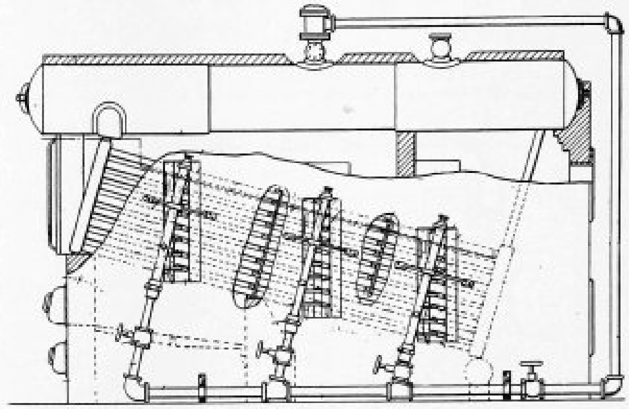
Claim 4.—In a device of the character specified, a separator comprising an open top casing, transverse baffle plates of lesser height than the casing dividing said casing into a plurality of compartments, a feedwater pipe delivering to the front compartment, a skimming device in an-



other of the compartments, baffle plates in said compartment, overflow pipes leading therefrom, and means for conducting the sediment from the casing. Eleven claims.

978,830. BOILER-CLEANER. LEO JNO. BAYER, OF ST. LOUIS, MO.

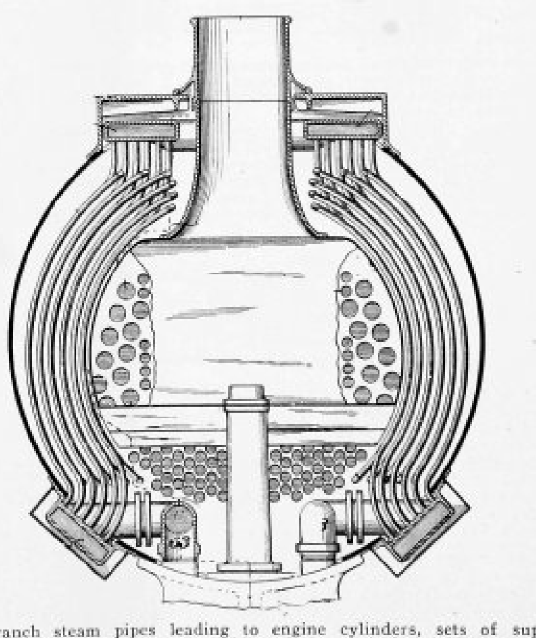
Claim 1.—In combination with a boiler having series of water-tubes disposed in superposed parallel planes, a series of transversely disposed baffle-plates intersecting the tubes and dividing the boiler into inde-



pendent sections, nozzles located opposite each section for projecting a cleaning fluid into and through the spaces between the tubes, and means for moving the discharge ends of the nozzles in planes parallel to the general planes of disposition of the tubes. Six claims.

978,987. STEAM-BOILER SUPERHEATER. FRANCIS J. COLE, OF NEW YORK, N. Y.

Claim 1.—The combination, with a tubular steam boiler, of saturated steam headers fixed to the upper portion of the smoke-box and communicating with the main steam supply pipe of the boiler, superheated steam headers fixed to the lower portion of the smoke-box and communicating



with branch steam pipes leading to engine cylinders, sets of superheater pipes located on opposite sides of the smoke-box and connecting the saturated and superheated steam headers on each side thereof, a deflecting plate extending transversely in the smoke-box in front of the flue head, a discharge casing extending longitudinally from the deflecting plate to the smoke-box front and vertically from the exhaust pipe to the lower opening of the stack, and grated or perforated plates covering lateral draft openings in the discharge casing. Two claims.

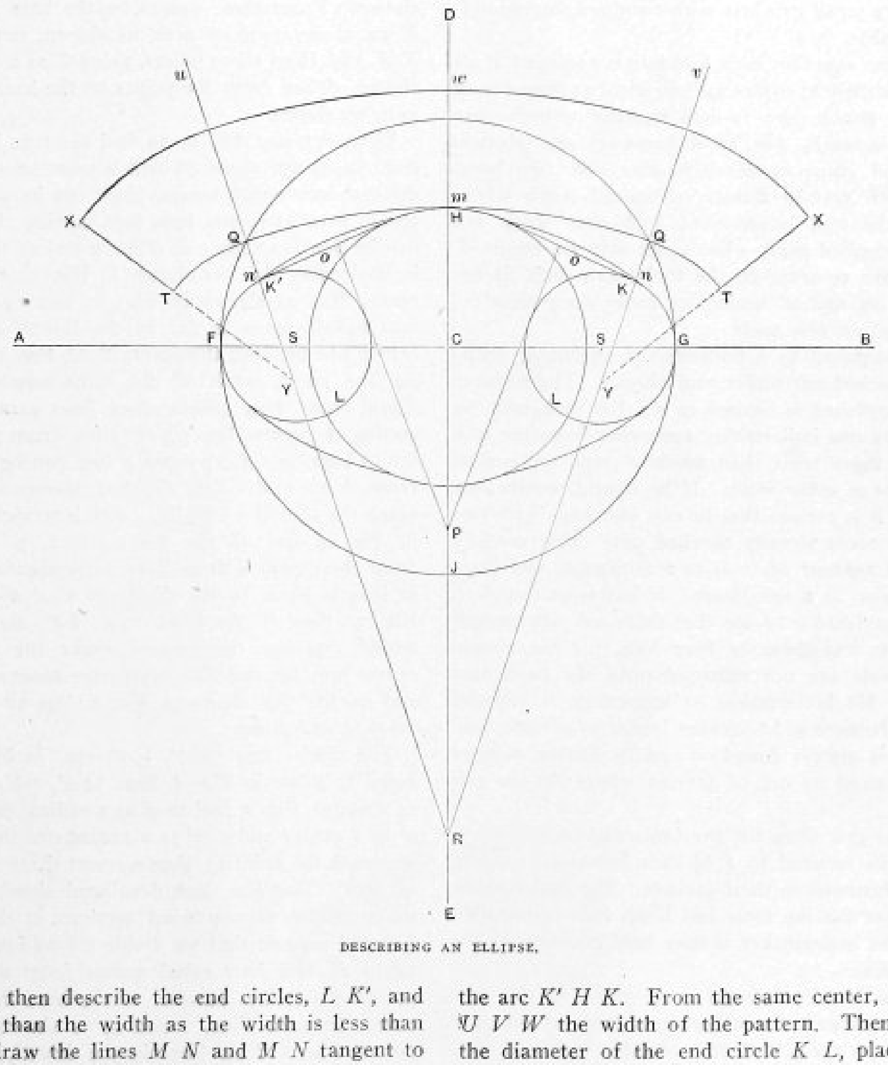
THE BOILER MAKER

MARCH, 1911

TO DESCRIBE AN ELLIPSE.

BY P. J. SWEENEY.

To describe an ellipse of any length and width, and by it to describe a pattern for the sides of a vessel of any flare, first draw an indefinite line, *D E*, perpendicular to the line *A B*, and from *C*, the point of intersection, as a center, describe a circle, *F G*, having the diameter equal to the length of the ellipse. From the same center *C*, describe a circle, *H J*, equal to the width, then describe the end circles, *L K'*, and *L K*, as much less than the width as the width is less than the length. Then draw the lines *M N* and *M N* tangent to the circles *K' L*, *H J*, and *K L*. From the middle of the line *M N*, at *O*, erect a perpendicular, produced until it intersects the indefinite line *D E*. From the points of intersection, *P*, as a center, describe the arc *K' H K*, and with the same sweep of the dividers mark the point *R* on the line *D E*. From the point *R* draw the lines *R U* and *R V* through the points *K'* and *K* where the arc *K' H K* touches the end circles *K' L* and *K L*. Then place one foot of the dividers on the point *R* and span them to the point *H* and describe the arc *Q H Q*, which will be equal in length to the arc *K' H K*. From the same center, *R*, describe the arc *U V W* the width of the pattern. Then span the dividers the diameter of the end circle *K L*, place one foot of the dividers on the line *R V* at point *Q* and the other at *Y* as a center. Describe the arc *Q T* the length of the curve line *K G*, and with the same sweep of the dividers describe the arc *T Q'* from the center, *Y*, on the line *R U*. Then span



DESCRIBING AN ELLIPSE.

the dividers from Y to U, and from Y as a center describe the arc U X, and from Y as a center describe the arc V X, which completes the pattern.

The more flare you want the pattern to have, the nearer the center point R must be to H; and the less flare you want, the farther the center poine, R, must be from H. In the same proportion as you move the center, R, toward or from H, you must move the center, Y, toward or from Q, or which would be the same as spanning the dividers less or more than the diameter of the end circle K L.

HANDLING AND MAINTENANCE OF BOILER SHOP TOOLS.

BY L. M. STEUART.*

At the Atlantic Coast Line shops at Waycross, Ga., we have a systematic, and what has proven to be very satisfactory, method of handling and maintaining various tools used in the boiler shop, particularly the small hand tools.

Each boilermaker and boilermaker apprentice is furnished with a number to check in and out, which same number applies to his tool checks and tool box. The boilermaker, when first employed, giving his name and check number to the tool room keeper, who, in turn, makes a record of same and furnishes six tool checks and a small iron box with numbers corresponding with check number.

The tool room man sees that each tool box is equipped at all times with three flat chisels, three cape chisels, two round nose chisels, one center punch, one 12-inch monkey wrench, one standard alligator wrench, one hand hammer, one electric extension cord and lamp, three drift pins and two hand calking tools. With certain classes of special work which sometimes occur the tool boxes used with that work are also temporarily supplied with what tools may be required. These tool boxes are returned to the tool room each Saturday night, checked up and all broken or badly worn tools replaced with repaired or new tools.

All other tools required by a boilermaker, including pneumatic tools, are checked out under tool checks. The number of these checks furnished is limited to six for each man, in order to prevent any one boilermaker removing from the tool room at one time more tools than actually required, and at the possible expense of other work. If he should require one or two other tools it is certain that he can exchange with one or two of the six tools already checked out. This reduces the actual required amount of tools to a minimum, and their time in actual service to a maximum. It has been found to be a very important feature to see that there are not enough tools on one job to run three or four jobs, for the simple reason that the tools are not returned until the particular job is completed. No boilermaker or apprentice is allowed to keep any tools whatever in his clothes locker or private box, as such a practice is always found to end by having a large number of tools locked up out of service where no one can locate them.

It is a practice at this shop for the boilermaker helpers to carry the six checks secured to a ⅛-inch brass wire safety pin, which can be fastened to their jackets. The boilermaker then sends his helper for the tools and holds him responsible for the checks. The boilermaker is then held responsible for both tools and checks.

All pneumatic tools are returned each night to the tool room, where the hammers are stored in a tank of oil over night. The air motors are placed on a suitable rack and each morning both air drills and hammers are thoroughly oiled ready for service. Every type of tool that is used in the boiler shop is thus kept in the boiler shop tool room. All wedge bars and holding-on bars are kept on a rack adjacent to the tool room and under the supervision of the tool room keeper. We also have an adopted standard make of air hammer and air motor, and keep in stock at the tool room a small number of repair parts to facilitate rapid repairs to all air tools, including those sent in by baggage from outlying points.

It might also be of interest to mention that we have experienced decided success in driving stay-bolts with the long stroke air hammer, and find it very economical in the saving of time as well as obtaining excellent results in bad water districts.

* Foreman Boilermaker, Atlantic Coast Line Railroad Company.

PIPE WITH A COMPOUND CURVE.

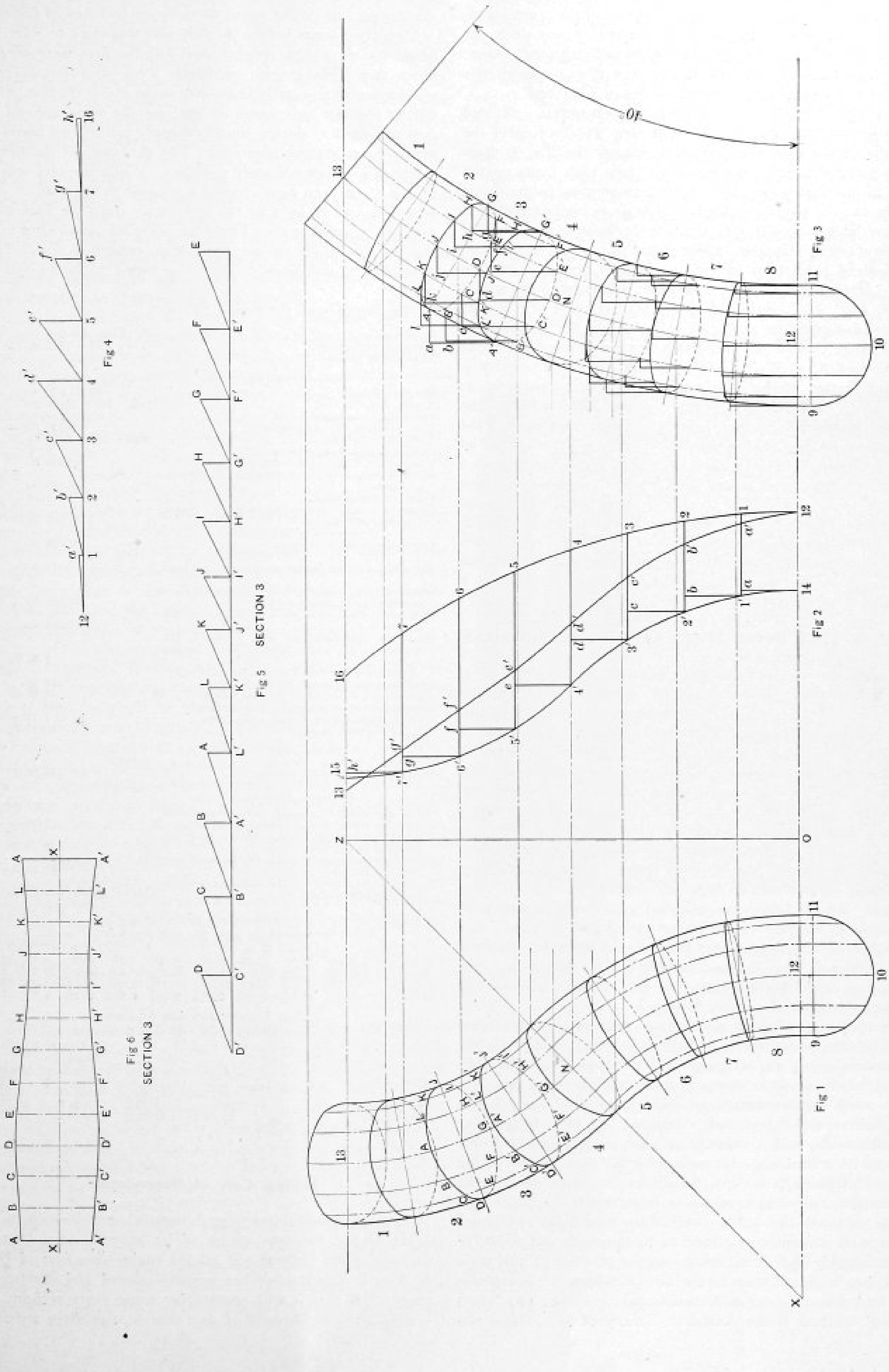
BY CLARENCE REYNOLDS.

In answer to the query regarding the development of a pipe having a compound curve, which was published in the December, 1910, issue of THE BOILER MAKER, the writer submits the following:

The plan is shown in Fig. 3, and the elevation in Fig. 1. The first step in this problem is to delineate the plan and elevation. After this is done draw the semi-circles, 9-10-11, as shown in Figs. 1 and 3; divide these arcs into any number of equal spaces (in this case, 6) and from these points draw lines at right angles to the base line, X-Y, and cutting it, as shown. From these points on the base line (Fig. 1), using X as a center, draw arcs, as shown, until they cut the line X-Z, and from these points, using Z as a center, draw lines as shown. Then from the points on the base line in Fig. 3, draw arcs, as shown.

The next step will be to find the true length of the center line, 12-13, the shape of which must be such that, when it is divided into equal spaces, lines can be projected from these points parallel to the base line, cutting the center line. This can be done as shown in Figs. 2 and 4; the line 14-15, Fig. 2, is the center line, as shown in Fig. 1; the line 12-16 is the center line as shown in Fig. 3; line 14-15 is to be divided into equal spaces as far as the line N-4′-4-N, which is the center line between the points Z, O, Fig. 1; then from 4′ to 15, on line 14-15, mark off the same number of equal spaces. Then, from these points, draw lines parallel to the base line, cutting the center line, 12-16; then from point 14, perpendicular to base line X-Y, draw a line cutting the line above, and from point 1 draw to the line above, and so on until you reach the point h. The line 12-16 is straightened out, as shown in Fig. 4, and all the points, 1, 2, 3, etc., are the same; from these points, draw lines perpendicular to line 12-16, and, in length, equal to the distances 1′-a, 2′-b, 3′-c, 4′-d, etc., in Fig. 2; then if the lines 12-a', 1-b', 2-c', etc., Fig. 4, were added together they would make the true length of the center line, but this line must have some shape to it before we can use it. As shown in Fig. 2, line 12-13, this shape is developed as follows:

The spaces 12-a', a'-b', b'-c', etc., in Fig. 2, are, in length, equal to those in Fig. 4, lines 12-a', 1-b', 2-c', etc. Using 12 as a center, Fig. 2, and 12-a' as a radius, cut the line 1′-1; using a' as a center and a'-b' as a radius, cut the line 2′-2, etc., until we reach the point 13, then connect these points with a number of arcs. This line just developed should be divided into as many spaces as you want sections in the pipe; in this case I would suggest that we divide it into four equal spaces, from 12 to d', and four equal spaces from d' to 13; from these points draw lines parallel to the base line, X-Y, cutting the center lines in Figs. 1 and 3, as shown. Then from these points, Fig. 1, draw lines in the direction of X, cutting both sides of the pipe and the upper half of the center line, draw lines from the points, in the direction of Z, cutting both sides of the pipe; then from these points, on the sides, draw lines parallel to the base line, cutting the center line in Fig. 3; the points on the sides (G'-G', A-A') are found the same as in



LAYING OUT A PIPE WITH A COMPOUND CURVE.

Fig. 1, with the exception that all the lines are drawn in the direction of one point, as shown; from the points just found, on the sides, draw lines parallel to the base line; cutting the center line in Fig. 1, this gives four points at each intersection; now draw an ellipse at each intersection through these four points; this will give the complete lines of intersection.

You will notice, the circumference of each section is divided into twelve equal spaces; the next step will be to find the lengths of the lines forming these spaces. In Fig. 3, draw lines perpendicular to the base line from each point on the lines of intersection as high as the corresponding points above, as shown; the perpendicular line *A'-a* is as high as the point *A*; the lines *a-A, d-B, c-C,* etc., are the altitude of a number of right angle triangles, whose bases are equal to the corresponding space lines in Fig. 1, *A'-A, B'-B, C'-C,* etc. In Fig. 5, spaces *A'-L', B'-A', C'-B'*, etc., are equal to the spaces *A'-A, B'-B, C'-C,* etc., in Fig. 1, and *A'-B, B'-C, C'-D,* etc., Fig. 5, are equal to *d-B, c-C, b-D,* etc., in Fig. 3, the lines *A'-A, B'-B, C'-C, D'-D,* etc., Fig. 5, are the true lengths of the space lines *A'-A, B'-B, C'-C, D'-D,* etc., in Fig. 1, section 3.

Each section of this pipe must be developed separately, as they are of different shapes. However, we will develop section 3, the other sections can be developed the same way. Find the circumference of this pipe by multiplying the diameter by 3.1416. Stretch out this circumference, as shown in Fig. 6 at *X-X*, divide it into the same number of spaces as each section is divided in Fig. 1 and 3, then, from these points, draw lines perpendicular to this line *X-X*, of indefinite length, each side; now take the lengths *A'-A, B'-B, C'-C, D'-D,* etc., Fig. 5, and place them in their proper places, equal distance each side the line *X-X*, Fig. 6; through these points draw a number of arcs, and this will complete the section 3.

BOILER EFFICIENCY TESTS AT THE PACIFIC MILLS.

An efficiency test on the boiler plant of the Pacific Mills at Lawrence, Mass., has been reported by Charles T. Main, mill engineer and architect of Boston, Mass., who designed this power plant and was in charge of its erection.

The boilers in this plant are all of the horizontal return tubular type, manufactured by the Bigelow Company of New Haven, Conn. These boilers, which are set in two rows, with a central firing aisle, are 72 inches in diameter and 21 feet 6 inches long, containing ninety-two fire tubes, 3½ inches in diameter and 20 feet in length. The boilers are set with overhanging fronts and are suspended from I-beams carried on columns, so that the settings are relieved entirely of their weight. All the boilers are equipped with Foster superheaters mounted in the rear of the boiler setting and designed for a superheat of 125 degrees F. Hand firing is used throughout the plant, and New England shaking grates, with 50 per cent air space, are installed under all the boilers. The battery under test consisted of four boilers.

As the object of these tests was to determine the performance of the boiler under ordinary operating conditions, the method of firing was not materially different from that ordinarily used except at starting and stopping when the fires were much thinner than usual. The amount of water fed to the boilers under test was measured in two rectangular wooden tanks, with a capacity of 2,400 pounds each and provided with a hook gage for measuring the exact height of the water. A third tank, into which the two measuring tanks discharged, served as a reservoir from which the boiler feed pump obtained its suction. All steam pipe drips and boiler drips were carefully examined as to tightness and found to be thoroughly tight in all cases. As the blowoffs proved to be cool they were not open to the air. Blanks were inserted in the feed-water lines to insure additional tightness. The "alternating" method of the American Society of Mechanical Engineers was employed, i.e., the method of estimating the amount of coal on the grates at the start and end of the test.

About two hours before the test was scheduled to start the firing was done with weighed coal and the fires were burned down thin. The general conditions were carefully observed and duplicated as exactly as possible at the end of the test. Also, during the last two hours of the test the same amount of coal was fired as during the preliminary run of two hours as nearly as conditions permitted. The thickness of the fire at starting was approximately 5 inches. While the test was in progress the fires were cleaned according to the regular mill schedule, and as soon as the tests were over the fires were carefully cleaned again. The ashes were all picked over after the test, in order to get any loose, unburned coal. This amounted to 200 pounds. The test lasted 35 hours and 20 minutes.

The summary of the results follows:

Grate surface	4 x 6 x 6 = 144 sq. ft.
Water heating surface	4 x 1878 = 7512 sq. ft.
Superheating surface	......
TOTAL QUANTITIES.	
Duration of trial	35 hrs., 20 min.
Weight of coal as fired	71866 — 200 = 71666 lbs.
Percentage of moisture in coal	3½%
Total weight of dry coal consumed	69,150 lbs.
Total ash and refuse	6052 — 200 = 5852 lbs.
Percentage of ash and refuse in dry coal	8½%
Total weight of water fed to boilers	543,695 lbs.
Water actually evaporated corrected for moisture in steam	543,695 lbs.
Factor of evaporation	1.29
Equivalent water evaporated into dry steam f. and a. 212 degrees F.	701,367 lbs.
HOURLY QUANTITIES.	
Dry coal consumed per hour	1,958 lbs.
Dry coal per square foot of grate surface per hour	$\frac{1958}{144} = 13.6$ lbs.
Water actually evaporated into steam at given superheat and pressure per hour	15,400 lbs.
Equivalent evaporated per hour f. and a. 212 degrees F.	19,850 lbs.
Equivalent evaporated per hour f. and a. 212 degrees F. per square foot of water heating surface	2.64 lbs.
AVERAGE PRESSURE TEMPERATURES, ETC.	
Steam pressure by gauge, per square inch	129 lbs.
Temperature of feed water entering boilers	38.6° F.
Temperature of escaping gases from boilers	493° F.
Force of draft between damper and boilers	.2" to 1.1" water
Degrees superheat in steam	126.2° F.
HORSE POWER.	
Horse power developed per boiler	$\frac{19850}{34\frac{1}{2}} \div 4 = 144$ H. P.
ECONOMIC RESULTS.	
Water apparently evaporated under actual conditions per pound of coal as fired	7.59 lbs.
Equivalent evaporated f. and a. 212 degrees F. per pound of coal as fired	9.78 lbs.
Equivalent evaporated f. and a. 212 degrees F. per pound of dry coal	10.15 lbs.
Equivalent evaporated f. and a. 212 degrees F. per pound of combustible	701367 ÷ 63298 = 11.08 lbs.

ANALYSIS OF FLUE GASES.

Taken from sample at main flue near No. 4 Boiler uptake.

	A. M.						P. M.		
Time	9:30	10:00	10:30	11:00	11:35	2:00	2:40	4:45	5:15
O_2	87.0%	11.3%	11.0%	8.4%	8.1%	6.0%	10.6%	10.5%	6.9%
CO_2	11.0%	7.4%	8.5%	11.6%	11.7%	14.2%	8.4%	7.6%	13.4%
CO	0.0%	0.3%	0.1%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%

COAL ANALYSIS AND ASH ANALYSIS.

Sample was average of the coal used during test.

			Average Results.	
	Coal.	Ash.	Georges Creek.	Victor.
Moisture *	1½%	....	1%	1.72%
Ash	9.7%	81.68%	8%	8.22%
Volatile matter	16%	1.22%	17.84%	25.71%
Fixed carbon	73.80%	17.10%	73.16%	64.35%

* Moisture for coal in pocket 3½%.

Taking Care of Depreciation.

"Depreciation requires most thoughtful consideration on account of the insidious nature of its growth," says Wm. B. Jackson of the Chicago and Boston engineering firm of D. C. & Wm. B. Jackson. When a well-designed and constructed property is new it will operate for some years without any expenditures on account of depreciation, but after a limited period apparatus becomes worn out or obsolete, and its renewal or replacement becomes necessary. In fact, depreciation must be provided against every part of the physical property except land. But the growth of depreciation or deferred maintenance expense does not necessarily become apparent in the operations of the property until the necessity of relatively large expenditures for replacements is at hand, and there is the possibility of such time arriving without those in charge of the plant realizing its approach. When such replacements become necessary they necessitate expenditures in large amounts which cannot be taken care of by the usual appropriations for current maintenance, and their cost may not be cared for by funds on capital account, for the replacements add nothing to the capital value of the plant except in so far as the replacements may be of a more costly character than the original, in which case the difference in cost may appropriately be charged to capital account.

Failure to appreciate the inexorable law that apparatus must come to the end of its useful life has resulted in the financing of economically unsound enterprises and in the embarrassment of good enterprises through the distribution to the stockholders of funds that should have been held in reserve for deferred maintenance.

It should be recognized that so long as a property is in condition to give as much and as good service as when it was new, its value, as represented by the amount of legitimate earnings to which it is entitled, cannot become reduced owing to depreciation in its plant. But any depreciation that may have occurred should be offset, when practicable, by a reserve carried for that purpose, or, if the property has been unable to make full appropriations to the depreciation account, complete knowledge of the situation should be possessed by the management, and the building up of the reserve in the future should be a most important financial consideration.

One of the simplest ways in which the books of a company may be arranged to show the facts in relation to depreciation, appropriations and reserves is to have accounts showing the amount by which the physical property of the company is depreciating month by month, as determined by estimate made in the manner heretofore explained; showing the actual appropriations made to the depreciation fund, and showing the amounts expended for replacements on acount of depreciation. Any income derived from the investment of depreciation reserve may be utilized as accretions to the reserve.

An appropriate combination of such accounts will show at all times the relation between the total amount that the property has depreciated and the amount of reserve held to care for this depreciation as well as the relation of the actual amounts appropriated to care for deferred maintenance to the amounts expended for this purpose.

GRILLE BOILERS IN FRENCH POWER PLANTS.

BY FRANK C. PERKINS.

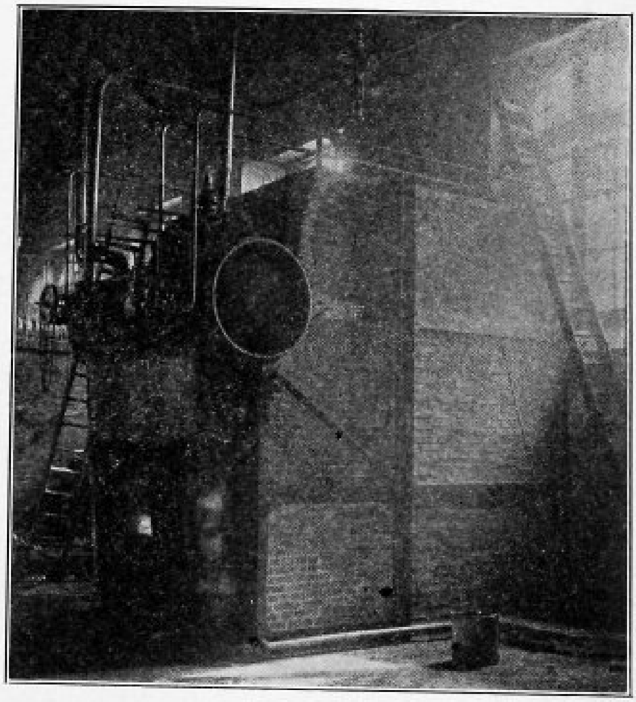
At the power house of the French Government powder factory at Bourget a marine boiler of the Grille type is utilized, as shown in the accompanying illustration, producing 5,500 pounds of steam per hour with natural draft under a steam pressure of 250 pounds per square inch. In France this type of marine boiler is largely used for stationary power purposes on account of its small size for a given output and its remarkable efficiency. At the Bourget plant the efficiency is said to be 74 per cent and the length of the boiler only 8.2 feet with a width of 7.2 feet.

Four of these boilers are installed at a Bordeaux plant utilizing forced draft and producing 22,046 pounds of steam per hour. These boilers are provided with superheaters, the steam being generated at a pressure of 250 pounds per square inch and superheated to 300 degrees centigrade. The boilers have a grate area of 86 square feet and an air pressure of 1 3/16 inches is employed in the forced draft system.

The space occupied by the boiler room at this plant is remarkably small considering the quantity of steam produced per hour under the above conditions, as the boilers, with all the fittings, including the feed pump, fans and other accessories, are installed within an area measuring 26.3 feet long and 26.3 feet wide.

In the French boiler illustrated, the aim has been to design the new boiler with smaller floor space for equal duty minimum weight with maximum strength, as well as higher duty and efficiency, the highest possible duty without priming, facilities for cleaning and overhauling with less loss, and prevention of accidents to stokers through scalding.

It is held that with these French boilers scalding accidents to stokers are non-existent. In the English construction of the Grille boiler the original form with the water-legged tube, having what is termed the free discharge tube, in which, after generation, the steam passes, without obstacle, direct to the steam drum.



GRILLE WATERTUBE BOILER.

It is stated that in the water-legged type the tubes connect directly or indirectly at both ends with the water space of the drum; consequently the water fills the tubes and, a rupture occurring, water flows from either direction towards the opening. In a severe rupture an amount of water will be discharged equal to the delivery of a tube of double the area; consequently the whole quantity of water in the boiler above the rupture is free to flow from two openings and, in a confined space or a closed stokehold, the risk to the stokers is appalling, especially with tubes of large diameter.

With the Grille tubes the design is such that with equal area of tube the most severe rupture would only allow of one thirty-second of the amount of water being discharged and 32 tubes must burst in a Grille boiler simultaneously to produce equal discharge of water to any water-legged tube of equal diameter. This introduces a remarkable factor of safety for the stoker. The standard Grille tube is 1 inch internal diameter, boiler tubes run up to 4 inches diameter, and in such the risk of accident is enormously increased.

It is held that taking the risk in the Grille tube as unity, the ratio of disaster in a 4-inch water-logged tube is increased as 1 is to 512, or that number of tubes must burst simultaneously in this boiler to give the same discharge of water. A boiler of 512 tubes would evaporate 15,000 pounds of water per hour, and it is not within the region of probability for more than one tube to rupture at the same time.

It is claimed that it is the rapid development of steam from high temperature water suddenly escaping at atmospheric pressure wherein lies the danger to the stoker. As it has seemed heretofore impossible to prevent the rupture of tubes, it has been desirable to minimize the danger; but it is claimed that this French boiler not only reduces the danger but makes it non-existent without question.

At Bromley-by-Bow, in England, tube rupture demonstrations have been made on the boiler with experimental apparatus in full blast under 160 pounds steam pressure per square inch, the rupture in the tube being equal to double the tube area, the draft on the gage at the bottom of the chimney being one-half inch. To produce the maximum effect possible, water and steam were discharged simultaneously from the water and steam spaces of the drum, two separate 1-inch tubes being led to the back of the combustion chamber, the water and steam being discharged directly downwards on to the fire at the back of the brick arch. It is held that these trials proved that with this boiler the stoker is safe from scalding accident.

It is plain that if the water admitted to the tube is of a limited nature, the discharge of water in case of a rupture must be confined to the size of the orifice through which the water passes, and this aperture being of the size stated, the discharge is so small as to entirely prevent accident. A safety or limitation cartridge is used in position in the end of the tube.

There is a prejudice against the bent tube on the question of scale formation. It is held that mechanical apparatus does not keep a tube clean, but is merely a way of maintaining it dirty, for mechanically-cleaned boilers are only clear of scale for short periods after cleaning. It is maintained that this French boiler can be kept constantly clean, no matter how hard the water or how long it is kept in commission.

The Reformation of Boiler Engineering.

We admire Dr. Nicholson for the persistence with which he attempts to reform boiler engineering. He holds that the practice of making steam, as now followed, is antiquated and inept. He is prepared to show the world a more excellent way; and failure and rebuffs leave him undaunted. The faith that is in him enables him to support reverses; and if he cannot achieve success, at all events he deserves it. What he writes and does in the way of boiler engineering are interesting and instructive. They deserve careful consideration. It may be easily conceded that Dr. Nicolson is a very excellent example of the results of the highest type of technical education; and it is well worth while to study his methods of dealing with the usual problems of boiler engineering. For him, the transmission of heat, the combustion of fuel, the manufacture of steam, are simply matters of mathematical investigation. Each question, as it turns up, is solved by an equation; and we have statements put forward as demonstrable truths which are enough to make the hair of common boiler designers, makers, or steam users stand on end. We have, from time to time, put his views before our readers. Quite recently we dealt with Mr. Longridge's report on a Nicolson experimental boiler. It will be remembered that that report would have proved very disheartening to anyone who had not a fair proportion of faith in himself. Dr. Nicolson, however, has been equal to the occasion. He has apparently abandoned the attempt to make the Cornish or Lancashire boiler better, and has produced a new design which he has made the subject of a very clever paper read before the Institution of Engineers and Shipbuilders in Scotland recently. The subject is "Boiler Economics and the Use of High Gas Speeds."

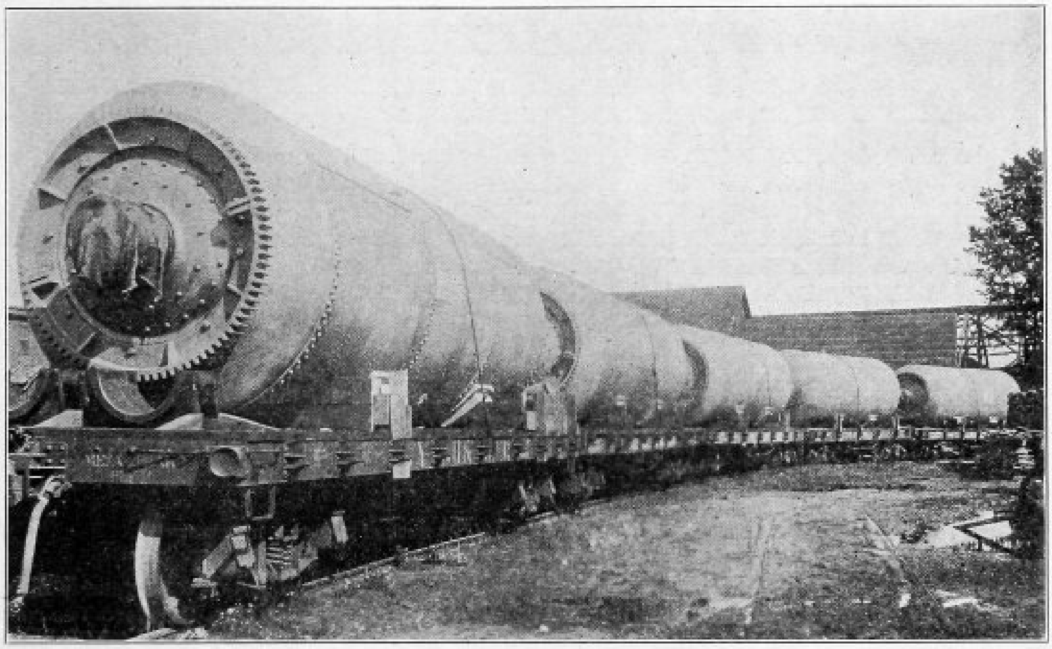
The history of Professor Nicolson's labors is quite simple. He became acquainted with a statement made by Professor Osborne Reynolds as far back as 1874, to the effect that the amount of heat transferred from hot air to a metal surface is almost in direct proportion to the difference of their temperatures and to the product of the speed of movement and density of the air. At first sight it would seem that this simply means that if we double the weight of hot air flowing through a tube we shall double the weight of water which it will evaporate. To Professor Nicolson, however, it means much more than this. It means that if we pass the same weight of gas through a tube at different velocities, the rate of evaporation will augment with the velocities. He says, then, in effect, instead of letting the flame and products of combustion roll languidly through the great flues of a Cornish or Lancashire boiler, compel them to move at a high velocity. This can only be done by contracting the calorimeter of the boiler—that is to say, reducing the cross-sectional area of the flues. But if this is done the friction will be so great that air enough will not get to the fires. Use, then, an exhaust fan, and make a vacuum at the foot of the chimney of 15 to 20 inches of water, and the thing is complete. Furthermore, as we shall not now want a high, or, indeed, any particular chimney temperature, let us combine with the boiler an economiser, and if high speed is good for the former, so it must be good for the latter. Contract, then, the calorimeter of the heater, because the fan will deal with the resistance, and employ a good big circulating pump to keep the water going at high speed through very small and long tubes.

It will be remembered that in the first experimental boiler a water drum was put into the flue of a Cornish boiler, which was of so nearly the same diameter that only 1 inch of space intervened all round. Through this space the products of combustion had to find their way under the influence of a fan. Unfortunately, this was too much for the drum, which was speedily burned, and then Dr. Nicolson substituted the long fire-brick cylinder, which was in the boiler when Mr. Longridge carried out his tests. Mr. Longridge held that the theory of the boiler was admirable; its practice execrable. For one thing, every time the boiler was inspected the fire-brick drum would have to be pulled out. We now learn from the paper before us that Dr. Nicolson has abandoned the Cornish boiler, as we have said, and has designed a new mechanism for generating steam. To call it a boiler would be, perhaps, profanation.

We hasten to say that this generator is extremely ingenious. That it complies very fully with scientific indications of what a boiler should be, in the sense that it is intended to absorb the largest possible quantity of heat in any unit of time, per square foot of surface, there is no room to doubt. But, when we have got thus far, it seems to us that we have reached a limit. Dr. Nicolson is left to face the problem of proving that his boiler represents any advance on existing commercial methods of making steam in boilers which are undoubtedly the survivors of the fittest—the result of years of practice in land stationary boilers and locomotives, and of most costly and tedious experiments, in the case of the great army of water tube boilers in use at sea.

The proportions of the Nicolson generator, its economizer, fan, etc., and the results to be obtained, have all been settled by elaborate formulæ, over twenty-two in number. These, however, depend for their utility on their coincidence with facts. Thus, if surfaces become dirty, the rate of evaporation may be diminished, and so on. But, leaving this to be settled in a few years, or months, or perhaps days, let us proceed to consider what the new boiler is like. The description comes in Part VI. of the paper, under the head "Rational Design of Steam Boilers." Hitherto, apparently, the designs have been irrational. The author now proceeds to show how, "by the application of Stefan-Boltzmann's law of radiation, and Osborne Reynold's law or heat transmission, the designing of a steam boiler may be rationally carried out, with the assured expectation that the results actually obtained on trial will be in close accordance with those predetermined by calculation." We may remark incidentally, that Dr. Nicolson does not seem to be aware of the fact that the laws of radiation by hot gases are just now in the melting pot, and that without the least knowledge of either Boltzmann or Stefan, designers of irrational boilers secure results on trial which are just what they had predetermined they should be. The high-speed rational boiler consists essentially of three horizontal drums connected by tubes, so arranged that they resemble an L; the horizontal tubes lie along the crown of a furnace; the flame passes from this, through openings in a fireproof wall, to a combustion chamber, from which, again, the hot gas rises through a forest of vertical tubes, uniting the upper and lower drums, and thence flows downward through another forest of vertical tubes uniting two more drums, which is called the economizer. Here they are got hold of by a big exhaust fan, and so sent to the chimney. There are, in all, five drums. The furnace arrangements are such that we should not be surprised to hear that the bricks "dripped" in the combustion chamber, as they did with the Cornish boiler in the original experiments. Honestly, we have no exception whatever to take to the design of the new boiler as the embodiment of Dr. Nicolson's theories. But there our approval, we fear, must end. The generating tubes are only ⅝ inch in diameter, with a bore of ⅜ inch. The economizer, or feed heater, has tubes only ½ inch diameter and ¼ inch bore. It must, of course, be understood that circulation is maintained by a rotary pump. We fail to see how dry steam can be made. We should, indeed, anticipate heavy priming. The use of tubes of such small diameter and some 10 or 12 feet long will not, we think, commend itself to engineers. We may safely leave the settlement of the endurance of this generator to time.

It may be asked, after all, in what way is Dr. Nicolson's generator better than its predecessors? Such, for example, as its congeners of the Stirling type. The reply is that for equal powers it is much smaller; also that it is much cheaper to work. Dr. Nicolson compares a "rational high-speed" generator with an ordinary water tube boiler, each making 10,000 pounds of steam per hour. The first will cost $4,160 per annum, the second only $3,380—a saving at the rate of $1,560 a year per 1,000 indicated horsepower installed. As to space, he estimates that in the *Lusitania* no less than 37 percent would be saved by the substitution of his for Scotch boilers. He draws another comparison between the Chilian warship *Libertad*, fitted with twelve Yarrow boilers, and alternatively with twelve Nicolson boilers, a saving of 565 tons being effected, and the radius of action at 20 knots raised from 3,800 to 5,100 miles. We have done our best to place Dr. Nicolson's boiler fairly before our readers. If he is successful in producing a steam generator which will satisfy the demands of purchasers in the way he hopes, then he will have done really a new thing in boiler engineering. But he will, no doubt, be the last man to be surprised if his claims are regarded with incredulity. Faith in long boiler tubes of small diameter and intensely heated has been worn very thin.—*The Engineer.*



A SHIPMENT OF CYLINDRICAL ROTARY BOILERS.

Rotary Boilers.

BY J. J. NORRIS.

The photograph reproduced herewith is a portion of a shipment of cylindrical rotary boilers made by the Manitowoc Boiler Works Company, of Manitowoc, Wis., and shipped to Kalamazoo, Mich. The boilers are 8 feet in diameter and measure 24 feet in length on the cylindrical part. The shells are double-butt strapped and quadruple riveted. They are furnished with three blow-off valves and have three stock openings 20 inches by 30 inches efficiently reinforced. Rotation of the above shells is effected by three trains of gears, the driving ring being directly secured to one of the large air-cooled trunnions. The boilers were constructed to meet requirements of the Hartford Steam Boiler Inspection & Insurance Company.

COMBUSTION AND BOILER EFFICIENCY.*

The Importance of Carbon Dioxide as an Index to Combustion and to Boiler Efficiency.

BY EDW. A. UEHLING.[1]

It is now fully recognized by all progressive and observing engineers and managers of power houses that there is more room for economy in the boiler house than in any other part of the plant. It is therefore not due so much to lack of recognition of the fact that there is still from 5 percent to 25 percent of the available energy of the coal needlessly wasted that this waste continues to an appalling degree, as to the inherent difficulty in regulating combustion so that the loss may be reduced to a minimum.

The efficiency of the steam generator depends on complex conditions, many of which are not only beyond control but are continually changing. Some of them are: (1) Atmospheric condition; *i. e.*, the barometric pressure, humidity of the atmosphere, direction and velocity of the wind, all of which affect combustion. (2) The quality of the fuel, which at best is never quite uniform, even when similar in kind, and which often varies greatly in its content of moisture, fixed carbon, volatile combustible matter, oxygen, ash, etc.; also its physical condition, unless specially prepared, may, and often does, vary from large lumps to fine powder. (3) The condition of the boiler as to setting, dirty heating surface, air infiltration, draft, etc. The grates become choked with slate and clinker, obstructing the air passage and causing irregular flow, resulting in a deficiency of air in one place and an excess in another. Every one of these variables affects the efficiency of the boiler furnace. (4) The required output, which varies in some plants between very wide limits, not infrequently from 50 percent overload to 50 percent below normal capacity in short intervals of time.

From the foregoing it becomes quite evident that steam boiler economy is a complex problem, and no matter how well a boiler may be designed and how perfectly constructed, it cannot be permanently adjusted to operate with maximum efficiency under the varying conditions which obtain, even under the most favorable circumstances. Permanent adjustments of a steam boiler cannot be made, as in a steam engine, to obtain maximum efficiency.

The heat energy carried off by the flue gas in general boiler-room practice is rarely as low as 15 percent, and not infrequently reaches 40 percent of the calorific value of the fuel burned under the boiler. This loss is made up of two distinct factors—the sensible heat of the flue gas and the potential heat of the combustible constituents it contains. The former varies directly as the stack temperature and inversely as the percentage of CO_2. The latter is independent of the stack temperature, but for any given percentage of combustible constituents in the flue gas the loss also varies inversely as the percentage of CO_2. The only heat loss that is independent of the percentage of CO_2 in the flue gas is that due to the moisture contained in the fuel, but it is dependent on the stack temperature. The percentage of CO_2 and the stack temperature are, therefore, the two controlling factors.

For any given boiler and setting driven at a given rate the temperature of the flue gas depends on the condition of the heating surface and on the amount of air infiltration. When the heating surface becomes dirty, either inside or outside, or both, the stack temperature will be correspondingly higher, other conditions being the same. Air infiltration lowers the stack temperature in proportion to its ratio to the actual products of combustion. We have, therefore, two conflicting conditions that influence the stack temperature. Because of dirty heating surface, it should be above normal, but air infiltration may actually bring it below normal, so that the stack temperature alone cannot be depended upon as an index to either economical or wasteful operation, especially since it gives no clue to the efficiency of the furnace.

An excessive air infiltration becomes manifest at once by an abnormally low percentage of CO_2, so that a knowledge of the latter is necessary to understand the true significance of the former. Hence it is evident that to produce maximum economy, or even good average results, some means should be provided to indicate to the attendant continuously what his fires are doing.

Provided the boiler is properly designed and set and is otherwise in good condition, *i. e.*, clean inside and out, its economy depends entirely on the regulation of the furnace. This again depends upon the regularity of fuel and air supply in the correct proportion and through the proper channels. Since the composition of the products of combustion gives immediate evidence concerning the furnace operation, it follows that in the analysis of the flue gases lies the key to the attainment of maximum efficiency, and the most progressive engineers and managers of power plants have employed gas analy-

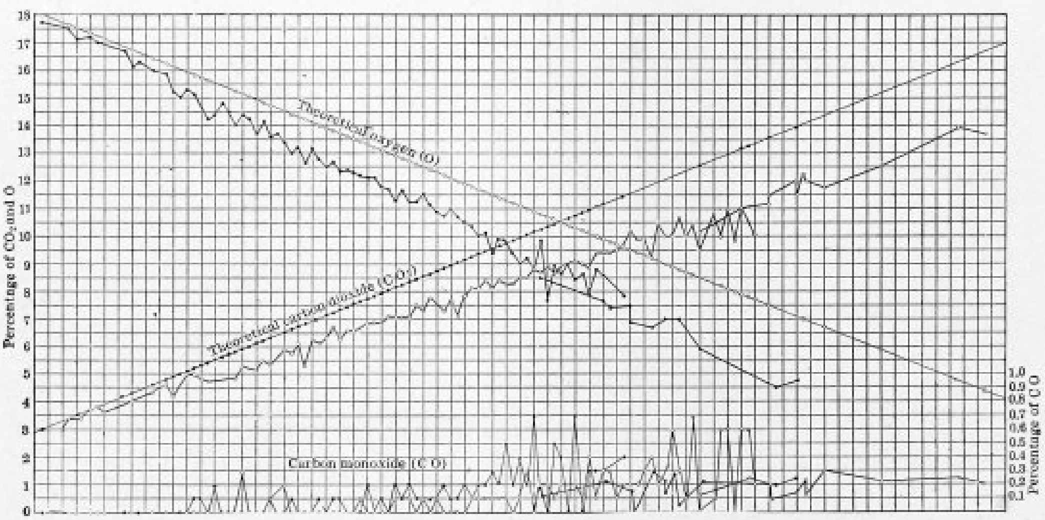


FIG. 1.—DIAGRAMMATIC REPRESENTATION OF ANALYSIS MADE AT THE ST. LOUIS EXPOSITION.

* A paper read at the New York (December, 1910) meeting of the American Society of Mechanical Engineers. We are indebted to *Industrial Engineering* for use of the cuts.

[1] President Uehling Instrument Company, Passaic, N. J.

sis in a more or less thorough manner as a means for obtaining increased boiler-house economy.

Since an excess of oxygen is necessary for complete combustion, it is held by some combustion experts that oxygen is a better index to the efficiency of combustion and boiler economy than CO_2. A study of Figs. 1 to 4, plotted from these analyses, obtained from many sources, may lead to the conclusion that the percentage of oxygen might answer as well as the percentage of CO_2, but hardly better. When we consider that CO_2 is more readily determined than oxygen, and that there are a number of practicable instruments on the market that will autographically record the percentage of CO_2 in the flue gas at short intervals, one of which will make a continuous record and at the same time indicate the percentage of CO_2 at the boiler front, there can be little room for doubt as to which of the constituents is the better adapted to serve as the index of economical combustion.

It may be questioned whether a knowledge of the percentage of CO_2 is sufficient for economical firing. Is it not necessary to know the percentage of oxygen, carbon monoxide (CO), hydrogen (H) and hydrocarbons (C_xH_y) as well?

For scientific tests and investigations, complete analyses of the products of combustion should always be made, but such tests can only be carried on by an expert with the necessary scientific apparatus and the help of competent assistants. They are, therefore, not available for everyday practice. Occasional tests are undoubtedly of great value, especially for the purpose of determining the most economical percentage of CO_2 for the kind of fuel used and the conditions prevailing, but what is needed is a continuously available index. For such index the choice can lie only between CO_2 and oxygen, and, for reasons already given, CO_2 is much to be preferred. The graphic illustrations show conclusively that under normal conditions of combustion there is a very definite relation between the percentage of CO_2 and oxygen contained in the flue gas. The percentage of oxygen falls almost exactly in the same ratio as CO_2 goes up and *vice versa*. The analyses also show conclusively that there is no relation between either oxygen or CO_2 and CO. High oxygen and low CO_2 is no guarantee that CO may not be present, nor does it follow that high CO_2 and low oxygen means incomplete combustion. All that we can discern with certainty is that there is a tendency toward higher CO as the percentage of CO_2 goes up. This tendency increases very moderately at the lower range of CO_2, but more and more rapidly as the maximum percentage of CO_2 is reached. Since the ratio of carbon burned to CO to that burned to CO_2

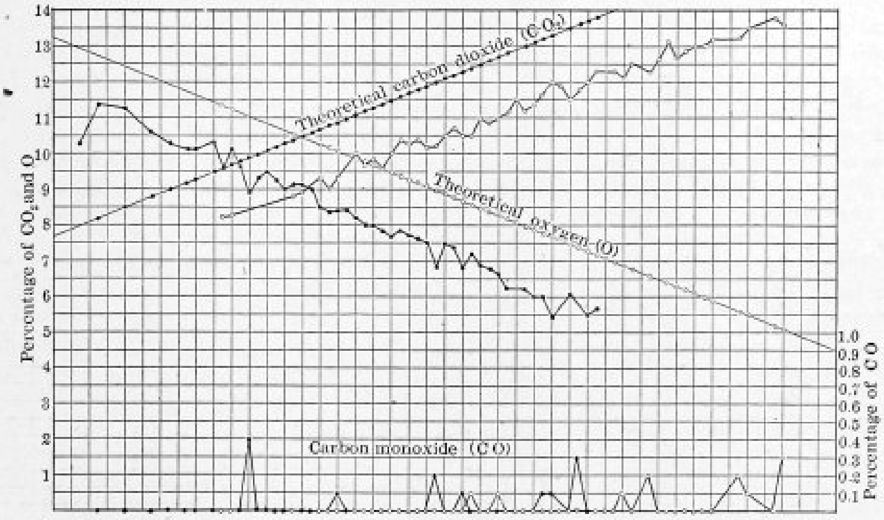


FIG. 2.—DIAGRAMMATIC REPRESENTATION OF ANALYSIS OF FLUE GASES OF LOCOMOTIVE.

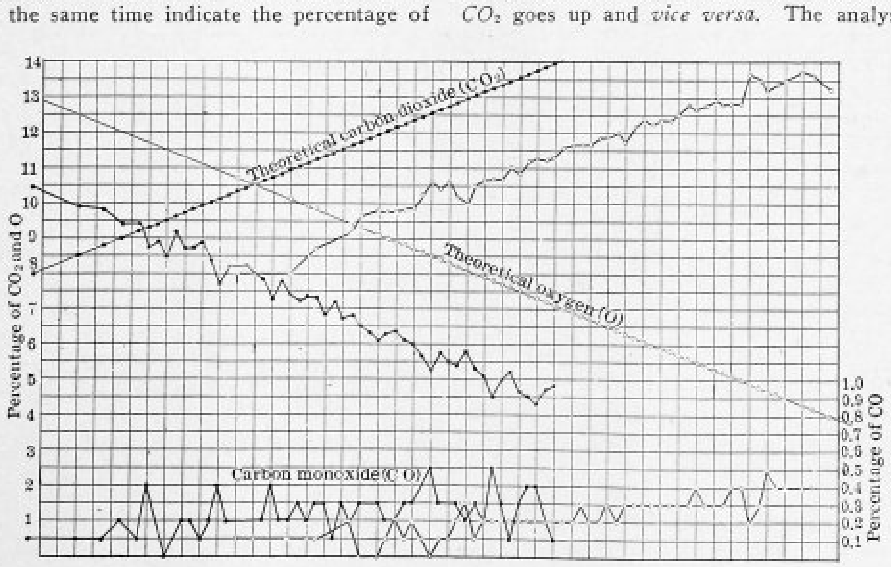


FIG. 3.—DIAGRAMMATIC REPRESENTATION OF A SERIES OF ORSAT READINGS.

equals $P_c \div (P + P_c)$, it follows that the loss (L_c) due to carbon monoxide for the same percentage of CO varies inversely as the percentage of CO_2, *e. g.*, 1 percent of CO in flue gas containing 5 percent of CO_2 causes as great a loss as 3 percent CO associated with 15 percent of CO_2. The same holds true of the loss due to all the combustion products with the exception of the moisture contained in the fuel. The general conclusion that the chimney heat loss varies inversely as the percentage of the CO_2 in flue gas seems, therefore, warranted.

The sum of percentages of CO_2, oxygen and CO contained in flue gas varies with the excess of air, the degree of completeness of combustion, the composition of the fuel and the temperature at which the gas is analyzed. When combustion is complete and the fuel consists of carbon only, the sum of CO_2 and oxygen cannot exceed the percentage of oxygen in the air, viz.: 21 percent. It will always be less than this, because the gas is saturated with moisture, which in general gas analysis is hydrogen require, respectively, 152 and 457 cubic feet of air for complete combustion. The products of combustion are composed of 31.92 cubic feet of CO_2 and 120.08 cubic feet of nitrogen for carbon, and 361 cubic feet of nitrogen for hydrogen. When burning fuel containing a high ratio of available hydrogen to carbon, Illinois bituminous coal, for example, in which $H_a \div C = 0.06$, assuming complete combustion with the theoretically required volume of air, then $(152 \times 21) \div [152 + (361 \times 0.06)] = 18.4$ percent is the maximum CO_2 obtainable from this coal. If the above coal is burned with 50 percent excess of air, again assuming complete combustion, the flue gas would be composed of $(152 \times 21) \div (228 + 32.5) = 12.25$ percent CO_2, and $(86.8 \times 21) \div (228 + 32.5) = 7$ percent oxygen, or a total of 19.25 percent. Now, if we assume the gas to contain 0.5 percent CO, the sum of $CO_2 + O_2 + CO = 12.25 + 7 + 0.4 \times 0.5 = 19.45$ percent. If the gas were analyzed at a temperature of 92 degrees the result would be

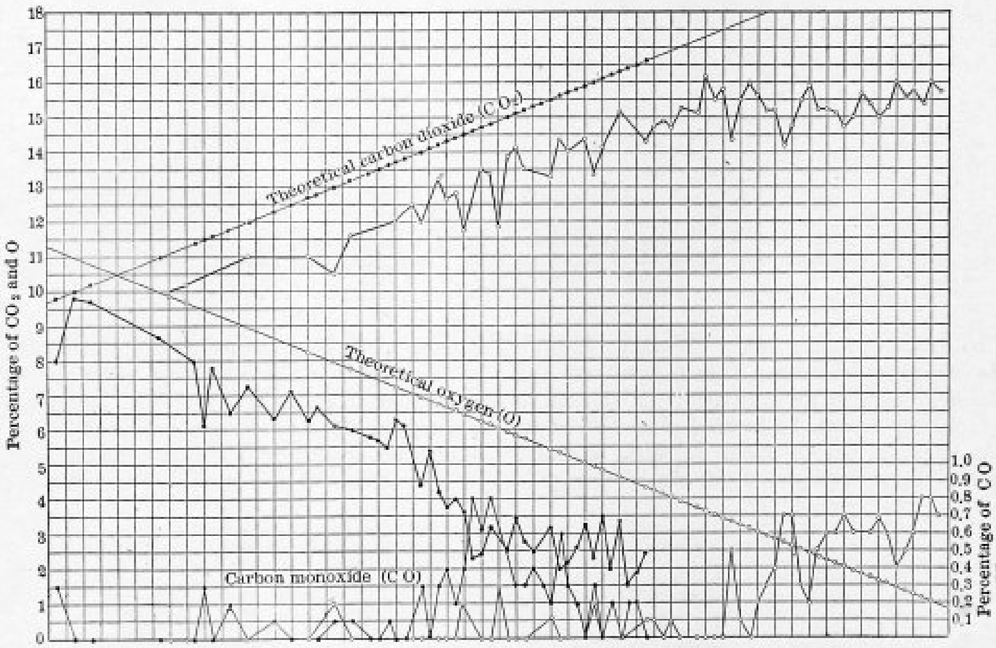


FIG. 4.—DIAGRAMMATIC REPRESENTATION OF A SERIES OF ORSAT READINGS.

reckoned with the nitrogen. This introduces a possible difference of 1.3 percent, due to the differences in the moisture content of the gas between 62 degrees and 92 degrees, a range of 30 degrees.

INCOMPLETE COMBUSTION.

When carbon is burned to CO every molecule of O_2 combines with two atoms of carbon and forms two molecules of CO. The gas may, therefore, contain 34.7 percent of CO as a maximum. Therefore, if combustion is incomplete and CO is present, the sum of $CO_2 + O_2 + CO$ in dry gas may be greater than 21 percent by an amount equal to $[(34.7 - 21) \div 34.7] \times CO = 0.4\ CO$, so that in this case the sum of the oxygen components in saturated gas would be $21 + 0.4\ CO$ $[(H_2O \times 21) \div 100]$. Since the percentage of CO in normal flue gas reaches 1 percent only in exceptional cases, and the reduction due to moisture is not likely to be less than 1 percent, flue-gas analyses in which the sum of the oxygen components exceeds 21 percent must be looked on with suspicion.

In burning fuel containing any considerable quantity of hydrogen the sum of $CO_2 + O_2 + CO$ will always be less than 21 percent in normal flue gas, because all the oxygen which combines with the hydrogen forms water vapor, which is condensed, while the nitrogen remains as a dilutent. Carbon and

9.6 percent less than the above, due to moisture in the gas. The analytical result would, therefore, be 17.58 percent.

This is an extreme case, but it shows that large variations may legitimately occur in the sum of the oxygen components contained in combustion products. It also shows that the temperature at which gas analyses are made should be taken into consideration. It brings out the further fact that the maximum percentage of CO_2 that may be contained in flue gas decreases as the ratio of carbon to hydrogen in the coal increases, from which it becomes evident that the most economical percentage of CO_2 must vary with the kind of fuel. It will be several percent higher with anthracite than with bituminous coal, and varies in the latter with the ratio of carbon to available hydrogen.

The highest practicable furnace efficiency obtains when the greatest possible part of the potential energy contained in the coal is converted into sensible heat by combustion. The highest boiler efficiency results when a minimum of this heat is carried off by the flue gas. The former is realized when combustion is complete, the latter when the weight and temperature of the flue gas are a minimum. Since the weight of flue gas decreases as the percentage of CO_2 increases, high boiler efficiency requires high CO_2.

On the other hand, when the furnace is run so as to produce a maximum percentage of CO_2, there is danger of reducing its efficiency because of incomplete combustion due to a minimum of free oxygen. It would seem, therefore, that the highest combined efficiency of boiler and furnace would be obtained when the gain due to reduced weight of flue gas, *i. e.*, due to an increased percentage of CO_2, is balanced by the loss due to incomplete combustion.

The most economical percentage of CO_2 varies theoretically with the ratio of available hydrogen to carbon $H_a \div C$, but in practice it is influenced by many modifying conditions. In every case, however, there is a percentage of CO_2 which gives best results. Its value as an index, therefore, is not dependent on the kind of fuel used or the local conditions existing.

Next to careless or unskillful firing, air infiltration causes the greatest loss in the flue gas. Unless especially provided against it is rarely less than 15 to 20 percent of the volume of the flue gas, and not infrequently reaches 50 percent and over when cracks in the settings are allowed to exist, and warped and badly-fitting cleaning doors are tolerated. Prof. Breckenridge, in his discussion of the boiler tests carried on by the government under his direction at St. Louis, estimates the air infiltration at from 25 to 30 percent, and it would be presumptuous to assume that the boilers used for these tests were not in at least as good condition as those in the average power plant.

Comparing Tables 1 and 2 with Tables 5 and 6, it will be noticed that the percentage of CO_2 is much lower in the former than in the latter set of analyses, and, what is even more striking, that CO occurs with greater frequency and in larger amount in the government tests than in those represented in Tables 5 and 6. It would seem proper to infer that this is due, largely at least, to much greater air infiltration in the former case than in the latter, and that at least 20 percent should be added to the CO_2 and CO, and subtracted from the oxygen in order to represent correctly the composition of the combustion products formed in the furnace. From Tables 5 and 6 it is apparent that a high percentage of CO_2 is possible without undue loss of combustible in the flue gas.

We have already shown that when burning coal in which $H_a \div C = 0.06$ with 50 percent excess of air the flue gas should contain 12.25 percent CO_2 and 7 percent oxygen. It would, therefore, seem reasonable to conclude that when burning coal in which the ratio $H_a \div C$ does not exceed 0.05, if the CO exceeds 0.2 percent, or at most 0.3 percent, in flue gas containing 12 percent to 14 percent of CO_2 and 7 percent to 5 percent of oxygen, there is something wrong with the method of firing, the furnace, the construction, the setting, or all of them.

An attempt also has been made to show why the sum of the oxygen components contained in flue gas does vary and to what extent it may vary legitimately. It was shown that a considerable variation may be due to a variation in the temperature at which the gas is analyzed, that the presence of CO augments the sum of the oxygen components by 0.4 of its value, and that the presence of hydrogen in the fuel reduces this sum very materially. It follows, then, that for similar fuel the higher percentage of CO should coincide with the higher sum of the oxygen components.

DIAGRAMMATIC REPRESENTATION OF ANALYSES.

The averages varying by 0.1 percent of a large number of tests made at the coal testing station at the St. Louis Exposition and on locomotives are plotted in Fig. 1, those of a series of six-hour average samples in Fig. 2, and those of a series of Orsat reading in Figs. 3 and 4. The straight lines represent the theoretical amounts of CO_2 and oxygen which the combustion products would contain if pure carbon were burned with pure air. The analyses were plotted with regard to the percentage of CO_2 and oxygen, respectively. The CO_2 was placed in its proper position on the theoretical CO_2 line for the percentages of CO_2, and then the accompanying percentages of oxygen and CO were plotted on the same ordinate in the position called for by their value. In the same manner the oxygen was placed on the theoretical oxygen line and the CO_2 and CO were plotted according to their values on the same ordinate. To show the values of CO more clearly they are multiplied by five.

Fig. 1 shows that the percentage of oxygen diminishes as the CO_2 increases, and *vice versa*, the percentage of CO_2 increases as the oxygen decreases. It will be noted that both the oxygen and CO_2 lines converge toward the theoretical line as the CO_2 diminishes, which is as it should be if the analyses are correct, because when the CO_2 is zero the percentage of oxygen must be that of the air, viz.: 21 percent. The amount of divergence from the theoretical line towards zero oxygen depends on the value of $H_a \div C$ in the fuel.

Considering the great variety of fuels represented by the government analyses, it is remarkable with what uniformity the CO_2 and oxygen vary in accordance with what should be expected from the theoretical considerations. We may be justified in concluding that the relation of CO_2 to oxygen, shown in Fig. 1, holds true for all ordinary conditions of simple combustion. It therefore follows that if we know the percentage of CO_2 contained in the products of combustion, we may infer from it, with a practical degree of approximation, the accompanying percentage of oxygen, and *vice versa*.

That no such reliable relation exists between the CO and either of the former has already been stated. That this should be so becomes quite evident when we consider that the relation between CO_2 and oxygen depends on a natural law, whereas the percentage of CO in a large degree depends on caprice.

The CO line in Fig. 1 illustrates the irregularity of this component. It was stated at the outset that the tendency toward a higher percentage of CO in flue gas becomes increasingly greater as the percentage of CO_2 goes up; but the diagram shows a maximum of over 0.4 percent of CO with CO_2 between 10 percent and 11 percent, whereas with CO_2 between 11 and 14 percent the CO does not average above 0.2 percent. This apparent anomaly is explained by the fact that government analyses include from 20 to 30 percent of infiltrated air, and that the real combustion products contained about 25 percent more CO_2 and 25 percent less oxygen than the analyses show. In reality, therefore, the high CO readings occurred with CO_2 from 12.5 to 13.75 percent. This would place the high CO in its proper relation to CO_2, but the contrast, as compared with the CO found in the flue gas of the locomotive test, still remains, and is evidence of uneconomical firing.

Passing to Fig. 2, we notice the same characteristics as in Fig. 1, viz.: the oxygen line follows a trend which should meet the theoretical oxygen line at 21 percent when CO_2 reaches zero, and the CO_2 follows a trend which would meet the zero point of the theoretical CO_2 line when oxygen reaches 21 percent. The CO is irregular, and has a moderate tendency towards higher values as the CO_2 reaches the higher values. With the exception of the few analyses previously discussed, this diagram shows very good combustion.

Fig. 3 corroborates what has already been said about the analyses from which it was plotted. The CO line is irregular and high, and only slightly higher with CO_2 above 11 percent than below. Both the CO_2 and the oxygen line show that the analyses are deficient in the oxygen components, nor does the trend of the O line converge toward the theoretical line as it should. The correctness of the analyses from which these curves were plotted must, therefore, stand questioned, and other than showing this fact little value can be attached to the diagrams in Fig. 3.

The suspicion as to the correctness of the analyses is strengthened to an even greater extent by study of Fig. 4. The analyses appear to be particularly faulty with the higher CO_2 and the correspondingly lower oxygen content. The high and erratic CO line shows that the firing must have been irregular and bad. But reliable conclusions cannot be drawn from this diagram except that at least a large number of the analyses cannot be considered reliable.

CONCLUSIONS.

We must conclude from these calculations that the percentage of CO_2 and the stack temperature are the two controlling factors in the production of furnace and boiler efficiency. In view of the fact that both of these components are so easily determined and that apparatus is in existence which will continuously indicate and record them, it is lamentable that more general use is not made of these indexes.

There is to-day no valid reason why scientific methods should not prevail in securing fuel as well as in consuming it, especially for power purposes, nor is there any reason why consumers of large quantities of coal should be ignorant of its ultimate as well as its proximate composition.

It is not generally feasible, nor is it at all necessary, in order to obtain the most economical results, that calculations be based on the ultimate analysis of the coal, but a full analysis of the flue gas should form part of the daily routine. Inasmuch, however, as the most economical percentage of CO_2 varies considerably with the kind of fuel used, and also to some extent on the method of firing, hand or mechanical, the kind of stoker and rate of driving, it becomes very desirable, if not absolutely necessary, to make a series of tests in which all the essential elements are determined.

Having established the most economical value of CO_2, this component of the flue gas will serve as a correct guide to the fireman. An automatic record, preferably a continuous one, for the engineer is of the greatest value. If, in addition, the stack temperature is indicated for the fireman and recorded for the engineer in charge, there should be little difficulty in getting maximum efficiency.

Notes on Estimating.

BY D. M. MC LEAN.

In the general contract shop the estimator plays an important part, and to cope successfully with all the problems which come before him requires an all-around knowledge and experience seldom combined in one person.

Generally speaking, he requires a thorough knowledge of mensuration for this calculation of areas, volumes and weights, and must be familiar with current prices of materials, rates paid for various classes of labor, the processes of manufacture and the time required for the various operations. In addition, he should have a good knowledge of design and construction, and where field work is to be done he should, if possible, have had some experience in that also. Coupled with all of these he will find it necessary to exercise very careful judgment in the majority of cases, as there are so often contingencies or indeterminate items to be provided for, especially where certain work is done for the first time or where field work is included.

The ability to take out quantities and weights is readily acquired by the technical graduate or even by the average high school graduate, when instructed as to the necessary allowances for laps, overweight, waste in cutting and other losses, according to the practice of the particular shop he is with. The estimator soon learns to facilitate his labors by means of the various tables of circumferences, areas, contents, weights, etc., in various handbooks, and to supplement them with data of his own compilation. A systematic filing of estimates made, together with comparison of weights, etc., of the completed jobs, will assist very greatly in the preparation of other estimates, as well as prove very instructive as to correctness of previous work and allowances.

In some offices the work of the estimator ends here, the estimate of cost price and the final selling price being arrived at in other departments either on the basis of a price per pound or on the basis of the estimated labor as figured by the foreman or shop superintendent at regular rates plus the shop burden. The sales department then adds percentages for general and selling expense and for profit, and thus arrives at a selling price.

In other offices the estimator is expected to submit his figures to the sales department at the total estimated cost, leaving that department to add profit and make up the selling price. In such cases the estimator will require to have considerably more information on tap, and will find his resources considerably taxed at times. If lacking in experience himself, knowledge of construction, rates of doing work, etc., he must get after those who have such information, and by consultation with draftsmen, shop and field foremen, etc., to acquire all necessary data to embody in his estimate. The cost records of the firm should be open to him for study of actual results and checks on his deductions, especially in cases where through competition it is necessary to shade the selling price.

As regards current prices of materials in a large organization with purchasing department these figures may usually be readily obtained in that department. In a smaller concern the estimator may find it necessary to keep his own record of current prices, either in the form of a card index or a loose-leaf book. The writer has used both, and for office use prefers the card index, but if the work requires estimates to be made frequently when away from the office a pocket size loose leaf note book is best. These records may also include rates paid for labor of various kinds, freight rates, etc.

With reference to familiarity with the processes of manufacture and rates of doing work, actual all-around shop experience in doing work is almost indispensable. In the modern specialized shop this is often difficult to acquire in a reasonable length of time, and where this is the case the estimator will have to supply his lack by close observation of shop work as frequently as possible, and by compiling from the cost records, consultations with foremen and other sources, figures on rates of punching holes, rivets driven, feet of seam calked, etc., per hour or day, until he acquires facility in estimating on the time required to perform regular or special work.

Much of the standard work can be reduced to an average rate per pound for labor, which will vary but little in a well-conducted shop, except, perhaps, as improved methods are brought into use. In many cases such average prices will have to be arranged on a sliding scale, the smaller sizes of boilers of various types taking the higher pound rates. In the case of tanks, stacks, breechings, etc., the average rates will usually hold good, except in connection with unusually small or large orders.

With regard to design and construction, the estimator should have had drafting room experience if possible. If not, it is absolutely necessary that he acquire all the knowledge he can of the design and construction of the work his firm is engaged in, by observation of the work itself, and by study of suitable books on boiler design, machine design and structural steel if necessary. It frequently happens that the drawings submitted by consulting engineers and others for estimate are more or less of the nature of diagrams, and unless the estimator knows what is lacking serious omissions are liable to occur in the estimates. For example, in a drawing of a marine boiler, the completed weight of which boiler was 17,000 pounds, stays and parts to the amount of 3,500 pounds were not indicated in any way. The estimator, however, realized from his knowledge of boiler design that they would be required, and added them, making the estimated weight 17,250 pounds. It very seldom occurs that the drawings of light plate work submitted for estimate show all the angles and stiffeners required, but these must, nevertheless, be provided for in the final figures.

In the case of field work, embracing the erection of such work as stand-pipes, water towers, penstocks, blast furnace work, structural steel, etc., the greatest care must be taken in the preparation of estimates, and all possible judgment and forethought exercised. Each job is a separate problem, and the cost of erection as a whole or per pound on one job is seldom a reliable guide with reference to another. A careful examination should be made of the site of erection and a study of the local conditions as to hauling of freight, transportation and board of workmen, supply of labor, sanitary conditions, etc. In the writer's observation these items are seldom looked into with sufficient care. Owing to keen competition the preliminary and other expenses are generally kept as low as possible, and previous to the award of the work very few firms go to the expense of sending a representative to the location for information, depending solely on the more or less meagre particulars in the purchaser's specifications. As in most cases, tenders must be on forms or in accordance with forms prepared by purchasers' engineers, or otherwise be treated as "informal" and thrown out, the bidder is at the outset shut out from putting in a saving clause or making any claim or securing any revision of the price after the work has begun and unfavorable circumstances have developed. Of course, the cost-plus-a-fixed-sum or cost-plus-a-percentage method is the best for bidders on field work, but in the writer's observation they have not been employed to any noticeable extent in the erection of steel plate work by contract shops, if at all.

It is safe to say that when field work contracts result unfavorably it is due in nine cases out of ten to failure to secure sufficient information about field conditions in advance, and to consider fully the contingencies bearing on them. The grade of the penstock site may look easy on the profile, but what if on arrival at the site you have to spend time chaining the rings as you place them beside the location preparatory to bolting up, in order to keep them from sliding to the bottom of the slope?

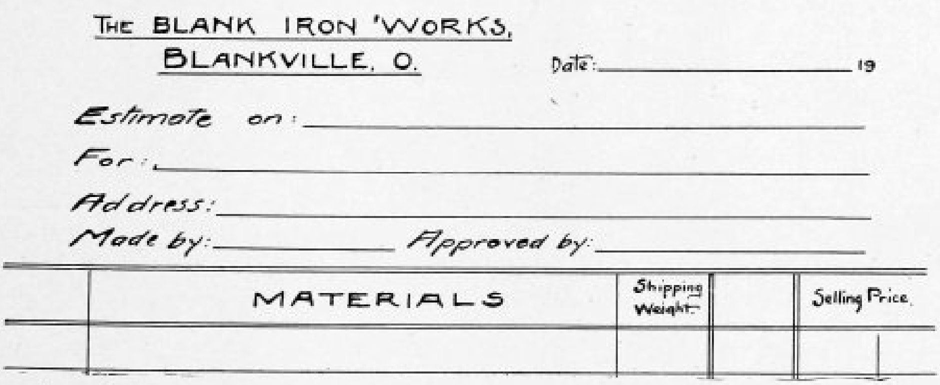
Or what if you did beat out the Blank Construction Company on that dust flue for the smelter, if on erection your men are driven off their staging at intervals all day long by the passing of hot cars of slag beneath them, so that the work takes thirty days instead of the three weeks you figured on? You did not know the conditions, but the Blank people did, and their price was equivalent to 5 cents per pound over yours, which was based on ordinary good working conditions. The smelter company closed like a steel trap, and now you can only sit tight and look as pleasant as you can.

The engineer's drawings of the Hayville stand-pipe did not show anything with reference to the neighboring properties, but on arrival at the site you find that John Smith's board fence passes within 16 inches of the side of the pipe when in place. In order to get working space it costs you $25 for the privilege of taking down the fence and replacing it in good condition. Ten dollars would have paid expenses of a day's investigation previous to bidding and saved a small hold up.

On an important heavy plate contract, a firm with which the writer was connected bid $22,000. Another firm at a distance bid $18,000 and got the work. After proceeding with the work until their costs ran up to $18,000 they withdrew from the contract, and secured a rearrangement under which they resumed and completed the work, the total price paid being, I have understood, something over $22,000, and it being a question if a loss was not made even at that figure. The differences in the bids seemed to be due to our having already done work in that locality, while our competitor had not.

These are a few instances from actual cases given to emphasize the necessity for thorough investigation of the conditions before estimating on field work of any description, especially where the contract requires delivery and erection ready for use.

A point which has been raised in connection with field work estimates is that burden percentages should be added to shop work only, nothing being added to field work, and the estimated field expenses being compiled separately and included, of course, in the total field estimate. The writer's practice on both estimates and cost sheets has been to add burden percentages to direct manufacturing labor, whether shop or field, the burden percentage rate being calculated on the basis of the combined direct shop and field labor for the previous year, or for three years previous, if available. To meet the views of those who believe the field work should carry no burden, the burden percentage may be calculated on the shop work only for the last year's work and then applied in the estimate to the shop work only. The percentage will, of course, be higher, being calculated on a smaller base. The result of making the shop carry all the burden will be that the field work and total cost will show up more favorably in the final cost sheet.


THE BLANK IRON WORKS,
BLANKVILLE, O.
Date: ______ 19
Estimate on: ______
For: ______
Address: ______
Made by: ______ Approved by: ______

MATERIALS	Shipping Weight		Selling Price

Herewith is a sample estimate sheet, size 8½ inches by 11 inches, so as to suit an ordinary letter file. They are generally put up in pads, preferably not numbered, so that one or more carbon copies may be made. Some prefer to have the weight columns at the left, making a complete separation between weights and prices. As a rule, the original copy goes to the sales department, while the carbon is filed and indexed by the estimator. In some offices the estimates are made in book form, so as to come in order of their date. They are made on each right-hand page, the left-hand page being kept for notes as to actual weights and costs after completion of the work.

The estimator in a contract shop will often find it useful to have some knowledge of estimating on brick, concrete and woodwork, as used in mill buildings. A builders' pocketbook or architectural hand-book will be of much aid, bearing in mind that prices of materials and labor vary greatly according to locality.

TO MAKE A MANHOLE ELLIPSE.

BY JOHN COOK.

A simple way to get an ellipse for manhole or hand hole is as follows:

First, draw the line *A B* and erect the perpendicular line *A C*. Lay off from *A* to *B* the radius of smaller axes and describe a quarter circle. Next, divide the line *A B* into any number of equal spaces, in this case three, as shown at *B* 1, 2, 0. Lay the square at those points and draw lines cutting the arc as shown at 1′ 2 C. These give the lengths of lines on Fig. 2.

For Fig. 2 draw the line *D E*, also the perpendicular line *F G*, cutting the line *D E* at *H*. From *H*, on line *D E*, lay off half the length of its longer axis, as shown at *H D* and *H E*. Divide each of these parts into the same number of spaces as on the line *A B*, Fig. 1. With the square laid on the line *D E* and touching the points 1‴ 2‴, draw lines indefinitely, then set the dividers from the points 1, 2, 0, on line *A B* to point 1′ 2′ C on the curved line, Fig. 1, and carry to Fig. 2 and mark the points as shown from the line *D E*. Connect those points and there will be a perfect ellipse. To get the curved line on the ends, set the dividers from *D* to 2‴ on line *D E*, and make an arc there from the point 1″ cutting the arc made from *D* to 2‴. In this case the point 2‴ is right for drawing the curved line 1″ *D* 1″. With a steady hand the other points can easily be connected.

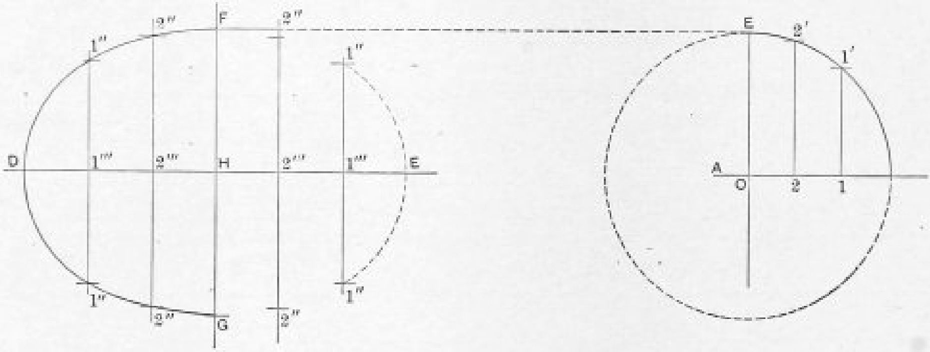


Fig. 2 Fig. 1

MAKING A MANHOLE ELLIPSE.

This is not a new plan, as I have seen it used; and I used it myself over forty years ago. I have studied everything I could see in books and papers, but I think this makes the best form for manholes or handholes I have ever seen.

LEGAL DECISIONS OF INTEREST TO BOILER MAKERS

Liability for Boiler Explosions.

A young man, 21 years old, was scalded to death by the explosion of a tube in one of the boilers at the power plant belonging to and operated by a railroad, light and power company. His father sued the company and recovered damages. The defendants excepted to the petition on the ground of vagueness, the negligence complained of not being described. On this point the court ruled against them. The rule undoubtedly is that the particular facts constituting the alleged negligence must be stated, especially when called for, but this case was one of the exceptions to the rule. In cases where the plaintiff cannot be expected to have any information as to the causes of the accident, whereas the defendant, on the contrary, must be assumed to be fully informed on the subject, and where the accident is of the kind which ordinarily does not occur when due care has been exercised, the rule of evidence is that the accident speaks for itself; that is to say, that a presumption of negligence arises from the fact, itself, of the acident. In such cases, the plaintiff not only need not allege the particular acts of omission or commission from which the accident has resulted, but need not even prove them. The accident itself makes out a case, and the burden is on defendant to show absence of negligence. The thing speaks for itself. That rule is of peculiar applicability in cases of boiler explosions. The decision of the case upon the merits gave the court much trouble. Negligence was charged against the defendant company in four respects; First, in using bad water in the boiler; second, in failing to inspect the boiler; third, in failing to clean it; and fourth, in screwing down the safety valve so that the steam could not blow off. The first of these charges was held to be entirely unfounded, and the second was disproved. On the third and fourth the testimony was so flatly contradictory and hopelessly conflicting that the court gave up the task of arriving at a satisfactory conclusion upon it as impossible. The greater number of witnesses was on the side of the plaintiff; but those of the defendant were men of better education and higher rank in the field of employment. The latter, however, were employees of the defendant company, and that, to some extent, had to be taken into consideration in weighing the evidence. There were three similar explosions at the same plant within the year. Under these circumstances, the court, according to its usual rule, affirmed the judgment of the court below, awarding the plaintiff $5,000.—*Lykiardopoulo v. New Orleans & C. R. Light and Power Company, Louisiana Supreme Court.*

Injuries to Engine Repairer—Guarding Machinery.

An action was brought for damages for the death of a repairman in the employment of the defendant railroad company, who was sent to repair a gasoline engine and to make pump work in the defendant's pumphouse, a detached building. While so engaged he was killed by his clothing being caught in an unguarded shaft and a protruding key thereon, which it was practicable to have guarded. The jury were instructed by the judge of the trial court that the pumphouse was in the same class as a factory, mill or workshop, and, if the shaft with the key was so situated as to be dangerous to workmen, it would be within the provisions of the Statute requiring it to be guarded. It was held on appeal that this instruction was correct. Whether the defendant was negligent or the deceased was guilty of contributory negligence or assumed the risks, were questions which the evidence made questions of fact. The key, when the engine was at rest, was always in a position slightly under the shaft and between the shaft and the engine. It could not be seen when the shaft was in motion. The deceased's body, when he was discovered, dead, was wound around the shaft. Examination showed that it was at the unguarded key where his clothing commenced to wind around the shaft. The evidence was held to be amply sufficient to justify the jury in finding that the deceased, having finished repairing the engine, started it, to test it, to see if it would properly operate the pump; that it was necessary to put oil in the cup, and he stepped upon the base upon which the shaft rested and reached over the shaft, and was in the act of oiling when the key, which was then revolving and could not be seen, caught his clothing.

The damages, as reduced by the trial court from $5,000 to $3,250 were held not to be excessive.—*Thomas v. Burt, Minnesota Supreme Court.*

PATCHING A SECOND-HAND BOILER.

Some years ago the company I worked for traded their old boiler for a larger, second-hand boiler. After it was in place and all the pipe connections made, I filled it with water and built a fire, but before the boiler was warm I noticed water dropping on the grates. Drawing the fire I found that the boiler was leaking at the first girth seam over the fire. This boiler was built, as shown in the illustration, and consisted of three sheets with single-riveted lap-joint seams. Securing a calking tool and hammer I tried to stop the leak, but was not successful, writes a correspondent of "Power."

After emptying the boiler I cut out a rivet and, holding a candle in the rivet hole, found that the under sheet was cracked in the rivet hole. Cutting out a rivet on each side of the first one, I found that the crack still extended beyond the remaining rivets. Considering this a job beyond me, I got a boiler-maker to come and look over the boiler. He continued cutting out rivets until he got past the crack, which extended through twelve rivet holes.

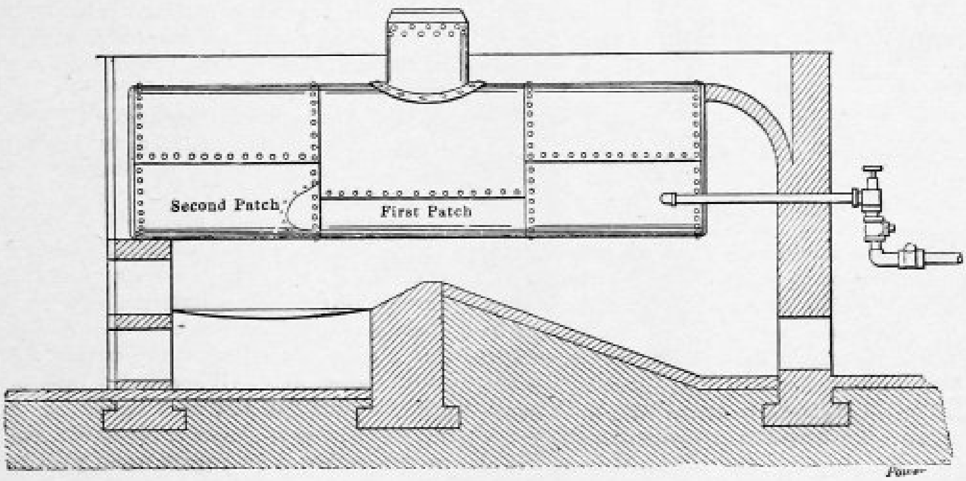
We then cut out a piece of plate back to the next girth seam, as illustrated, and put in a patch.

After this job was complete, I filled the boiler again and got up steam, when I found that the tubes were leaking at the back end. By means of a tube expander and a trip into the back end about twice a week, I managed to keep things going for a while, but I soon reached the limit with the expander, as the tubes were rolled to thin that it was impossible to stop the leaks by further expanding. I also discovered that the back head was in two pieces and that there was a seam about 2½ inches above the top row of tubes. When the water level dropped below this seam, I had trouble with the tubes leaking.

It became necessary in order to keep the plant running at all to consume a lot more fuel than should have been necessary. Then the boss agreed to get a new set of tubes, and I cut out the old and put in the new ones. I found it necessary, in order not to roll the new tubes too much at the back end, to insert thin strips of copper around the tubes to help fill up the holes which had previously been enlarged. After this job had been completed, there was no trouble for about six months.

One morning, when starting a fire, I noticed a wet spot on the firebricks, but not being able to discover anything wrong, I fired up, but did not neglect to keep my eye on this part of the boiler.

During the day I noticed a thin spray of steam and water coming from the seam near where I had noticed the wet bricks, and at once let the steam pressure drop. I found that the first sheet was cracked through nine rivet holes. A section was cut out and a patch put on as shown. This disgusted the owner so much with second-hand boilers that he purchased a new boiler.



PATCHING A SECOND-HAND BOILER.

TWO METHODS OF LACING BELTS.

Belts may be joined by lacing, riveting, sewing or cementing. A method of lacing a belt that may be relied upon is shown in Fig. 1, writes a correspondent in "Power."

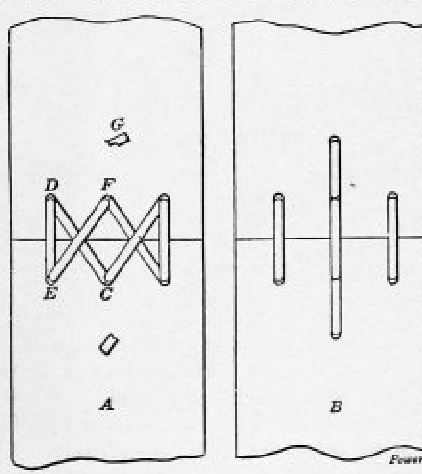


FIG. 1.—LACING FOR BELTS.

First, cut the ends of the belt square, using a sharp knife and try square. Then punch a row of holes exactly opposite each other in each end of the belt, using three holes for a 4-inch belt and five holes for a 5 and 6-inch belt. The number of holes in the row should always be uneven for the style of lacing shown.

A represents the outside of the belt and *B* the pulley side. The laces should be stretched as much as possible before using, and should be drawn half way through one of the middle holes, from the under side, as at *C*, and before proceeding see that the belt is not twisted, or, in the case of a crossed belt, that it has not been given a wrong twist. Then pass the end of the lace on the upper side of the belt through the hole *D*, under the belt and up through *E*, back again to *D* and *E*, through *F* and up through *G*. Then an incision is made in one side of the lacing which forms a barb that will prevent the end from pulling through. Then lace the other side of the belt in the same manner. This method may be used for belts up to 6 inches wide, but soft wire should be used instead of laces on belts smaller than 3 inches in width. If a lace is used on a small belt it makes the joint clumsy-looking and the belt will travel unevenly over the pulley.

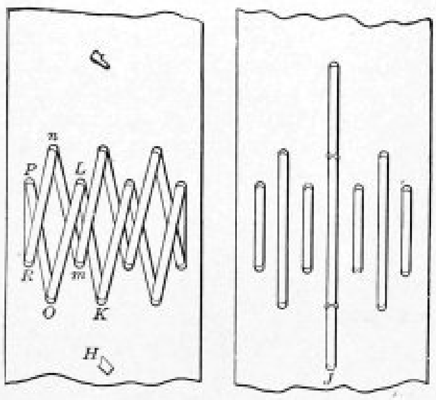


FIG. 2.—LACING FOR BELTS.

For belts wider than 6 inches the lacing shown in Fig. 2 is good. Two rows of holes should be punched. The number of holes in the row nearest the joint should exceed by one the number of holes in the second row. For 6-inch up to 7-inch belts I have always used four and three holes, respectively. For larger belts make the total number of holes in each end either one less, or one for each inch of belt width. I never care, with large belts, whether the number of holes near the end of the joint is odd or even. In a 10-inch belt, for example, nine and eight holes are used, respectively. The outside holes of the first row should not be nearer the edge of the belt than ¾ inch, nor should the first row be nearer the joint than 1 inch. The second row should be at least 2 inches from the end of the belt. In Fig. 2, *H* is the outside and *J* the pulley side of the belt. Begin at one of the center holes, always in the outside row, as at *K*, and continue through *L, m, n, O, P, R, P, R, n, O, L, m*, etc.

The lacing may also be started on one side, instead of at the middle, and it should not be crossed on the pulley side of the belt.

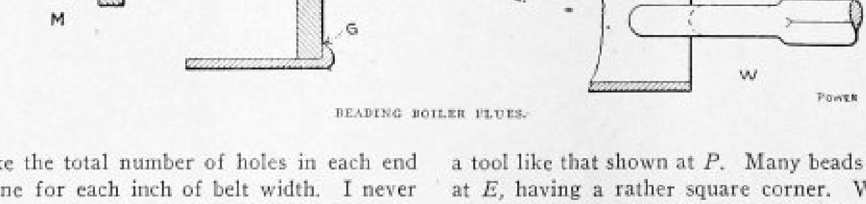
BEADING BOILER FLUES.

In beading boiler flues, much more skill is needed in doing this work properly than is generally considered, says "Power." As to beading the body of the head down solid, there is no reason why this should not be done. Care must be used, however, not to overbead. When the head is once solid upon the flue sheet any more hammering or beading will stretch the head and tend to loosen it from the plate. The turning of the head should be carefully done from the start. Many workmen start a bead too hurriedly or use too heavy blows. With the ball end of an ordinary hammer used as shown in the accompanying figure the bead can be turned nicely. The hammer strokes should not be too heavy, but moderate, and until the bead has been started or slightly turned. Flues are too frequently cracked by hammering too much at one point. It is the peening-action of the hammer that stretches the end of the flue; therefore the "licks" must be distributed entirely around the circumference of the flue in order to stretch it evenly. When this has been done (it is fully understood, of course, that the flue has been previously rolled tight in the sheet) the turned edge of the flue will appear as shown at *X* in the illustration.

When this has been done the tube is ready for an application of the beading tool. This tool should be properly shaped in order to do the right character of work; for instance, the surface that comes against the end of the flue should be slightly rounded as shown at *W*. With this shape the tool has a stretching effect on the metal. Another view of the tool is given at *P*. It requires a little practice in order to get this little tool just as it should be. Many repairers get the tool shaped as shown at N; such a tool makes a poor job, as the surface is too square to do good beading.

Heads are often found that are not properly done; they appear as shown at *M*. A small ridge is thrown up on the inside. In such a case it would be well to use the flue roller.

At *F* is shown a nice form of bead which can be made with a tool like that shown at *P*. Many beads are shaped as shown at *E*, having a rather square corner. With such a bead the edge of the flue does not fit against the edge of the sheet as will a bead shaped as shown at *F*.



BEADING BOILER FLUES.

To do a beading job properly the sharp edge of the tube hole in the sheet should be taken off with a flue-hole reamer or a half-round file.

I can see no reason for throwing the edge *G* down tight against the head and not beading solid. The beading tool should not reduce the thickness of the metal.

LOCOMOTIVE BOILER INSPECTION IN NEW YORK.*

The general duties of the Commission, in connection with this branch of its work have been stated in previous annual reports, but a brief summary may be of interest at this time.

Sections were added to the Railroad Law by chapter 611 of the laws of 1905, which provided for the inspection of locomotive boilers, the appointment of boiler inspectors by railroad companies, the filing of certificates of inspection with the Board of Railroad Commissioners, and for the appointment of a State boiler inspector. The act was made more specific by chapter 208 of the laws of 1907, and the duty of enforcing this law was placed upon the Public Service Commission for the Second District, as the successors to the Board of Railroad Commissioners.

The law makes it the duty of every railroad corporation operating locomotive boilers in this State—

1. To provide for an inspection of locomotive boilers at least every three months, by an inspector qualified to perform the service required and able to form a definite opinion regarding the safety and proper maintenance of locomotive boilers.

2. To provide necessary safety appliances on all locomotive boilers, and maintain these appliances in good working condition at all times.

3. To require all locomotive boiler inspectors to sign, under oath, a certificate covering the inspection of each locomotive, and to file one copy of this certificate with the chief operating officer of the railroad company and one copy with the Commission.

4. To require all locomotive boilers to be washed out at least once in thirty days.

The law requires the Commission to formulate regulations for the inspection and testing of boilers in accordance with the above requirements, and gives the Commission the right to order the removal of incompetent railroad inspectors.

Mr. G. P. Robinson was appointed State boiler inspector by the Board of Railroad Commissioners after a civil service examination. He has been retained by this commission.

Regulations for the inspection of locomotive boilers in conformity with the law were prepared by this commission shortly after it took office. These regulations were framed after extended conferences with railroad mechanical officers and were approved by representatives of the brotherhoods of locomotive engineers and firemen. Much effort was made to incorporate the best railroad practice and to provide effective and business-like methods of enforcing the law. These regulations have been in force over three years. Although the fullest criticism has been invited, no serious objections to them have been received from any source.

There are between five and six thousand locomotive boilers constantly used in this State, and nearly two thousand which are used occasionally and which are, therefore, maintained and inspected in accordance with State regulations, making a total of 7,900 boilers under the supervision of the commission. As there are about 58,000 locomotives used in the United States, about 14 percent thus come directly or indirectly under the supervision of the New York State inspection.

Some of the smaller railroads report all the locomotives on their lines, even though some of them may never enter the State. Reports of such extra locomotives are received, as it does not increase the work of the Commission materially, and it helps the companies to secure uniform inspection.

The boiler inspection regulations contemplate two forms of report:

First, a specification card, giving a description of the general design and principal dimensions of the boiler, the results of calculations of the strains to which the principal parts are subjected and from which the proper working pressure and factor of safety can be computed, the age of the boiler, the test to which the material was originally subjected, and any other data which may aid in determining the safe working pressure. This specification card is signed by the mechanical engineer of the railroad company or by some other expert qualified to pass upon questions of boiler design. These specification cards have been filed for all the boilers which are under the supervision of the commission, all of the cards have been carefully examined by a mechanical engineer working under the direction of the State boiler inspector, and the calculations of strength and factors of safety have been checked, and errors in reporting and in calculations have been adjusted after correspondence with the railroad companies.

Second, a certificate of inspection is required by law to be filed with the commission once in three months for each locomotive in the State. A copy of this certificate is posted in the locomotive cab, and a copy is filed with the chief mechanical officer of the railroad. All certificates are checked upon receipt in the office of the commission, and are compared with certificates previously filed. Special filing cases are provided for the specification cards and inspection certificates, so that in case of accident to any boiler all the data reported to the commission can be used in the investigation.

If errors are found in the inspection certificates, letters are at once written or personal visits made by the State boiler inspector or an assistant. A great many specification cards and several hundred inspection certificates have been returned each year for correction. A record is kept of all errors made by railroad inspectors, so far as they are discovered. If the error indicates continued carelessness or incompetency, the case is reported to the proper railroad officer, and if necessary, removal of the inspector is required.

Reports are also received from a number of manufacturing companies and railroad contractors owning locomotives which are used occasionally on railroad companies' tracks, counsel to the commission having advised that railroad companies, under the law, may be required to refuse outside companies the right to use locomotives on the railroad tracks or right of way, unless the requirements of the boiler inspection law are complied with.

The commission employs but two inspectors to supervise this work—the State boiler inspector and his assistant. It is evident that it is not possible, with this force, to make detailed inspection of all boilers. An examination is, however, made of a sufficient number to enable the commission to determine with a reasonable degree of accuracy, whether the companies are maintaining their boilers in safe condition and in accordance with the law. The work of the railroad companies' inspectors is thus generally supervised, and a special check for their work is made whenever the general condition of the boilers at any terminal indicates improper inspection or insufficient care. During the year, 367 inspection trips have been made to points where locomotive boilers are inspected and repaired. The following is a summary of the results of this work:

Number of boilers reported for service Jan. 1, 1911	7,900
Number of boilers examined by State inspectors	2,649
Number of trips of inspection	367
Number of places where inspections are made	245
Number of boilers reported defective by State inspectors	725
Number of boilers reported with broken stay-bolts in excess of number allowed by regulations	193
Number of broken bolts found in above boilers	1,201
Number of boilers found with a large number of tell-tale holes in stay-bolts filled with paint or otherwise closed, preventing a proper indication of broken bolts	225
Number of broken stay-bolts reported with telltale holes hammered over to avoid renewing same	376
Number of boilers reported with leaks which would have obscured the vision of the engineer or which indicated a bad condition of boiler	89
Number of defective steam gages reported	75
Number of defective water glasses reported	125
Number of defective gage cocks reported	151

*From the Fourth Annual Report of the Public Service Commission, Second District, New York.

More defects were found in boilers during the year 1910 than in the preceding year. This is accounted for by the fact that it was possible to make a closer inspection this year than previously, as the office work in connection with the original checking of specification cards and the establishment of a proper office system had been completed and the inspectors were thus able to spend more time on the road.

The State boiler inspector is giving considerable attention to recent reports of breakage of so-called flexible stay-bolts. Those reports indicate the need of careful inspection of this class of bolts, as well as of ordinary rigid stay-bolts, and the investigation of this subject will be continued.

It is the opinion of the inspectors that the condition of locomotive boilers in this State has been substantially improved, as compared with last year, and that increased care is evident in inspection and maintenance. This has resulted in a reduction in the number of boiler accidents and in the engine failures caused by boiler defects.

All accidents to locomotive boilers involving death or injury to any person are required to be reported by telegraph, and immediate investigation is made. The following is a summary of all accidents reported for the past three years:

SUMMARY OF ACCIDENTS TO LOCOMOTIVE BOILERS, 1908, 1909 1910.

Number of Accidents.				Number of Persons Killed.			Number of Persons Injured.		
1908.	1909.	1910.	Cause of Accidents.	1908.	1909.	1910.	1908.	1909.	1910.
12	4	4	Low water	8	6	1	15	6	5
0	1	0	Broken stay-bolts	0	0	0	0	1	0
3	0	4	Burst flue	0	0	0	3	0	4
1	0	0	Burst arch tube	0	0	0	1	0	0
1	1	0	Flue pulled out	1	0	0	1	1	0
1	5	1	Burst water-glass	0	0	0	1	5	1
1	0	0	Pocket flue blew out	0	0	0	1	0	0
6	1	2	Plugs blew out. Injector nut broke	0	0	0	6	1	2
25	12	11	Totals	9	6	1	28	14	12

This shows a continuous decrease in casualties from defective boilers since the present law took effect.

It will be noted that although there are only four accidents reported, on account of low water, which resulted in death or injury, it remains true that accidents caused by low water are the principal source of danger in locomotive boiler operation, and it is, therefore, the intention of the commission to investigate, as far as possible, all cases of low water which result in a rupture of the crown sheet or in the sheet being pulled away from the stay-bolts, whether personal injuries result or not. It is believed that accidents due to this cause can be still further reduced by increased care in the maintenance of water-glasses, gage-cocks, injectors and feed water connections. An investigation of a recent accident, for instance, which resulted in the injury of two men, showed that the cause was low water. Investigation of the engineer's work reports showed that the water-glass was reported out of order on each of three days previous to the accident. Investigation also showed that the middle gage-cock was out of use and that the tender tank had not been properly cleaned, so that the injector supply pipes could readily have been clogged. The gage-cocks, water-glass, and injectors had been removed from the locomotive before the inspector of the commission arrived, and therefore a proper and satisfactory examination of these parts could not be made, and a formal order of the commission was necessary to secure the information required to complete the investigation. In most cases of low water, the burden of responsibility is properly placed upon the engineer, as it is his business to report defective water-glasses, gage-cocks, or injectors. In a case such as the one cited, however, where defective maintenance is clearly shown, the burden of responsibility is to a great extent shifted upon the parties who are responsible for such maintenance.

The boiler inspection records show the age of each locomotive boiler used in the State, and from these records an estimate can be made of the average age of the locomotives in service.

On January 1, 1910, there were reported for service 7,604 locomotives of an average age of 8.94 years. The average age of the 7,900 locomotives reported for service January 1, 1911, was 9.64 years.

The boiler inspection records show the following distribution of locomotives according to age:

	January 1, 1910	January 1, 1911
Number under 10 years of age	4,783	4,775
Number 10 years and under 20 years	2,040	2,221
Number 20 years and under 30 years	715	853
Number 30 years and under 40 years	58	49
Number 40 years and over	8	2
Total	7,604	7,900

The total number of new locomotives installed by railroad companies, by contractors, or by manufacturing companies and used constantly or occasionally on railroad companies' tracks in 1909 was 137, and in 1910 it was 439.

An examination of the specification cards filed with the commission quickly showed that many of the locomotive boilers in use were carrying pressures higher than good practice would warrant. A circular letter was therefore issued to all the railroads, calling attention to boilers with low factors of safety, and suggesting certain minimum factors for consideration. A large number of conferences have been held with railroad mechanical officers, and the proposed factors of safety have, to some extent, been modified accordingly. As a result of this study, the following minimum factors of safety have been adopted for boilers now in service in the State and for such as are placed in service after January 1, 1911.

PROPOSED FACTORS OF SAFETY.

	Boilers Now in Service.	Boilers Placed in Service On or After Jan. 1, 1911.
1. Boilers with butt seams, under 30 years, factor.	3¾	4
2. Boilers with butt seams, 30 to 40 years, factor.	4¼	4½
3. Boilers with lapp and cover seams, under 30 years, factor	4	4½
4. Boilers with lap and cover seams, 30 to 40 years, factor	4½	4¾
5. Boilers with plain lap seams, under 30 years, factor	4¼	4½
6. Boilers with plain lap seams, 30 to 40 years, factor	4¾	5
7. Boilers 41 or more years old to be condemned.		

It should be clearly understood that these factors of safety have been decided upon as the minimum that should be used and are not as high as the commission would like to see adopted for new construction or when boilers are reinforced in the process of making heavy repairs. The commission believes that the following extract from a letter on this subject, received from the general manager of one of the largest railroads affected by these requirements, accurately expresses the situation:

> The minimum factors of safety as indicated by you seem to be reasonable, and there is no engineering data or authority that will justify any recommendation for a lower factor than that suggested by the commission.

As a result of the conferences with railroad officers, it has been found that in many cases boilers with doubtful factors of safety can be reinforced at slight expense, by changes in longitudinal seams or in the bracing. Considerable work of this character has already been done by the railroad companies by agreement and without formal order. In other cases, boilers having low factors of safety have been withdrawn by the regular practice of the railroads of retiring old locomotives and substituting new ones. In other cases, railroads have agreed to reduce pressures to the required amount.

The State boiler inspector estimates that, through these methods, the number of boilers having doubtful factors of safety have been reduced by at least five hundred since the commission undertook the investigation of this subject. Although most, if not all, of the weakest boilers in the State have been reinforced or withdrawn from service, 208 locomotives remain whose boilers do not meet the factors of safety above given, and arrangements have been made for their prompt withdrawal or reinforcement. A summary showing the classification of such boilers is as follows:

SUMMARY OF BOILERS WHICH DO NOT COMPLY WITH THE FACTOR OF SAFETY ADOPTED.

Boilers with butt seams, under 30 years, factor less than $3\frac{3}{4}$	11
Boilers with butt seams, 30 to 40 years, factor less than $4\frac{1}{4}$	0
Boilers, lap and cover seams, under 30 years, factor less than 4	16
Boilers with lap and cover seams, 30 to 40 years, factor less than $4\frac{1}{2}$	1
Boilers with plain lap seams, under 30 years, factor less than $4\frac{1}{4}$	174
Boilers with plain lap seams, 30 to 40 years, factor less than $4\frac{3}{4}$	4
Boilers 41 or more years old, to be condemned	2
Total	208

The present boiler inspection regulations of this commission took effect September 1, 1907. Conferences have recently been held by representatives of this commission with the Ohio and Pennsylvania State Railroad Commissions, with the object of adopting uniform requirements. Some changes in New York regulations were agreed to at these conferences, and will be issued accordingly. The result is the adoption of practically uniform rules by Ohio, Pennsylvania and New York, which we believe will result in effective supervision in each of these States with a minimum of friction or interference with the proper jurisdiction of the officers of the railroad companies. It will be possible, under this system, for the railroad inspectors in each State to have their inspection reports accepted by all three States. Arrangements are being made for an annual conference of the Ohio, Pennsylvania and New York commissions to discuss proposed changes in boiler regulations, with a view to the maintenance of uniform rules.

The theory of the boiler inspection law of this State and of its administration by this commission, which has now been accepted by Ohio and Pennsylvania, is that the State inspection shall be entirely supervisory, except where cases of serious neglect are found. It is considered the province of the commissions to insist upon the adoption of adequate rules for inspection by the railroad companies, and upon full compliance with these rules. A sufficient system of reports and check inspections has been established to enable the commissions to determine whether the railroad companies are doing their full duty under the law. The result in this State is that the commission is able to do the work satisfactorily with but two inspectors, and no need has yet been shown for increasing this force. This system results in cordial cooperation between the commission and most of the railroads, as the New York law and its administration recognize the right and responsibility of the railroad officers to do the work themselves so long as they can show to the satisfaction of the State inspector that it is being done thoroughly and in strict accordance with the law.

OXY-ACETYLENE WELDING AND CUTTING.

In an article on the above subject which was contributed to a recent issue of the "Railway Age Gazette" by William G. Reyer, general foreman, and R. W. Clark, foreman boiler

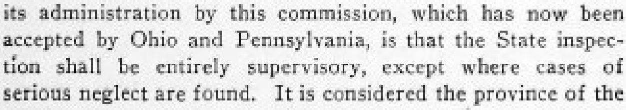


FIG. 1.—PARTIAL VIEW OF PATCH ABOUT TO BE WELDED TO THE SIDE SHEET.

maker, of the Nashville, Chattanooga & St. Louis Railroad, it is stated that side sheets can be successfully welded in a locomotive fire-box in a comparatively short time and with very little trouble, if the work is properly done. Provision must be made for contraction when the weld cools off. The cutting of the opening for the patch in the fire-box should be done with a pneumatic hammer and not with the blow-pipe, as in the latter case the steel will oxidize where it is cut and it will be difficult to make a successful weld. The sheet and the patch should be trimmed with a bevel such that when the patch is set up ready for welding the two sharp pointed edges will touch and an opening or V will appear, leaving an angle of 45 degrees between the two edges of the sheets (Fig. 1). To allow for contraction of the patch a U should be formed near its edge, as shown in Figs. 1 and 2, and projecting on the same side as the open side of the V formed between the edges of the two sheets. This can be made on a press, or under clamps or with a fuller. On a 5/16-inch sheet, for instance, the U depression should be about ½ inch deep with a radius of about ½ inch. While the weld is cooling off the U should be hammered down with a pneumatic hammer.

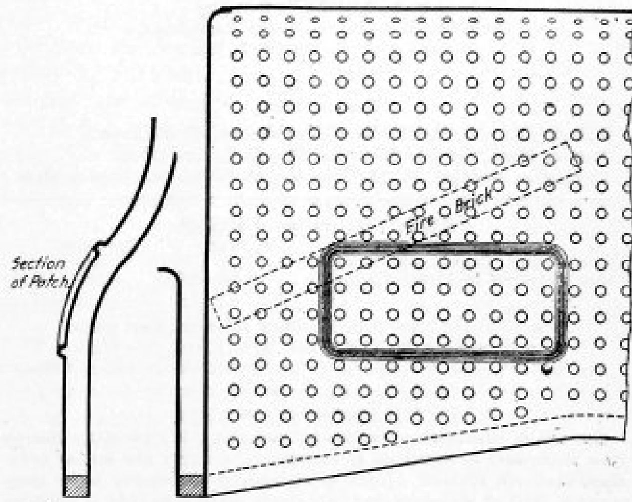


FIG. 2.—SHOWING PATCH WELDED ON FIRE-BOX BEFORE U WAS HAMMERED DOWN.

The welding torch should be kept clean. If too much oxygen is used the metal will oxidize and will not weld. To get a perfect weld in applying a half side sheet, form a U along the top of the sheet. In welding a fire door flange where the sheet is cracked in the knuckle of the flange, do not cut out any more of the door sheet than is necessary, keeping the weld as near the turn of the flange as possible, thus leaving it free to contract without putting much stress on the weld. If this cannot be done it will be necessary to use a U, as described above. It is good practice to hammer on the heel of the flange after welding.

Cracks develop in the fire-box that can be welded perfectly, and, again, there are cracks that cannot be welded satisfactorily. For instance, if a crack in the knuckle of the flange runs the long way of the flange, it can be cut with a diamond point chisel and a good weld can be made. If the crack is around the knuckle of the flange it is useless to try to weld it, as there is no way to provide for contraction, and nine times out of ten the weld will pull apart. Where the crack is in the center of a side sheet, we have never been able to make a successful weld; the first effort to weld a crack in a side sheet caused no end of trouble; the crack extended 12 inches from one stay-bolt to another, taking in three stay-bolts. It was cut out with a diamond point tool and apparently welded very satisfactorily, but after the weld cooled off it was found that the next row of stay-bolts had developed a similar crack—the contraction had pulled the sheet apart in the weakest place. The new crack was cut out and welded and after cooling a similar crack developed which opened 3/32 inch. We continued to weld one crack after another until the first weld made had broken. We tried to weld it again but found it impossible to make a successful weld because of oxidization. We cut out the bad place in the sheet and applied a patch, which proved entirely satisfactory.

The Boiler Maker

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

NOTICE TO ADVERTISERS.

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

Just as we were going to press with this issue of THE BOILER MAKER our editor, Mr. Brown, slipped and fell, so injuring his head that he lay unconscious in the hospital for several days. We, therefore, ask indulgence for any mistakes or oversights which may occur, as we have not been able to communicate with him.

While the engineering world is debating and considering the respective values of steam turbine and reciprocating engines, the initial power for either must come from the boilers. From year to year the pressures in general use have crept up in all boilers, demanding better material, better workmanship, better design and fittings.

In most cases the demands have been well met. No amount of praise should, however, be omitted to those who have produced material of such high grade as is now obtainable, and it is, of course, the first step towards perfection, for which we all strive. We do not think boiler builders always remember that, with the increased demand for high pressure, how very essential—in fact, how very imperative—it is that the smallest details of construction should have close care and scrutiny, and that the design should absolutely be followed up in shop production. It may seem of small account that not quite enough lap was allowed here or there, or that a plate on hand is a little bit below what is wanted and could be used, and, it is sad to say, is too often used—keen competition no doubt affects us all in these matters; but we have been told that "competition is the life of trade," and, while that may be, we know that it is absolutely death to profits. With the increased thickness of plates, heavier tools have to be provided, and the lack of what is required in this direction often accounts for what seems to be absurd differences in bids.

A desire to, apparently, save money results far too often in the very disastrous decision of ordering a boiler that is too small: no more annoying condition can be met with in a manufacturing plant than to have too little steam. In many cases the question of a boiler size is settled by guess or by a builder's assertion that such and such a size will be "large enough." The consulting engineer is a good investment at times, and never more so than in buying a boiler. The actual production of a modern boiler demands great manual skill. In fact, while in many trades machines do work of a high order, say for the machinist, the boiler maker must know to-day not only what he knew a few years ago, but much more, and be able to do not only better work, but more of it. The hard, noisy work of boiler making is apt to give the impression that the mental side of the boiler maker is not as much developed as it really is.

When some of the tools and appliances are looked at in many boiler shops throughout our country, it is to be wondered at that the character of work turned out is as good as it is. But it clearly shows why the cost goes up for boiler work. Extraordinary differences in bids can only be accounted for by differences in equipments, if the estimate records all that is to be done and used. Here it will often be found that the drawing office is seriously at fault, as seldom are angles and stiffeners properly laid out in a complete working drawing and given to the estimator. It seems to be forgotten that everything that has to be made about a boiler takes far more time to work out in a shop than on a drawing board, and that such work properly belongs there, and not to the man with the hammer.

To recapitulate our thought, we say: The best tools and appliances should be provided.

The work should go to the shop so as to leave nothing for the men to do but produce it from a clearly-made and properly-figured drawing.

That everything produced should be exactly up to drawings.

That the man who lays out the job does not produce excessive waste and expense either in material or by leaving too much to be trimmed up.

That the man who orders the boiler must know what he wants, and not leave it to the boiler maker to guess at and then blame him.

COMMUNICATIONS.

Some Experience I Have Had.

EDITOR THE BOILER MAKER:

In the month of November, 1861, I went to Erie, Pa., in answer to an advertisement for riveters and calkers. When I got there I found they had a lot of ten-barrel stills to make. Two other men came the same day I did. We found the firm was paying $1.25 per day to their old hands and in due bills payable six months after date. It was on a Saturday that the other two men and I arrived. We considered the matter and came to the conclusion that we would not work for less than $1.50 and get the cash every Saturday night, so we went to the foreman and told him what we wanted and he agreed to it. On Monday morning we started to work. I went to calking, and the next day the foreman told me to have an eye on the other calkers, of whom there were five or six. On Saturday the boss came to me and told me not to go for our money until after supper, or between 8 and 9 o'clock; so we went at that time and the clerk handed out $9 to be divided among the three of us and three due bills for each of us. I told him there was a mistake, we were to have cash every Saturday night; but he could not see it that way, so we left the $9 and we did not go to work Monday morning. The boss sent after us, and it was about 9 o'clock when we reached the shop, and we were asked what was the matter. When we told him he took us into the office and we got our money, and then the boss wanted us to go and get changed and come right back to work. We had no more bother about our pay while we worked there, and one of the men is there yet, I think.

About a week afterward the boss came to me and says, "Ah! mon Jock, I have the right mon now, he is a right and left-hand chipper and calker and riveter, flange turner, blacksmith and machinist." Great Scott! thinks I, my cake is dough if he is all that, he will get my job looking after the calkers. The man was to come in the next morning; but he did not show up until the day after, and then had his left hand tied up, and made the excuse of its being very sore. The boss told him to try and be in the next morning, and he would give him a soft job. The next morning he was on hand by 7 o'clock, and he had his right hand tied up then. I did not say anything about it but was easier in my mind about my job. The boss told me to start him chipping a still bottom. We took a light chip to straighten it for calking. I showed him what to do, and chipped about 6 inches so he could see how deep the chip was, I then went on with my own work and gave him no further thought. About 9 o'clock the boss came tearing in and told me to go and see what that man was doing. He had three holes chipped into the head, which spoiled it. Well, I talked to him, and gave him another head and he started again. It was well that I went back to him in half an hour, had I put it off a few minutes more he would have spoiled another head.

By this time the old man began to suspect right and left-hand calkers, so he told me to give him a try on a shell, which was 1/4 inch thick. I started him, and he just champered the edge by taking three chips and was cutting the tops off the rivets when I arrived. I sent him to the boss, and he took him to the office and gave him 50 cents and told him to get. At that time I could use both hands chipping or riveting, but I never went into a shop to blow about what I could do. When there is a job for either hand riveters I go for it, and if there is a flange to be turned I am "Johnnie on the spot."

In one shop, however, I was very near getting my block knocked off because I did not tell what I could do. In '75 I went back to Buffalo and got a job as a left-hand riveter. In about a week the boss came to me and asked if I knew where he could get a flange turner. I told him I did. He told me to get him. I said he was right here; I could do his flanging. He hit me a belt alongside the head, and says, "Damn you, Cook, why don't you tell what you can do?"

He told his son about me, who said, "that man Cook was a foreman, and I worked for him. The next morning the old man came to me and we had a long talk, and I got quite a raise in my wages. At night I worked making crowfeet and braces, so instead of ten hours per day I made fifteen, or a day and a half every day through the week except Saturdays. I made eight and a half days per week for quite a while.

In about a year there was a party wanting a foreman, and the boss recommended me and I got the job. Now there is nothing like a man knowing how to do any part of his trade. In those days there were but very few practical books published for boiler makers and no journals by practical men as there is to-day. My advice to both boys and men working in boiler shops is to take THE BOILER MAKER. I know of several who have become first-class workmen and foremen through taking THE BOILER MAKER. I know of five that were with me that are holding down first-class jobs. JOHN COOK.

P. S.—The two men who went with me from Buffalo in '61 were John Feeny and John Whalen. If John Feeney is alive I would like to hear of him.

A Question of Efficiency.

EDITOR THE BOILER MAKER:

In your issues of November, December and January there has been a discussion on the above subject, and in your December issue a correspondent, signing himself "Brace Crank," has something to say on the riveting of palms to shells. I think that "Brace Crank" is rather on the wrong track, and I uphold everything that James Rumgay has to say on the subject in your December issue.

If "Brace Crank" can explain to me why there is such a thing as a *chain riveted joint,* and what is the use of putting more than one row of rivets in a riveted joint (since, by his theory, all the load is taken by the first row of rivets), I may be led to look at the whole thing in a different light. Where there is any likeness between a chain and a riveted joint I fail to see. I should be glad if your correspondent will enlighten me on this point. If your correspondent knows the reason why every other rivet in the outer row of a treble-riveted joint is left out, then, surely, he cannot fail to see that two rivets are twice as strong as one, whether placed one behind the other or placed side by side, so long as there is a direct pull and no lateral stresses on the rivets. If there is breakage at the joint of palm and first rivet, it is certainly not because the back rivet is only an ornament and is not taking its share of the load; *i. e.,* half that on the stay in the case of these two rivets.

I have always understood that the calculations for a riveted joint would be taken along its whole length was it not for facilitating the calculations necessary to design the joint. Provided the pitch is the same all along the joint we get the same answer whether we take the whole length or only one pitch; but in this case I think that the whole length should be taken, which as James Rumgay says, "barely reduces the efficiency of the joint 2 percent."

I hope that we shall hear from "Brace Crank" on the points mentioned in a future issue of your valuable and interesting paper. FRANCIS GARRETT.

Lincoln, England.

Cutting-Off Tool.

EDITOR THE BOILER MAKER:

In reply to "Boiler Manufacturer" in the November issue, I will say that the most efficient tube cutter I know of is the Thornton tube cutter, sold by the Scully Steel & Iron Company. We have one in our shop that has been in constant use for over three years, and we have never put out a cent for repairs to the tool during that time. This cutter has a capacity of 125 tubes per hour when used with an air machine, and it is very readily adjusted to the different sizes. FRANK T. SAXE.

Boston, Mass.

Feed-Water Heating for Locomotives.

Some interesting data are given in *Engineering* on the subject of feed-water heating as applied to locomotives, from which we abstract the following: The reduction of operating expenses is now recognized as the only available means, in many countries, of increasing the return on capital invested in railways, and every endeavor is therefore made on well-managed lines to take advantage of such possible economies as modern knowledge points out.

Feed-water heating has been brought within the range of practical application on the London and South-Western Railway in England, the Central Georgia Railway in the United States and the Egyptian State Railway. For some ten years on this last-named railway, Mr. F. H. Trevithick, M. Inst. C. E., chief mechanical engineer, has experimented with his system, and has produced an efficient feed-water heater by combining feed heating and a moderate superheating or steam drying. Mr. F. F. Gaines, of the Georgia road, uses for his system exhaust-steam heaters and smoke-box heaters combined.

The trouble with injectors when handling hot water caused Mr. Drummond, of the London & South-Western Railway, to abandon its use, replacing it by an independent pump in order to use satisfactorily the tank-heating system. With this arrangement the feed water is delivered to the boiler at 180 degrees F., saving, it is claimed, 13 percent in coal.

The Gaines system comprises the use of exhaust-steam heaters and smoke-box heaters. The two exhaust-steam heaters, consisting of drums 5 feet long, containing twenty-nine 1¼-inch tubes, are supplied with steam from the exhaust passages in the cylinder casing, and also with the exhaust from the feed-pump and the air-brake pump. The feed passes successively through these two heaters, and then through two smoke-box heaters. The latter are each formed of seventy-five tubes, 1¼ inches in diameter, fixed, at the top and bottom, in headers measuring 36 inches by 13 inches. The tubes are bent to an arc of a circle, and are arranged close up to the smoke-box side, the flue gases being deflected to pass over and among them. The feed passes up and down the tubes, first in one heater and then on through the other in similar manner, the temperature at delivery to the boiler being about 200 degrees F. A gain of 15 percent is reported by the Gaines system.

The diagram above gives the economies reported on the three systems referred to.

After many experiments, most carefully made, by Mr. Trevithick, he completed his system as shown in the engraving.

The feed water is led from the tender to the pump placed on the left, or fireman's side of the engine, on the running board just in front of the cab, the pump in this case being a simplex direct-acting Weir pump, with a steam cylinder 6½ inches in diameter and a water cylinder 4½ inches in diameter, the stroke being 9 inches. This pump worked at about twenty-eight double strokes per minute. The steam valve for the pump was attached to the whistle mounting on the top of the fire-box shell. From the pump two pipes ran forward in the original arrangement, of which one conveyed the pump exhaust steam, and the other the delivery, to one of the exhaust-steam heaters placed on the running board alongside the smoke-box. In this arrangement it was found that the pump exhaust steam was liable to be drawn through the engine cylinders and passed out of the blast nozzle when the engine was drifting with the regulator closed. Subsequently, therefore, the pump exhaust was dealt with separately, as stated above, and as shown in Fig. 1. This heater consists of a cylinder of 4 inches internal diameter, fitted at the upper and lower ends with covers and tube plates ⅜ inch thick. The distance between the steel tube plates is 2 feet 6 inches, and the heater contains thirty-seven steel tubes of ¼ inch inside and ⅜ inch outside diameter. The steam enters at the top end, and emerges in the form of water by the drip pipe at the lower extremity. The feed water enters near the bottom, and passes out to the pump at the upper end.

In its final form there was thus only one pipe passing forward from the pump to the main exhaust-steam heaters, viz.: the delivery pipe, as shown in Figs. 1 and 2. The two exhaust-steam heaters were placed one on either side of the smoke-box. Each of these heaters consisted of a steel barrel or tube 1 feet in diameter and 3/16 inch thick. At each end was a tube plate ⅝ inch thick, the distance between the tube plates being 4 feet 11½ inches. Each heater contained seventy-five ¾-inch steel condenser tubes, of a thickness of 1/16 inch. At either end was a cast iron cover, the front cover in each case

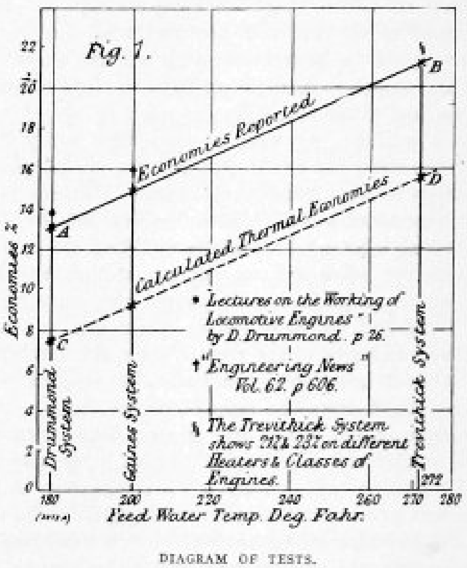


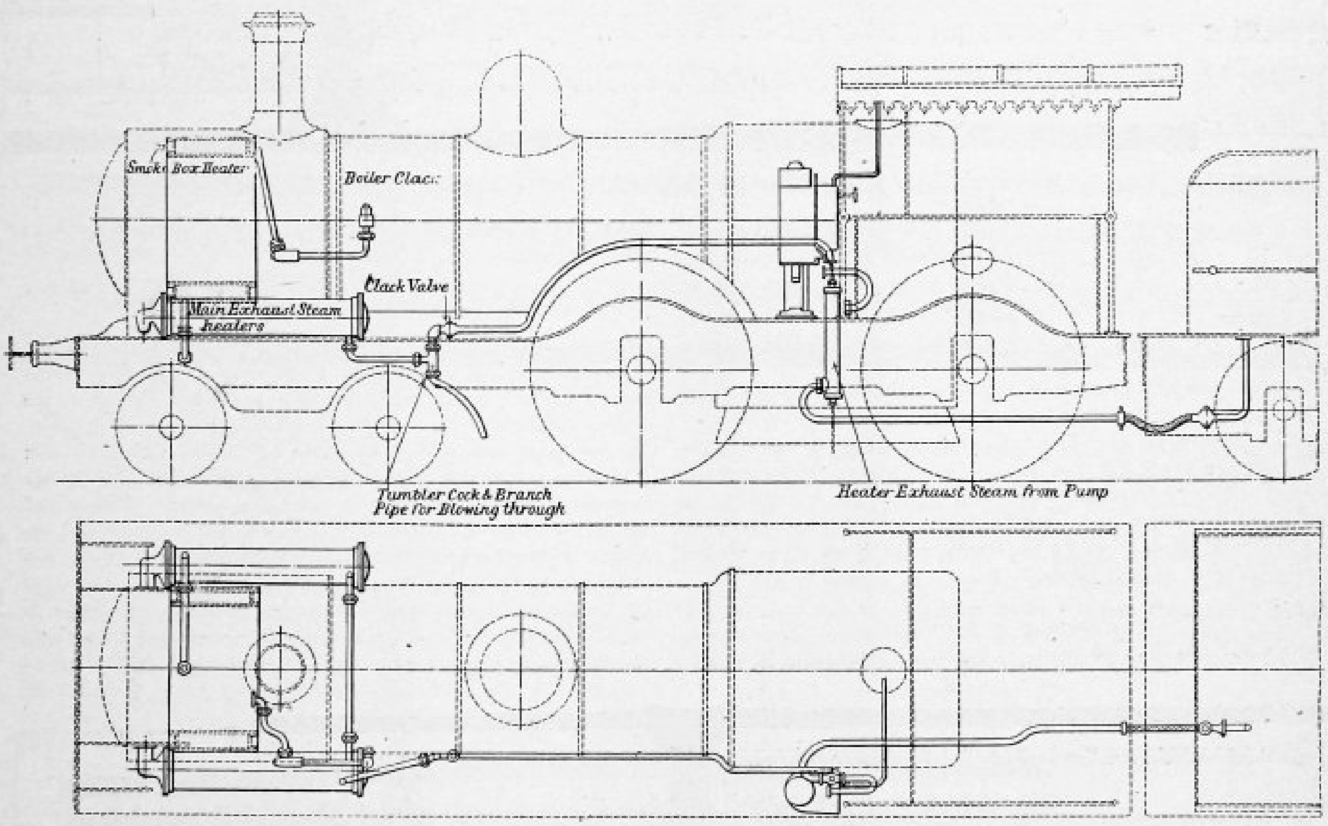
DIAGRAM OF TESTS.

being connected by means of a 3-inch pipe to the exhaust chamber of the cylinder casting, while the back cover was provided with a drain pipe to carry off the water of condensation. The water from the pump was delivered into the left-hand heater near the back end. By means of the cross-shaped cast iron diaphragm, of 5/16 inch thickness, inserted among the tubes of this heater between the tube plates, the water was forced to flow to the far end of the heater along one section and back through another, then forward again through a third, returning by the fourth, when it passed out of that heater. The object of thus compelling the water to flow backwards and forwards was to increase the velocity of the flow by restricting the area of the passage. This was done in order to lessen the tendency to scaling, and, as far as can be gathered, experience has shown the principle to be sound. From the left-hand heater the water was led through a 1½-inch pipe, passing over the slide bars to a similar heater in a corresponding position on the right-hand side of the engine. This heater was, however, only divided into three longitudinal sections by the diaphragm, and the water therefore left it at the front end. These two heaters, as well as the small pump-exhaust heater, were protected by asbestos mattress covered with cleading of 12 W. G.

The smoke-box heater was designed on the return-flue system. The return passage in this case was, however, made up of a large number of tubes. The heater consisted of two barrel plates arranged one within the other with an annular 5⅛-inch water space between them. At the back and front ends this ring was closed by U-section tube plates, the flanges facing outwards. The outside diameter of the heater was 4 feet 6 inches, the outer shell plate being 9/16 inch thick. The internal diameter of the heater was 3 feet 5⅝ inches, the inner plate being ½ inch thick. The channel-section flanged rings forming the back and front tubes plates were 5⅛ inches deep in the web, with 2⅞-inch by ½-inch flanges, the web forming the tube area being ⅝ inch thick. The distance between the tube plates was 1 foot 11 inches, and the heater, which was of mild steel throughout, was provided with 268 cold solid-drawn steel tubes 1⅛ inches external diameter and ⅞ inch internal diameter. These and certain other figures do not quite tally with those of the original design, but are given for the arrangements which have been proved to give the most satisfactory results on this engine. The length of the outer barrel plate was 3 feet 4 inches. The overlap in the case of this plate was at the front end, where its edge was brought close up and fixed to the smoke-box front. The inner barrel plate was 2 feet 7¼ inches long, but in this case the overlap was set back towards the tube plate, and connected thereto by means of other plating, so that the whole of the tube area was enveloped. The blast pipe, as in the earlier engine, was prolonged and made to eject in the outer space, and the direct action of the blast was thus removed from its usual sphere, near the ends of the boiler tubes, to a separate chamber, to which the waste gases only had access by the passage afforded by the heater tubes. The outer chamber is partly formed of horizontal and vertical diaphragm plates in the interior of the smoke-box heater. The vertical diaphragm is attached to the inner barrel plate. A petticoat extension was fitted to the chimney base; this was introduced to modify somewhat the effect of the blast on the tubes in its immediate neighborhood, and to distribute the effect of the draft more evenly over all the tubes in the heater.

The two exhaust-steam heaters on one engine gave, together, a heating surface of 140 square feet. The smoke-box heater provided a heating surface of about 175 square feet, while the aggregate flue area of the 268 tubes was 161 square inches, compared with the chimney area of 145 square inches. The increased efficiency of the new arrangement was evident from the fact that feed temperatures of over 260 degrees F. were obtained with it—a higher degree, in fact, than was obtained with the apparatus fitted to engine No. 620, which had rather more exhaust steam-heating surface, and more than twice the amount in its smoke-box heater.

Before leaving the feed-water arrangements proper it is as well to mention that in the position shown in Fig. 1 a clack valve was subsequently fitted, between the pump delivery end and the first exhaust heater, to prevent the hot water getting back to the pump. A special boiler clack* was also fitted, which, in conjunction with the three-way cock and blow-off pipe shown in Fig. 1 on the delivery pipe, between the first exhaust heater and the pump, enabled the heaters to be blown through for cleaning. The three-way cock could be turned so that communication was open through from the pump to the heater, or from the exhaust heater to the blow-off pipe leading down into the pit, when the engine was standing in the sheds the cock was turned to the latter position for cleaning. The boiler clack is fitted with a recessed head, which formed a yoke for the enlarged end of a screwed spindle. By turning this spindle, on which the clack head fitted quite loosely, the clack could be raised off its seat, and all the heaters blown through, and any sediment, etc., cleared out. The clack valve is allowed sufficient freedom of movement for its primary action not to be interfered with, and the spindle is prevented from being screwed down too far by a cap fixed to it, which comes down over the gland on to a flange which acts as a stop.



LOCATION AND PIPING ARRANGEMENT OF THE FEED-WATER HEATER.

* Check valve.

BOILER STRENGTH AND HORSEPOWER.

BY THE SLIDE RULE AND BY FIGURING.

In nearly all examinations a problem is found of figuring the working or bursting strength of a boiler shell. The solution is the same, whether the cylinder be used for a boiler shell, a condenser or a steam storage tank, but the strength is more frequently required for the boiler shell, as this carries higher pressures.

RULE FOR STRENGTH.

For figuring the safe pressure on a cylinder the rule is: Multiply the tensile strength of material in pounds per square inch by twice the thickness in inches and divide by the diameter in inches; this gives the bursting strength considering the plate. But there are joints, and to get the strength of the actual cylinder this should be multiplied by the efficiency of the joint, whatever that may be, and this efficiency depends, of course, on the type of joint and the proportioning. The matter of proportions of the riveted joint and of the different types is too large a subject to be taken up here, but will be treated in a separate article later.

If the working pressure is required rather than the bursting pressure, the value found for bursting pressure must be divided by a factor of safety, which for ordinary boiler practice is from 5 to 8, the usual value being 6. The efficiency of the riveted joint will vary from 50 to 59 for single riveted, from 65 to 75 for double riveted and from 85 to 90 for triple riveted in lap joints, and from 80 to 85 for double riveted and 85 to 90 for triple riveted in butt joints.

FINDING THE STRENGTH.

The easiest way to illustrate the use of this rule is by example, and if we assume that a boiler is 60 inches in diameter, made of 3/8-inch iron plate, having tensile strength of 50,000 pounds per square inch, that we are to use a double-riveted lap joint with the efficiency of 80 percent and a factor of safety of 6, we would then have $50{,}000 \times 2 \times 3/8 \div 60$; the result to be multiplied by 0.80 and divided by 6. Combining all these operations into one expression we get the fraction

$$\frac{50{,}000 \times 2 \times 3 \times 0.80}{8 \times 60 \times 6}$$

When using the slide rule, as when using long-hand computation, it is desirable to make quick cancellations wherever possible to reduce the number of operations. In the expression as given we have 2 and 3 in the numerator, which will cancel into 6 in the denominator, and 8 in the denominator, which will cancel into 0.80 in the numerator, giving 0.1, which will cancel out with one of the ciphers in 50,000, also the cipher of the 60 in the denominator will cancel out another cipher of the 50,000 in the numerator, leaving as the result $500 \div 6$. This division can easily be done in the head, but it is quicker on the slide rule. We set 6 on scale *C* over 5 on scale *D*, and under 10 on scale *D* we find 8335; the 35 is an estimate as between 8300 and 8350. Judgment tells us without hunting further that this is 83.35 pounds as the safe working pressure of this boiler.

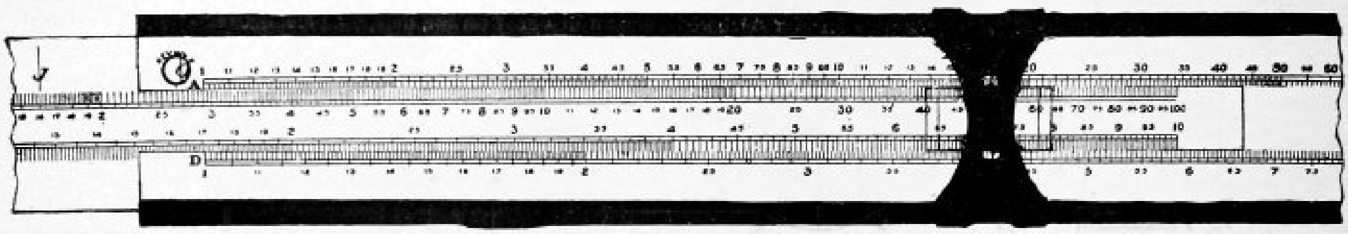


FIG. 1.—LAST OPERATION OF COMPUTING THICKNESS OF BOILER PLATE AT 78 ON C SCALE AND READING OF 5855 ON D UNDER 10 ON C.

A SECOND PROBLEM.

As another problem, suppose that we have a boiler 72 inches in diameter made of a steel with tensile strength of 65,000 pounds, plate 9/16 inch thick, efficiency of the joints 0.83, and the factor of safety 5. By the same rule as before we have as our expression when worked out:

$$\text{Pressure} = \frac{65{,}000 \times 2 \times 9 \times 0.83}{16 \times 72 \times 5}.$$

Cancellation will not reduce the number of slide rule operations materially in this problem. We would use, therefore, the regular method for a continued multiplication and division. We set 16 on scale *C* over 65 on *D*. Bring the runner to 2 on *C*, and bring 72 on scale *C* to the runner, then bring the runner to 9 on *C*, and we find that this is off the scale *D*. This makes no difference, however, in the operation of the rule and we simply bring 5 on *C* to the runner. We now wish to carry the runner to 83 on *C*, but cannot do it, as 83 is outside the range of operations, so the runner is carried to 1 on *C* and then 10 on *C* brought to the runner in order to reverse the slide. We can then carry the runner to 83 on *C*, and under this on *D* we find 1690, which, from the common sense of the case, is 169 pounds.

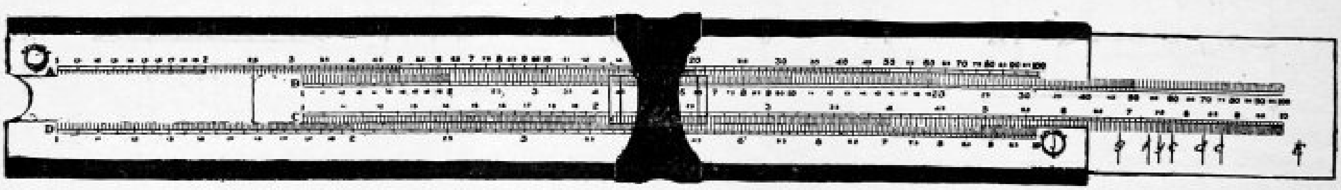


FIG. 2.—SETTING AT "C" FOR FINDING CIRCUMFERENCE OF A CIRCLE.

Any number of problems can, of course, be solved by the same process, but the ones given are sufficient to illustrate the method. The reverse of this problem is to find the thickness of plate required when the working pressure is known.

THICKNESS OF PLATE NEEDED.

By transposition of the rule we have: To find the thickness of plate required, multiply the pressure in pounds per square inch by the diameter in inches, and divide by two times the tensile strength of the material; multiply this by the factor of safety and divide by the efficiency of the joint.

Assuming that we have a plate of tensile strength 65,000, that the efficiency of the joint is 0.78, factor of safety 6, and that we wish to carry 150 pounds pressure on a boiler 66 inches in diameter. We then have from the rule: $150 \times 6 \times 66 \div (2 \times 65{,}000 \times 0.78)$, and expressing these operations in combined form we have:

$$\text{Thickness} = \frac{150 \times 6 \times 66}{2 \times 65{,}000 \times 0.78}.$$

To perform this operation we first take 2 on scale *C* and place it above 150 on *D*. Then bring the runner to 6 on *C*, and bring 65 on *C* to the runner. Bring the runner to 66 on *C* and bring 78 to the runner. Under 10 on *C* we shall then read on *D* 5855, Fig. 1, which by the method of approximate cancellation is found to be 0.5855 inch, or about 19/32 inch, as the thickness of the plate. The thickness used in practice will be 5/8 inch. The method of figuring for any other set of conditions would be the same.

Leaving out the factor of safety, which is a matter of judgment, and the efficiency of the joint, which depends on the kind of joint and the method of proportioning, the bursting pressure is seen to depend on the thickness, the tensile strength and the diameter. It is, therefore, possible to work out a diagram embodying these four values, so that from this diagram we can quickly find the thickness for any pressure, tensile strength and diameter within the limits of the diagram or find the bursting pressure for any tensile strength, diameter and thickness. We could then, in the case of safe pressure required, multiply the value for bursting pressure by the efficiency of the joint and divide by the factor of safety to get the working pressure; or for thickness required we could multiply the thickness for a given bursting pressure by the factor of safety and divide by the efficiency of the joint. Such a chart has been worked out and will be found in the Practical Reference Tables in this issue.

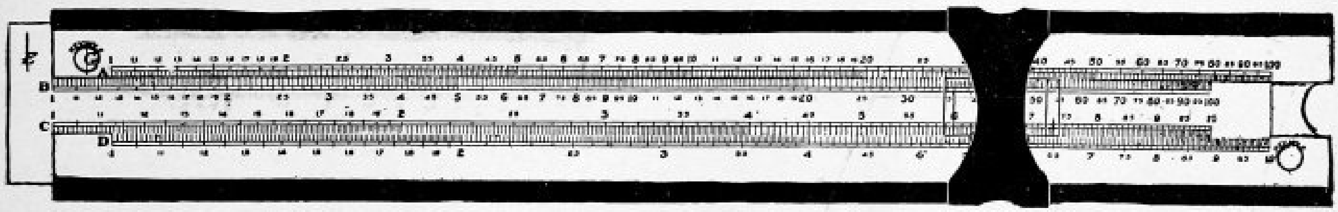


FIG. 3.—SETTING AT "G" TO FIND AREA OF A CIRCLE.

BOILER CAPACITY.

While ideas are changing rapidly with regard to the heating surface required to develop a boiler horsepower, and recent investigations with rapid flow of gases across heating surfaces seem to show that we shall shortly be halving or quartering our requirements for heating surface by the means of forced water circulation and forced gas circulation, still in present examinations the rating for the horsepower of a boiler is based usually on 10 feet or 12 feet of water-heating surface per horsepower. The problem is frequently encountered of figuring the rated horsepower of a boiler.

Opinions differ as to the surfaces which should be reckoned on, but a safe method seems to be to consider half the shell for a return tubular boiler, the total tube surface and the area of the back head which is not taken up by the tube ends.

FIGURING THE HORSEPOWER.

For a boiler 54 inches by 16 feet, with thirty-eight 4-inch tubes, we would have then, first, to find half the area of the shell. Using the key settings on the rule we note first that 54 inches is equal to 4½ feet. Then setting at *j* in the lower keyhole, as shown in Fig. 2, we find above the diameter 4½ on scale *B* the circumference on scale *A*, which is 14.25 feet.

To get the surface of one-half the shell we must divide this circumference by 2 and multiply by the length, 16 feet. We therefore set 2 on scale *B* to the runner, which is standing at 14.25 on scale *A*, and bring the runner to 16 on *B*, and above this point on *A* we find 114 square feet as the useful area of the shell. We might find the surface area of a tube in the same way, but the dimensions of standard boiler tubes have been worked out by makers. From them we find that the length of a 4-inch tube for 1 square foot of outside surface is 0.955 feet, hence a 16-foot tube will have $16 \div 955$ square feet, and thirty-eight such tubes will have this amount multiplied by 38. We have then $16 \div 0.955 \times 38$, and we set 955 on *C* over 16 on *D*, and bring the runner to 10 in order to reverse the slide, then 1 on *C* is brought to the runner, and the runner is carried to 38 on *C*, and under this on *D* we find 633, the square feet in the tubes.

To find the area of the rear head we set *G* in the upper keyhole, and over 4½ on *C* we find 15.75 on *A*, which is the square feet in the head. From this must be subtracted the area of the tube ends. The outside area of one 4-inch tube in square feet is 0.0872, and this must be multiplied by 38. We therefore bring 1 on *C* to 872 on *D*, and below 38 on *C* we find 3.31 square feet as the area of the tube ends. Subtracting this from 15.75 we get 12.44. Adding together now the three values for shell, tubes and head, we have $114 + 633 + 12.44 = 759.44$ square feet of heating surface. If we assume the older value of 12 square feet of heating surface per horsepower, we then divide 759.4 by 12; that is, we bring 12 on *C* over 759.4 on *D*, and under 1 on *C* we find 63.2, the required rated horsepower of the boiler.—*Practical Engineer.*

It frequently happens in the shop that unpleasant electric shocks are received from some part of the electrical equipment or other metallic fixtures or perhaps even parts of tools. It is sometimes supposed that this shock indicates an electrical leakage or ground from some part of the apparatus. This supposition is usually unfounded, and in all probability the cause of the trouble can be traced to the generation of static electricity by moving belts. Many times very painful shocks are received, due entirely to this cause. A remedy is to ground the frames of all electrical apparatus and to ground all rapidly-moving belts of any size, making use of a brush collector composed of a series of wire points placed a short distance from the moving belt. These points need not, and better not, come in contact with the belt system, as the static electricity will jump across a short intervening air gap. These brushes can be grounded to a water pipe on the metal frame of the building.

Though not generally known, perhaps, spirits of camphor applied with a rag will remove those inevitable ink blots on tracing cloth, leaving the cloth in much better shape than if some mechanical means were employed. It may also be used to good advantage for erasing lines and figures if the rag is drawn over a pencil point or pointed stick. The texture of the cloth is unchanged by the camphor.

PERSONAL.

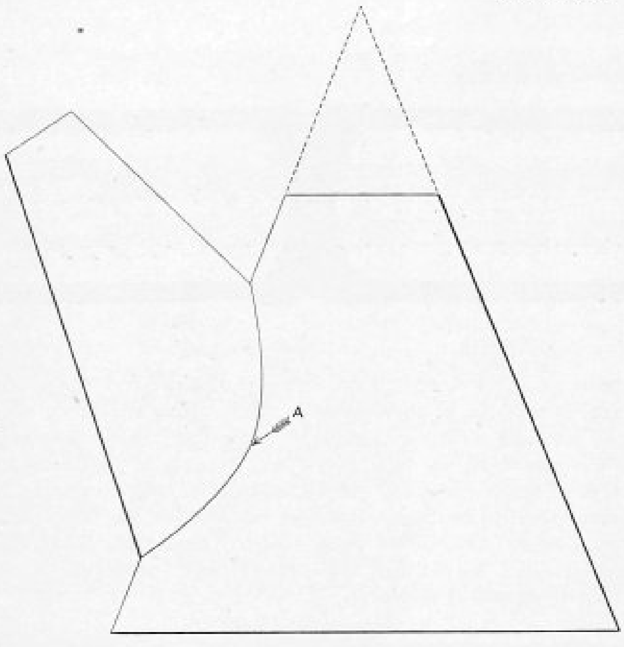
MR. JAMES WHITEACRE has recently resigned his position as foreman boilermaker at Goldies & McCulloch Company, Galt, Ont., and accepted the position of foreman boilermaker at John McDougal Caledonia Iron Work Company, Montreal, Que. The employees of Gouldie & McCulloch Company made Mr. Whiteacre an elegant present of a watch-fob and signet ring as a memento of their love and esteem, with a neat address.

J. P. LITSINGER, foreman of the Thompson Iron Works, Philadelphia, has resigned to take a similar position with the Lancaster Iron Works, Lancaster, Pa.

EDITOR THE BOILER MAKER:

I write to ask if some of the readers of THE BOILER MAKER cannot give me information as to how to lay out intersecting cones, as shown in the attached sketch? What I especially want to know is how to determine the line "A."

CALIFORNIA.

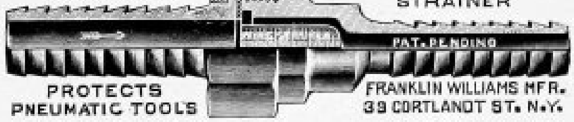


HOW IS LINE "A" DETERMINED?

ENGINEERING SPECIALTIES.

Quix Pneumatic Hose Coupling Strainer.

In the use of pneumatic tools considerable difficulty is experienced by loose pieces of foreign matter entering the delicate mechanism. To overcome the loss of time and expense caused by this, the "Quix" combination hose-coupling strainer

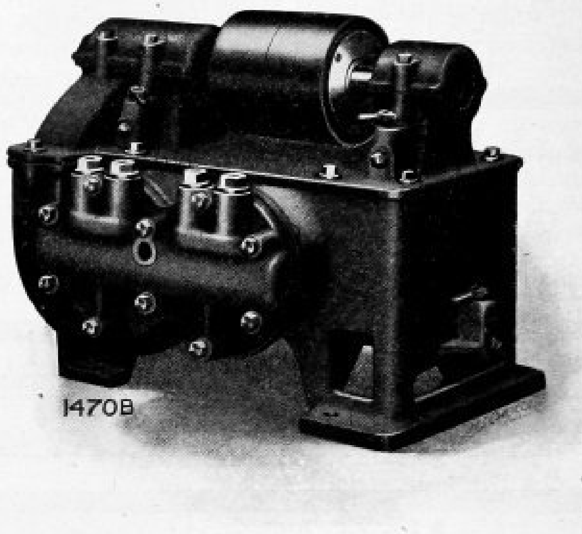


QUIX STRAINER.

was designed. It is a substantially made brass hose coupling fitted with a renewable wire strainer. This strainer is deep and cup shaped, and has ample area between its sides and the inner walls of the male end of the coupling, so that an accumulation of dirt will not reduce the air passage until the strainer is filled. In practice this is usually from one to three days. The strainer should be emptied daily out of working hours, preventing loss of time of tool operator and helpers. This strainer takes the place of the coupling used in common practice and is not an extra fitting on the hose line. These strainers are manufactured by Franklin Williams, 39 Cortlandt street, New York.

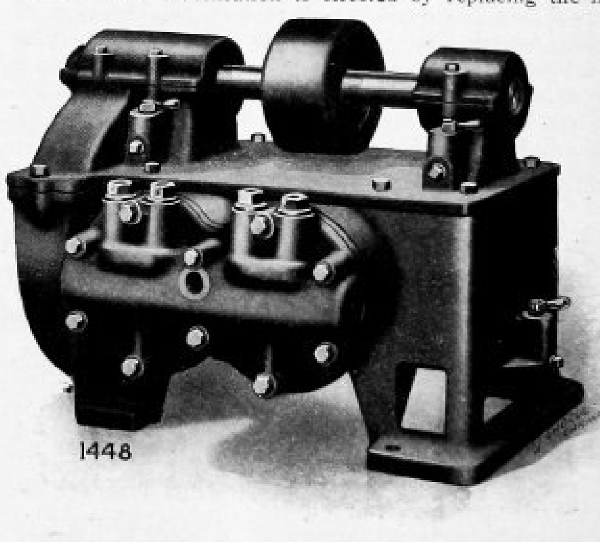
Belt-Driven Air Compressors.

Quite frequently boiler shops and other industrial plants desire to utilize compressed air, yet do not find it convenient to employ electric current. In many such instances the only power available is from shafting. The air compressors herewith illustrated are Type "H-3" Belt-Driven Compressors, manufactured by the National Brake & Electric Company, Mil-



BELTED COMPRESSOR FOR INTERMITTENT SERVICE.

waukee, Wis., and are especially designed to meet the conditions outlined above. They differ from National air compressors with motor drive in that a pulley is substituted for the motor. This modification is effected by replacing the motor



BELTED COMPRESSOR WITH TIGHT AND LOOSE PULLEY.

with an iron cover on which housings, for bearings, are cast. The housings contain oil chambers into which the oil rings dip, thus providing for effective lubrication of all working parts.

The bearings are of phosphor bronze. Midway between them a paper pulley is mounted on a shaft, on one end of which is a standard pinion that meshes with the gear. In order that the compressor may be manually started or stopped it should, whenever possible, be belted to a jack shaft by means of a tight-and-loose pulley on the jack shaft. Once started, however, the control of the air pressure between fixed ranges of minimum and maximum can be effected by means of a pneumatic unloading device installed on the inside of the suction valves. This device consists of a cylinder, piston and piston rod, and serves to automatically lift the suction valves from their seat, thus stopping any further compression of air when the air pressure has reached a fixed maximum. When the air pressure has reached a fixed minimum the valves are automatically seated and the compression of air is resumed. The air is admitted to and exhausted from the cylinder of the unloading device by means of a governor, which operates at a pressure variation of 10 pounds between maximum and minimum pressures, but not exceeding 125 pounds nor less than 25 pounds. If it is not required to shift the belt too often a small brake cylinder can be used in conjunction with the automatic unloader, thereby constituting a belt-shifting device which automatically controls the air pressure. This method of control permits the compressor to be stopped when not pumping, consequently is preferable to the method of control whereby the suction valves only are operated.

This type of compressor is designed for intermittent service only, and can be equipped with a tight pulley, as shown in Fig. 1, or a tight-and-loose pulley, as shown in Fig. 2. When equipped with a tight-and-loose pulley the jack shaft can be dispensed with. The National Brake & Electric Company also manufactures a belt-driven air compressor designed for continuous service. This type of compressor is similar in every way to the type just described, except that it is provided with water-jackets, which permit a free circulation of water around the cylinders and valve heads, keeping those parts at a minimum temperature. The methods of control are the same as in type "H" belt-driven air compressor.

Diamond Boiler Repair Bolts.

In the past it has been impossible to repair boilers where corrosion has occurred in spots, and caused leaks to develop. Soldering would not do any good, as the expansion and contraction of the metal as it was alternately heated and cooled prevented the solder from adhering. To enable permanent and satisfactory repairs to be made the Diamond Expansion Bolt Company, 90 West street, New York City, has developed a boiler repair bolt.

In use the operation of this bolt is very simple. The hole is first reamed out to the proper size, and a Diamond bolt, which is a separable T bolt, is inserted, as shown in Fig. 1. In Fig. 2 the bolt is illustrated, with the two halves separated, as it is being put in the proper position to stop the leak. After the threaded portions of the bolt have been brought together a hard rubber washer is placed over the bolt and against the shell of the boiler. A steel washer comes next, and finally a bonnet or cap nut is screwed down tightly upon them. The various washers and the cap nut are shown in relation to each other in Fig. 3, and Fig. 4 gives an idea of how the completed repair looks.

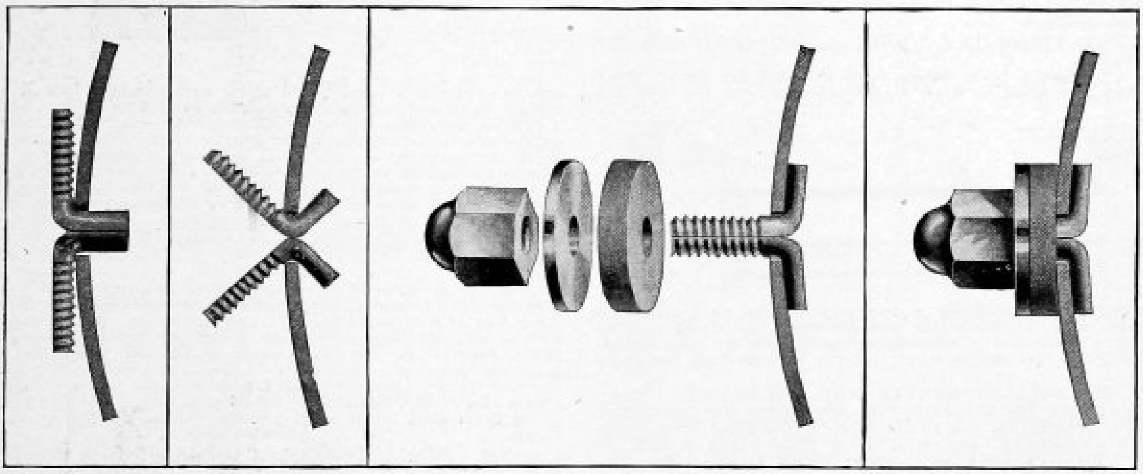


Fig. 1. Fig. 2. Fig. 3. Fig. 4.

REPAIRING A LEAKY BOILER WITH THE DIAMOND BOILER REPAIR BOLT.

Underground Pipe Covering.

Some years ago I was called upon to devise some means of protecting an underground steam pipe, writes a correspondent in "Power." The pipe was 4 inches in diameter and carried steam at 90 pounds pressure. The pipe was about 200 feet long and, up to the time of my investigation, had been laid in a box made of planks and filled with ashes or other material that would form a suitable insulation. Trouble had been experienced and the pipe had to be taken up for repairs about every five to eight months. At times the trench would nearly fill with water; this caused condensation to take place so rapidly that a very severe water hammer was the result, especially when the steam was shut off, or when first turned on.

After looking the situation over, I selected some old 6-inch wrought-iron pipe with screwed joints. This pipe was connected up and tested with steam at about 20 pounds pressure, which was left on for an hour, so that we could be sure that no leaks existed. We then placed the 4-inch pipe inside the 6-inch and laid it in the box formerly used, packing ashes solidly about the 6-inch pipe. A trench just wide enough to accommodate the box was then made. A space of about 8 inches was left underneath the box, which rested on supports spaced about 10 feet apart. One end of the 6-inch pipe was closed tightly about the 4-inch and the other end loosely so. This prevented a circulation of the inclosed air and formed a very satisfactory insulation. The entire arrangement proved so effective that I never heard from it afterward. In many cases of underground steam-pipe work the trench is dug with a pitch toward one or both ends, for the purpose of draining the water into a catch basin, which is arranged with a float to automatically control a siphon or steam pump to remove the water. In some cases the float is connected to a signal which serves to call the attention of the person who has been assigned to the duty of controlling the water in the basin.

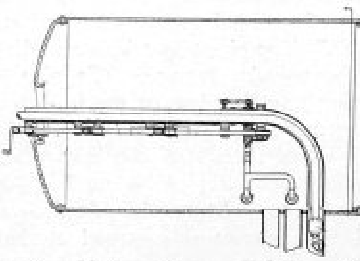
SELECTED BOILER PATENTS.

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

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

979,295. TUBE-CLEANING APPARATUS. ELMER E. HAUER, OF SPRINGFIELD, OHIO, ASSIGNOR TO THE LAGONDA MANUFACTURING COMPANY, OF SPRINGFIELD, OHIO, A CORPORATION OF OHIO.

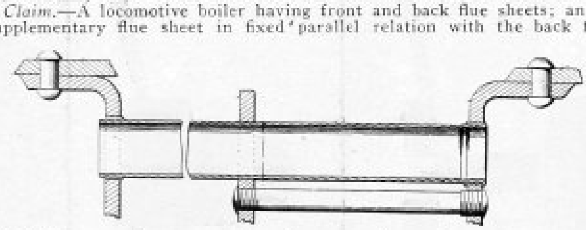
Claim 2.—In a device such as described, the combination of a channel-



iron and a shaft, said channel-iron and shaft each being divided longitudinally into sections jointed at their adjacent ends and means common to said channel-iron and shaft to secure the respective sections together. Five claims.

979,135. STEAM BOILER. JOHN A. DOARNBERGER, OF ROANOKE, VA.

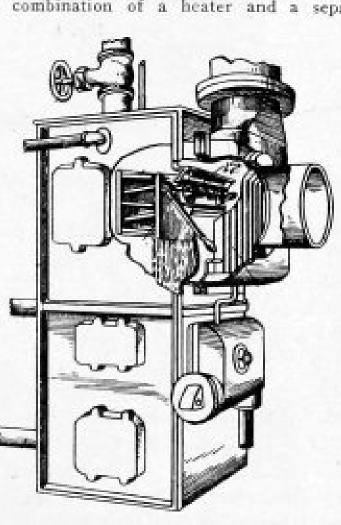
Claim.—A locomotive boiler having front and back flue sheets; and a supplementary flue sheet in fixed parallel relation with the back flue



sheet; tubes or flues consisting of two sections; the main section in fixed relation with the front and supplementary flue sheets and the section located within and in water-tight relation with the main section, and secured at its rear end in proper relation with the back flue sheet. One claim.

979,612. FEED-WATER HEATER AND SEPARATOR. AXEL BLYTT WALLEM, OF MOORES, PA., ASSIGNOR TO JOSEPH S. LOVERING WHARTON, WILLIAM S. HALLOWELL, AND JOHN C. JONES, DOING BUSINESS UNDER THE FIRM NAME OF HARRISON SAFETY BOILER WORKS, OF PHILADELPHIA, PA.

Claim 3.—The combination of a heater and a separator having a



passage therebetween; a spring pressed relief valve intermediate the heater and separator controlling said passageway. Fourteen claims.

979,661. FURNACE. JOHN R. FORTUNE, OF DETROIT, MICH.

Claim 1.—In a device, the combination of a hopper, inclined stationary grate bars, inclined movable grate bars alternating with the stationary bars, and means carried by the upper ends of the movable bars overlapping the stationary bars and forming a continuous shelf at the upper end of the grate movable with the movable bars. Eight claims.

979,669. STEAM SUPERHEATER. JAMES C. HERON, OF ST. PAUL, MINN., ASSIGNOR OF ONE-HALF TO ARTHUR C. DEVERELL, OF ST. PAUL, MINN.

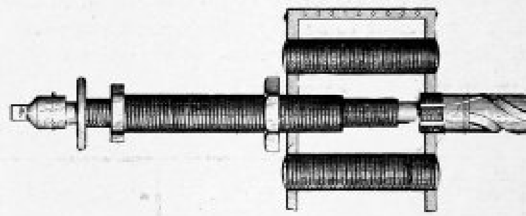
Claim 2.—In combination with a boiler a superheater comprising tubes extending longitudinally of the boiler and being open at both ends, said tubes being reduced in diameter at their discharge ends, a head connected with the steam outlet of the said boiler, pipes depending from the said head, coils located in said tubes and extending at right angles to the said pipes depending from the said head, a second head located vertically under the first said head, upstanding pipes mounted upon the last-mentioned head and connected with the discharge outlet coil, and the last said head being connected with service pipes. Three claims.

979,736. SECTIONAL BOILER. JOHN BLOOMFIELD BERNHARD, OF NEWARK, N. J., ASSIGNOR TO UNION BOILER COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW JERSEY.

Claim 2.—A steam boiler comprising end sections and intermediate sections extending from the front to the rear of the boiler, each of the intermediate sections being provided with an upper flue and with a lower flue, and with a reduced portion forward of the lower flue, and forming channels leading into the upper flue, the forward wall of the lower flue being formed by an upwardly and forwardly inclined water chamber extending over the fire-box, and the rear wall of said flue being formed by an upright water chamber connected at its lower end with the chamber forming the front wall of said flue, and means carried by the end sections for directing the furnace gases from the upper flue downwardly into the lower flue, and from the lower flue to the smoke outlet. Four claims.

980,139. STAY-BOLT DRILL. HARRY L. BARRICKMAN, OF RICHWOOD, W. VA., ASSIGNOR OF ONE-THIRD TO HAZE MORGAN, OF CLARKSBURG, W. VA.

Claim.—The combination of a tubular barrel having an enlargement at



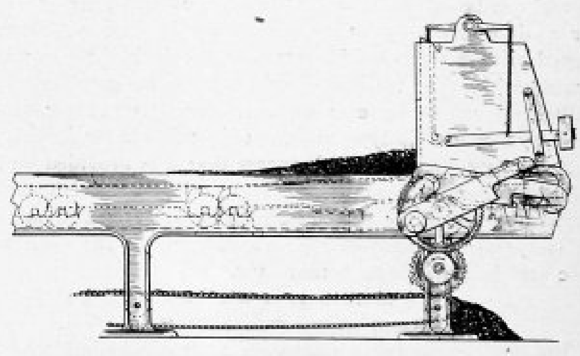
one end thereof, a tubular feed screw screw-threaded in said barrel, a spindle fitting and longitudinally movable in said feed screw, and having a drill-bit secured at one end thereof and the other end shaped to engage with a motor or other device suitable for imparting a rotary motion to it, the periphery of the barrel being screw-threaded from the end nearest the drill-bit to the enlargement at the opposite end of the barrel, and said enlargement being shaped to be engaged by a wrench, and a jam-nut on said screw-threaded periphery of the barrel. One claim.

979,738. DOUBLE SECTIONAL BOILER. JOHN BLOOMFIELD BERNHARD, OF NEWARK, N. J., ASSIGNOR TO UNION BOILER COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW JERSEY.

Claim 2.—A sectional boiler formed of two end water sections, a dividing water section midway between said end sections, a plurality of water legs or sections between the end sections and the dividing section, each of said water legs being formed with registering apertures forming lateral flues for the fire gases, means whereby the gases from one flue may pass to the other flue at one end of the boiler section and means whereby the fire gases may escape from said flue into the smoke outlet at one end of said lateral flue, valved pipe connections to supply water to the lower ends of the water sections and the dividing section. Five claims.

979,783. FURNACE-GRATE. GEORGE MINION, OF CHICAGO, ILL., ASSIGNOR OF ONE-FIFTH TO JAMES BELLE, ONE-FIFTH TO CHARLES H. SCHEUER, ONE-FIFTH TO ERNEST H. MILLER, AND ONE-FIFTH TO JOHN ROBERTSON, ALL OF CHICAGO, ILL.

Claim 1.—A device comprising a main frame, two series of alternately arranged grate-bars mounted to reciprocate longitudinally in said main frame, transversely disposed reciprocal bars connected with each series



of grate-bars, projections on one series of grate-bars set in the path of the reciprocal bar of the other series, means for causing alternate movement of said reciprocal bars in a rearward direction, and means for causing return movement of said projection engaging bar. Four claims.

979,737. CLAMP FOR ASSEMBLING BOILER SECTIONS. JOHN BLOOMFIELD BERNHARD, OF NEWARK, N. J., ASSIGNOR TO UNION BOILER COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW JERSEY.

Claim 1.—A clamp for assembling boiler sections comprising a clamp rod threaded at one end and adapted to receive a clamping nut, a gripping abutment movable on said rod and consisting of two members pivotally connected together, each of said members being adapted to engage a boiler section, and one of said members being formed with a gripping edge adapted to grip the rod and hold the abutment rigidly thereto. Eight claims.

THE BOILER MAKER

APRIL, 1911

THE LAYING OUT CONTEST.

The following paper, in the laying out for taper sheets, is awarded the prize of $5.00. It was submitted by Mr. John V. Petty, Lebanon, Pa.:

PROBLEM I.

The layout of one section of the pipe, shown in Fig. 1: Each section of this pipe is made from one sheet of ¼-inch plate with large and small ends, the rivets to be ⅝ inch diameter and spaced about 2⅛ inches pitch.

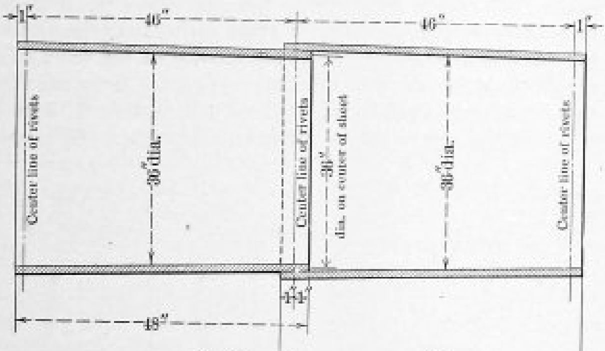


Fig. 1

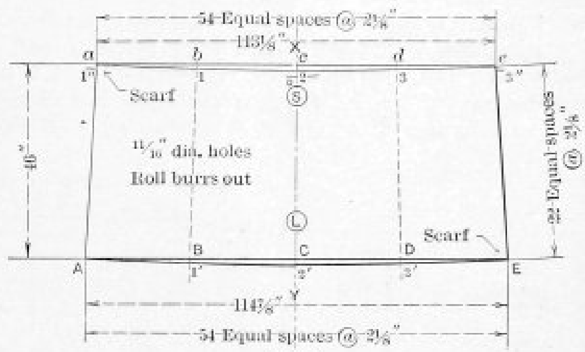


Fig. 1-A

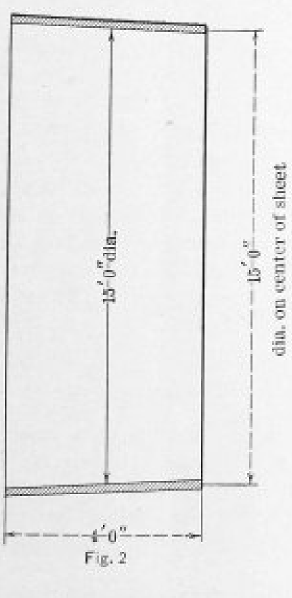


Fig. 2

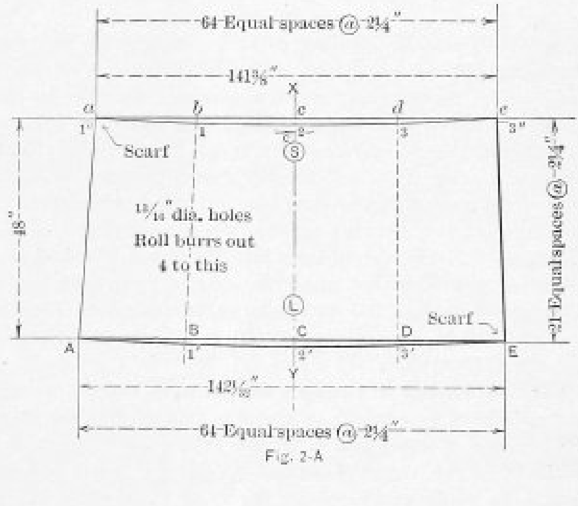


Fig. 2-A

The problem calls for the sheets to be 48 inches long over all, but it is assumed that rivet holes are wanted in each end, in which case, one sheet will serve as a pattern for the two courses. If each end is to be without holes, a separate layout will be required for each ring, but the same method will apply. A lap of 1 inch on all sides was allowed, which provides for square edges; i. e., no extra metal was allowed for beveling the edges for caulking. The layout of the sheet is as follows:

The diameter through neutral line on small end is 36 inches. The circumference corresponding to this diameter is $36 \times 3.1416 = 113\frac{1}{8}$ inches. On this class of work the proper allowance to add for the large end or outside ring for a telescope joint is seven times the thickness of the plates used, which is 7 times ¼ equals 1¾. Hence, 113⅛ plus 1¾ equals 114⅞ inches, which is the circumference for the large end. The straight height of the course between center lines of rivet holes is 46 inches. The slant height of the course is the hypotenuse of a right triangle whose vertical legs are 46 and ¼.

This value is $\sqrt{46^2 + \frac{1}{4}^2}$, which equals 46.0007 inches. In this case, with such a slight taper, the difference between these two heights is so small as to be negligible. Call the slant height 46 inches.

Referring to Fig. 1-*A*, draw the center line *X Y* on the plate and construct the right frustum, *a e E A*, symmetrical with *X Y*, conforming to the dimensions indicated. For the same reason above mentioned, the straight and slant heights in this figure are practically the same. This straight height is

$$\sqrt{46^2 - \left(\frac{114\frac{7}{8} - 113\frac{1}{8}}{2}\right)^2},$$ which equals 45.996 inches. Call it 46 inches.

Divide lines *a e* and *A E* into quarters, locating points *b*, *c*, *d*, *B*, *C*, and *D*, as shown. Connect these points with lines, projecting them slightly below line *A E*. From point *a* erect a perpendicular to line *a A*, intersecting line *X Y* at point *O*. From point *e* erect a perpendicular to line *e E*, intersecting line *X Y* at *o*. The intersection of these lines at the common point *O* will test the accuracy of the work thus far. Locate point 2 on line *X Y* equidistant from points *C* and *O*. Then distance *C* 2 equals the camber of the sheet. Lay off from point *a* on line *a A* and from point *e* on line *e E* a distance equal to one-half *C* 2, locating points 1″ and 2″, respectively. Lay a straight edge on points 1″ and 2 and draw that part of the line which intersects line *b B*, locating point 1. Likewise, draw that part of the line 3″-2 which intersects line *d D*, locating point 3. A smooth line drawn through points *a*, 1, 2, 3, and *e*, locates the center of the rivet line for the upper curve. With a pair of trammels set to the distance *a A*, strike off this distance downward on the radial lines from the points located on the upper curve, locating points 1′, 2′ and 3′. A smooth line drawn through these points locates the center of the rivet line for the lower curve. The distances measured on the curved lines *a* 2 *e* and *A* 2′ *E* should equal, respectively, the straight line distance *a e* and *A E*, but in this case, with such a small camber, the difference, as measured on the straight and on the curve, is negligible. Therefore, *a* 1 2 3 *e E* 3′ 2′ 1′ *A* locates the centers of the rivet lines for the layout.

For convenience in stepping off the rivet spaces, divide the circumference into halves and, with a pair of dividers, step off the number of equal spaces on the halves which most nearly conform to the required pitch. Allowance for a 1-inch lap should be made outide of all the rivet lines. For the sake of clearness this was omitted in the figure. To save turning the plate over, it should be rolled burrs out; *i. e.*, the underside of the sheet will be the outside of the ring after rolling. Considering the large end to be the bottom, the plate should be scarfed at the two corners indicated, to permit of a right-hand lap on the straight seam. On line *X Y*, under rivet hole at point 2, stamp the letter S, and likewise above point 2′ the letter L, indicating the large and small ends, and also locating the rivet hole that will come in line with the straight seam of the adjacent ring. In this case the straight seams of adjacent rings will be diametrically opposite each other. The job number, number of duplicates and any other necessary information should be written on the sheet. After centering the holes with a center-punch, the sheet is ready to be punched.

PROBLEM II.

The layout of a course for a hot-blast stove of the dimensions shown in Fig. 2. The course is to be made of four sheets of ⅜-inch plate, with rivets pitched about 2¼ inches. The plates are to have large and small ends; that is, the course fits outside the adjacent course on one side and inside the adjacent course on the other side. The width of the sheets for this course is 4 feet.

We will assume the course to be 4 feet long, center to center, of rivet lines.

As far as the method is concerned the layout of this problem is identical with that of Problem I., and the only difference in the layout will be the lengths of the upper and lower circumference and the height of the sheets. The diameter on the neutral line of the small end is 180 inches, and the circle corresponding to this diameter is 565½ inches. Adding 7 times ⅜, which equals 2⅝, to the circumference of the small circle, equals 568⅛ inches, the circumference of the large end. The course being divided into four equal plates, the width of the plate on the small end is one-fourth of 565½, which equals

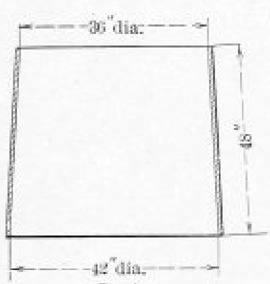


Fig. 3

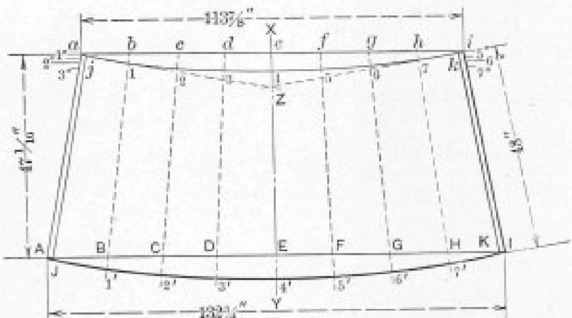


Fig. 3-A

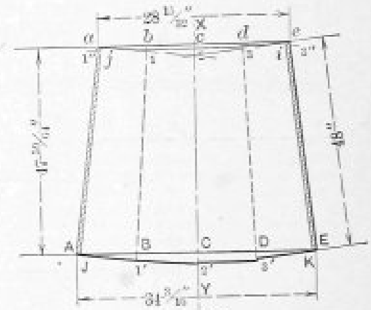


Fig. 3-B

141⅜ inches, and the width of the plate on the large end is one-fourth of 568⅛, which equals 142 1/32 inches. The slant height of the course is practically 48 inches, which is the same as the straight height. The camber is obtained by squaring in from the two sides to the center line *XY*, as in Problem I. Since the camber is small in this case five points will be sufficient to locate a smooth curve. The explanation in Problem I., and an examination of Fig. 2-A, will make this layout apparent.

PROBLEM III.

The layout of the frustum of a cone of the dimensions shown in Fig. 3. The cone is to be made first of one sheet of ¼-inch plate, and, second, from four equal pieces.

It is assumed that the frustum referred to is that of a right circular cone, and that no rivet holes are wanted in the ends.

Consider first the case where the ring is made from one plate. The diameter on the neutral line of the small end is 36¼ inches, and the circumference corresponding to this is 113⅞ inches. The diameter on the neutral line of the large end is 42¼ inches, and the circumference corresponding to this is 132¾ inches.

Draw Fig. 3-A on the sheet according to dimensions indicated, making the slant height 48 inches, as in Fig. 3. The straight height in Fig. 3-A may be determined by sketch or calculation. The formula is straight height equals

$$\sqrt{48^2 - \left(\frac{132\tfrac{3}{4} - 113\tfrac{7}{8}}{2}\right)^2},$$

which equals 47 1/16 inches.

After having determined the size of and drawn the frustum the same method of layout is followed as in Problems I. and II. Since the camber is greater in this case the upper and lower curves will be sharper, necessitating more points to determine accurate curves.

Divide the upper and lower lines each into eight equal spaces, and connect the respective points thus found, locating the lines *a A*, *b B*, *c C*, etc. To obtain the camber erect pendiculars from point *a* to line *a A* and point *i* to line *i I*, meeting at the common point *Z* on center line *X Y*. Locate point 4 on line *X Y* equidistant from points *e* and *Z*. Then line *e* 4 equals the camber of the sheet. With a pair of dividers step off line *e* 4 into four equal spaces (corresponding to four divisions of half the sheet), and from point *a* on line *a A*, and from point *i* on line *i I*, step off three of these spaces downward, locating points 1", 2", 3", 5", 6" and 7". Lay a straight edge on points 1" and 4, and draw that part of the line which intersects line *b B*, locating point 1. Likewise the intersections of lines 2"-4 and *c C* locates point 2, and the intersection of lines 3"-4 and *d D* locates point 3. In the same manner locate points 5, 6 and 7. Then the points *a*, 1, 2, 3, 4, 5, 6, 7 and *i* determine the upper curve. With a pair of trammels set to the distance *a A* strike off this distance downward on the respective radial lines, locating points 1', 2', 3', 4', 5', 6' and 7' on the lower curve. Smooth lines drawn through the points thus found locate the upper and lower curves. Remeasure on the upper curve on each side of point 4 the distance *a e* or *e i*, locating points *j* and *k*. Remeasure on the lower curve on each side of point 4' the distance *A E* or *E I*, locating points *J* and *K*. Then *j* 4 *K* 4' *J* determines the development of the layout. The detail of riveting not being specified in the problem no provision was made for same.

If the ring is made from four equal plates the same method of laying out will be involved, but the straight height and the length of the upper and lower curves will be changed. The slant height will remain the same. The length of the upper curve will be one-fourth of 113⅞, which equals 28 15/32 inches, and the length of the lower curve will be one-fourth of 132¾, which equals 34 3/16 inches. The straight height will be

$$\sqrt{48^2 - \left(\frac{34\,3/16 - 28\,15/32}{2}\right)^2},$$

which equals 47 59/64 inches. In this case four divisions of the upper and lower lines will give sufficient points to determine accurate curves. The remainder of the layout is the same as the previous problems, and an examination of Fig. 3-B will make this layout apparent. The camber is obtained by squaring into the center line as in the previous problems. In this case it will again be necessary to remeasure along the curved lines, after the same have been located, the distance as measured on the straight lines, as in Fig. 3-A. The detail of riveting not being specified in the problem no provision was made for same.

This method of laying out taper sheets is simple, quick and accurate. It is applicable to any taper, large or small. The good feature of it is that any desired number of points wanted to locate an accurate curve may be obtained by dividing the frustum into as many equal spaces as are points required.

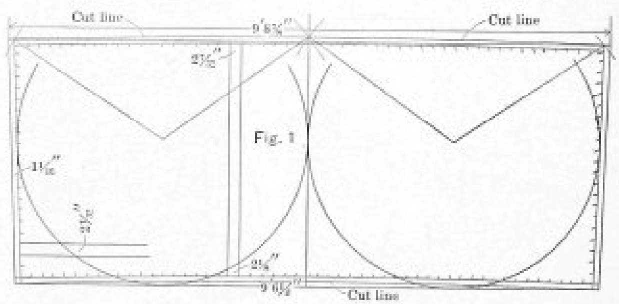
The calculations gone through above are not necessary, as these distances may be readily determined from sketches. This method of determining the camber will hold good for any division of plates to the ring. If the height of the course must not be exactly as called for it would be all right to make the straight height and slant height equal to each other, thus eliminating considerable sketching or calculation. It must be decided in each case whether the job will permit of this small error in height. After having determined the size of the development of the frustum, with the upper and lower sides straight, the camber may be computed by the formula

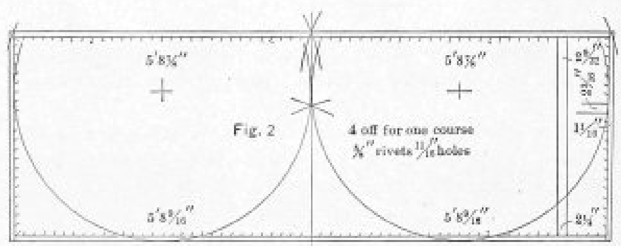
$$C = \frac{w\,(W - w)}{4\,H},$$

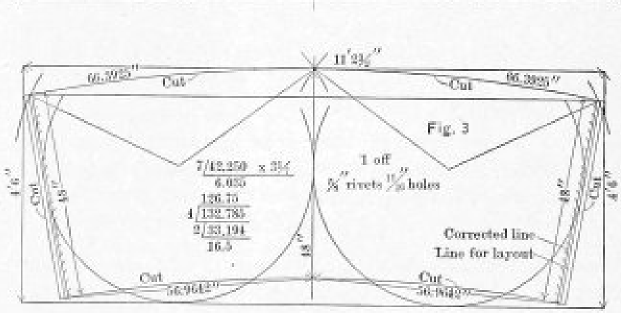
where *C* equals the required camber, *w* equals width of small end, *W* equals width of large end, and *H* equals straight height of development of frustum. Addition must be made for laps.

Explanation of the layout by John A. Higgins, Greenport, L. I.:

Fig. 1, section of pipe with large and small ends. Find the circumference of large end by multiplying the diameter of the large end by 3 1/7 inches, and add three (3) times the thick-

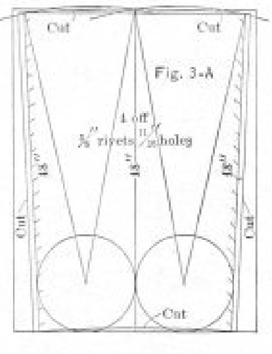






ness of metal, allowing enough extra for a lap at both ends. Now select a sheet according to height of course, allowing enough for extra camber.

Layout.—Find center of sheet and square center with one edge; *i. e.*, length of sheet; from straight edge of sheet mark height of course and strike line full length of sheet; this line will be the large circumference, of course. We now find circumference of small end and add three times the metal, and lay off one-half each side of center line on edge of sheet. Strike off on line each side of center one-half of circumference of large end. Strike off side lines from large to small circumference; we now have profile of layout. We will find the center of a circle which will strike the center line, the bottom line or line of small end and side line, then find same center each side of center line. From center of circle spread trammels to outer edge of large circumference, and with this distance bisect the center line. With strong, straight batten, held at both outer points of large circumference and sprung at center line to bisect mark on center line, strike off camber. From camber line on center line to small end mark height of course, and with batten held at outer points and sprung to mark on center line, strike camber of small end. On camber lines, one-half each side of center line, mark off true circumference and strike new side lines, which will be center of rivets, mark off for lap at each end. From camber lines mark off for center of rivet holes and strike off as for camber. We now have sheet laid out for holes. Set dividers at about pitch of rivets, and from center on camber line of large end step off to outer end, setting dividers until you find both centers, then step off other side of large end. Step off small end the same, being sure you get the same number of spaces. Step off your side lines the same way. Your sheet is now all laid out. All work being done by one man, using small screw clamps to hold



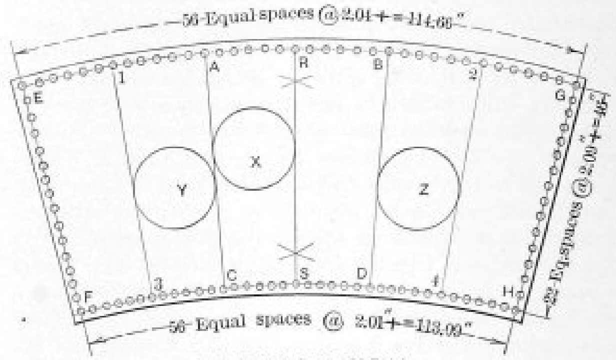
battens. Shear plate on all cut lines. Punch all holes 1/16 inch larger than diameter of rivets. Roll up, bolt together and rivet.

Fig. 2 will be laid out the same as Fig. 1, using one of the four sheets in course for layout. To find the circumference of top and bottom ends add three times the thickness of metal and divide by four. The answer will be the length of one sheet less the lap on both ends. Lay this sheet out as in Fig. 1; divide sheet for center line, and on each side of center line layout one-eighth of circumference, and proceed as in Fig. 1. Fig. 3, for one sheet, will be laid out as in Fig. 1; for four sheets will be laid out as in Fig. 2.

The following solutions of the problems were submitted by W. E. Connor, Hornell, N. Y.:

PROBLEM I.

Assuming that the sheets for the several jobs are on hand and are the required size, the first step necessary is to ascertain the correct data preliminary in developing the patterns. The requirements for Problem I. are: One sheet, ¼ inch thick, to be laid out complete full size. The outside diameter of the small end to equal the inside diameter of the large end. The mean inside diameter to be 36 inches; the length over all to be 48 inches. The rivet holes to be punched 11/16 inch of 1 inch to take a ⅝-inch rivet, pitched about 2⅛ inches. Commence Problem I. by drawing, midway on your sheet, and parallel to the long side of the sheet, about 1¼ inches from the edge drawn the line *A B*, and equal in length to the neutral diameter of the large end, or 36½ inches. Next, bisect the line *A B* with the tram points and draw the perpendicular line *R S*, as shown on the sketch. Now with the tram points set equal to 46 inches and point *A* as a center, scribe an arc at *C*; with the same radius, and *B* as a center, scribe another arc at *D*. Now, with the straight-edge, draw the line *C D* tangent to the arcs previously drawn. Next, with the tram points set equal to one-half the neutral diameter of the small end and using point *s* as a center, scribe an arc at *C* cutting line *C D* previously drawn. Do the same at *D*. Connect *A C* and *B D* as shown. We have now established the outline of the side elevation of the frustum of a cone as it would appear when



PATTERN FOR PROBLEM 1

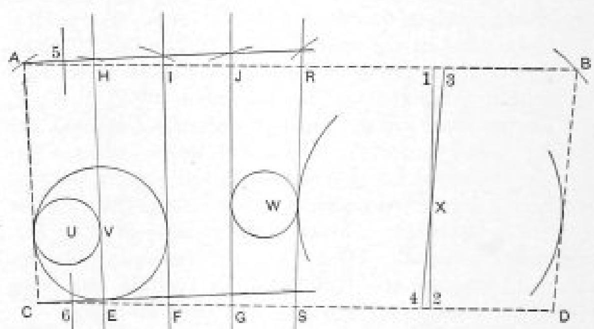
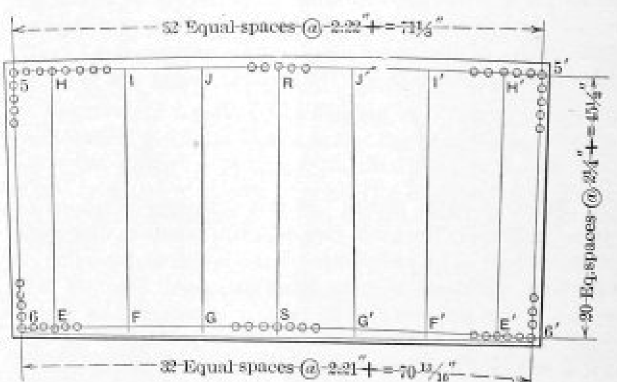


DIAGRAM TO LOCATE POINTS FOR PROBLEM 2



PATTERN FOR PROBLEM 2

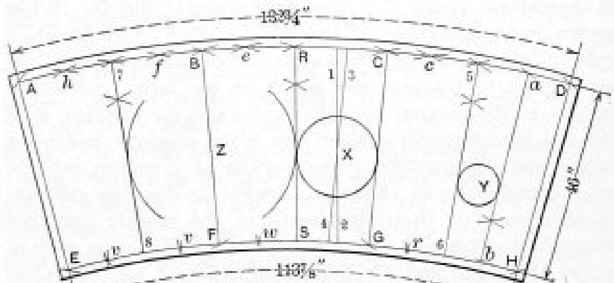
rolled up in its true position. Next, with the tram points set equal to the diagonal distance *A D* or *B C*, and point *C* as a center, scribe an arc at *E*. Now using the same radius, and *A* as a center, draw an arc at *F*. Then, with *B* as a center, draw an arc at *H*; also, *D* as a center, draw an arc at *G*. Then with the tram points set equal to the large diameter *A B*, and using point *B* as a center, intersect the arc at *G*; also, with the same radius, and *H* as a center, intersect the arc at *E*. Now with the tram points set equal to the small diameter

C D, and using point *D* as a center, intersect the arc at *H*; also, with the same radius, and point *C* as a center, intersect the arc at *F*. Connect *E* with *A*, and *F* with *C*; also connect *G* with *B* and *H* with *D*. We have now established four points, *E A* and *B G*, on the large end, and four points, *F C* and *D H*, on the small end. Next, locate the intermediate points 1, *R*, 2, and 3, *S*, 4. As follows, bisect *E A* and *F C* and draw the line 1-3. Also bisect *B G* and *D H* and draw the line 2-4. Now applying the axiom, any point in the bisector of two oblique lines cuts off equal distances at the foot. Keeping this in mind, locate, about midway of *A R* and *C S*, point *x*. This point may be found by trial or by the intersection of two parallels at a fixed distance from *R S* and *A C*. However, having located point *x*, draw a circle, and if the circle is tangent to *A C* and *R S*, will prove that you are right. Now, with the radius *X C*, and point *x* as a center, swing around and cut the line *R S* at *S*, locating point *S*. Then, with the radius *X A*, and point *X* as a center, cut the line *R S* at *R*, locating point *R*. Since points 1-3 and 2-4 are located in a similar way from points *Y* and *Z*, no further comment is deemed necessary. Now check up points on the large end with points on the small end with the tram points. Then, with a stick of a uniform width and thickness, say about one inch wide and one-fourth inch thick, draw a smooth curve, cutting points *E*-1-*A*-*R*-*B*-1 and *G*. On the large end do the same as on small end, cutting points *F*-3-*C*-*S*-*D*-4 and *H*. Of course it is customary to take in about three points or more at each setting of the stick. The circumference may now be layed off from the center line *R S*, as previously stated, the neutral diameter of the large end to be 36½ inches. The circumference corresponding to this is 36½ x 3.1416 inches. Lay off from both sides of the center line *R S* a distance equal to $\frac{114.66''}{2} = 57.33$ inches, locating points at *E* and *G* to represent the horizontal rivet line. The neutral diameter of the small end to be 36 inches. The circumference corresponding to this is $36'' \times 3.1416 = 113.09$ inches.

Lay off from both sides of the center line *R S*: on the small end, a distance equal to $\frac{113.09''}{2} = 56.54$ inches. Locating points at *F* and *H* to represent the horizontal rivet line, connect *E* with *F*, and *G* with *H*. This completes the rivet lines. The next step is to divide the extreme points into a certain number of equal parts to represent the rivet holes. Since the requirements call for a pitch of about 2⅛ inches, dividing the circumference of the large end by 2⅛ inches will determine the number of spaces to use, or $\frac{114.66}{2.125} = 53+$ spaces. Now, dividing the circumference by the number of spaces so found will give the pitch, or $\frac{114.66}{53} = 2.16+$ inches. As this is a little above 2⅛ inches, also 53 being an odd number, it is good practice, when conditions will permit, to use a number of spaces divided by 8, or 4 at least, and by so doing the layout is not only facilitated but more accurate, as well as the fitup or assembling of the parts when several are used. Since 56 spaces is divisible by 8, we will use 56. Having determined the number of spaces which is divisible by 8, the next step is to divide the circumference of the large and small into eight equal parts with the tram points, as follows: Commence by dividing the extreme into halves, then locate the quarter points, then the eight points. Now, center-mark each division point with a light center-punch. Now divide each division into seven equal parts. This completes the large end. In like manner divide the small end. Next, space in the horizontal seams *E-F* and *G-H*. As follows, set the divider points to 2⅛ inches and step off the distance from *G* to *H* or *F* to *E*, adjusting the divider points to suit at each trial until a correct division is obtained. No center mark for punching the rivet holes. Mark the rivet holes 11/16 inch, mark the lap for trimming, and the layout is complete.

PROBLEM II.

To Locate the Points.—The requirements for Problem II. are: One course to be made of four sheets; length, 48 inches over all, inside diameter of small end 180 inches; thickness of plate, ⅜ inch, with rivets pitch about 2¼ inches. The distance over all to be 48 inches. The practice of the writer is to work full size when conditions will permit; if not, half size is nothing out of the ordinary, since good results may be obtained from either. Commence Problem II. by drawing in the usual way a full-size side elevation of the frustum of a cone, as shown by the dotted lines *A-B* and *C-D* in the diagram for Problem II. of the following dimensions: The neutral diameter of the small end to equal 180⅜ inches. The neutral diameter of the large end to equal 181⅛ inches. The perpendicular distance between dotted lines to equal 45½ inches. Now draw line 1-2 parallel to *R-S*, also draw line 3-4 the same distance from *B-D*. Then will the intersection of these two lines locate point *X*, bisecting oblique lines *R-S* and *B-D*. Now with the trammels set equal to *X-B*, swing around and cut line *R-S*



PATTERN FOR PROBLEM 3
IN FULL SHEET

at *R*, locating point *R*. Now bisect *A-R* and draw the line *I-F*. Now locate point *V*; then with the tram points set equal to *X-A* swing around and cut line *I-F* at *I*, locating point *I*. Next locate point *W*. Again with the trammels set equal to *W-R*, and using point *W* as a center, cut line *J-G* at *J*, locating point *J*, also locate point *V*, and with radius *V-A* swing around and cut line *H-E* at *H*, locating point *H*. Now with the trammels set equal to *A-C*, and point *H* as a center, cut the line *H-E* at *E*, locating point *E* with the same radius, and points *I-J* and *R* as centers, locate points *F-G* and *S*. Now draw a smooth curve through the points *R-J-I-H* and *A*. Also draw a smooth curve, cutting points *S-G-F-E* and *C*. Now lay off on *R-A* from point *R*, a distance equal to one-eighth of the circumference of the large end, or $\frac{181⅛'' \times 3.1416}{8} = 71⅛$ inches. Also lay off on *S-C* from point *S* a distance equal to one-eighth of the circumference of the small end, or $\frac{180⅜'' \times 3.1416}{8} = 70.83$ inches, or practically 70 13/16 inches, locating points 5 and 6, which is all that is necessary to lay out the pattern.

To Lay Out the Pattern.—In laying out the pattern for Problem II. all unnecessary letters or figures have been omitted, since the sketches with the explanation given at each stage of the layout will be readily understood. Now the first step in laying out this pattern is to draw the line 5-5′ of an indefinite length about 1½ inches from the edge of the sheet. Then locate point *R* midway and erect the perpendicular line *R-S*. Now parallel to line 5-5′, and at a distance from it equal to 45½ inches, draw the line 6-6′. We are now ready to transfer points on the dotted lines *R*-5 and *S*-6 in the diagram to the parallel lines on the pattern previously drawn from both sides of the center line *R-S*, which we will designate as construction points. This may be done as follows: With a chalked stick or batten lift the several divisions on the dotted line in the diagram, as *S-G*, *G-F*, *F-E* and *E*-6, and transfer these several divisions to the pattern from both sides of the center line *R-S*, as *S-G*, *G-F*, *F-E* and *E*-6, also *S-G′*, *G′-F′*, *F′-E′* and *E′*-6′, locating construction points on the small end. Next lift the several divisions on the large end in the diagram, as *R-J*, *J-I*, *I-H* and *H*-5, and transfer these divisions to the pattern from both sides of the center line *R-S*, as *R-J*, *J-I*, *I-H* and *H*-5, also *R-J′*, *J′-I′*, *I′-H′* and *H′*-5′. Now draw the construction lines *H′-E′*, *I′-F′* to *H-E*, also draw the rivet lines 5′-6′ and 5-6, inclusive. Now we are ready to transfer points on the camber line in the diagram to the pattern, as follows: With the divider points take the distance at *S* from the dotted to the camber line in the diagram, and using the construction point in the pattern as a center at *S*, cut line *R-S*, locating point *S*. Now go back to the diagram and take the distance at *G* from the dotted line to the camber line, and using construction points at *G* and *G′* on the pattern as centers, cut the lines *G-J* and *G′-J′*, locating points *G* and *G*. In like manner locate points *F-E* and 6, also *F′-E′* and 6′ which locates all the points for the camber line of the small end. The next step is to transfer the points on the large end in the diagram to the pattern, as follows: Take the distance at *R* from the dotted to the camber line in the diagram, and using construction point at *R* on the pattern as a center, cut line *R-S*, locating point *R*. Now go back to the diagram and take the distance at *J* from the dotted to the camber line, and using construction points at *J* and *J′* on the pattern as centers, cut the lines *J-G* and *J′-G′*, locating points *J* and *J′*. Continue going back to the diagram until points 5 and 5′ are located on the pattern, which locates all the points for the camber on the large end. The next procedure is to draw the camber lines at the large and small ends, as follows: With a suitable batten draw a smooth curve through the points 6-*E-F-G-S-G′-F′-E′* and 6′ on the small end; do the same on the large end. Check up the pattern from the center line *R-S*. Now we are ready to space in the rivets, which may be done as follows: As previously figured out the length of the sheet between rivet lines 5-5′ on the large end to be 71⅛ inches, the pitch of the rivets, as stated above, to be 2¼ inches. Now divide the length of the plate 71⅛ inches between rivet lines 5-5′ on the large end by 2¼ inches will give the number of space, or $\frac{569}{8} \times \frac{4}{9} = \frac{2276}{72} = 31 +$ spaces. Then divide 71⅛ inches by 31, the number of spaces will give the pitch of the rivets, or $\frac{569}{8} \times \frac{1}{31} = \frac{569}{248} = 2.29 +$ inches. Since this is above 2¼, also 31 spaces being an odd number, let us try 32 spaces, or $\frac{569}{8} \times \frac{1}{32} = \frac{569}{256} = 2.22 +$ inches. Although in figuring the number of spaces to use, the strength of the net section of the plate and rivets should balance, or nearly so. However, since 32 spaces is divisible by 8 we will use 32 spaces. Now divide the large end 5-5′ in two halves, then locate the quarter points and then into eighths. In like manner do the same on line 6-6′, the small end. Then divide each one of the eight divisions into four equal spaces on the large and small ends, which completes the rivet spacing on the camber lines. Now step off the horizontal lines 5-6 and 5′-6′ by setting the divider points at 2¼ inches for trial, adjusting a little at each trial until an exact division has been obtained. Now center-mark for pushing, lay off the lap for trimming and the pattern is complete.

PROBLEM III.

Since the principle involving Problem III. is similar in all respects to Problems I. and II., and since the same method would be used, only a brief description of Problem III. will be necessary. Let *A-B-C-D* and *E-F-G-H* represent the outline of three elevations of the frustum of a cone of the following dimensions: Inside diameter of the small end to be 36 inches. The inside diameter of the large end to be 42 inches, the length over all 48 inches, the thickness of the plate ¼ inch. Now commence Problem III. by drawing on the sheet in the usual way three full-size side elevations of the frustum of a cone, as shown in Problem III. Now bisect *R-S* and *S-G* by drawing line 1-2 parallel to *C-G*. Now with the same distance from *R-S* draw the line 3-4. Now where these two lines intersect, as at *X* and *C*, as a radius, cut line *R-S* at *R*, locating point *R*. Next with the point *G* as a center and *R* a radius, swing around and cut line 5-6 at 5, locating point 5. Now with the same radius and point *F* as a center, cut line 7-8 at 7, locating point 7. Now with the trammels set equal to *B-F* or *C-G*, and point 7 as a center, cut line 7-8 at 8, locating point 8. Then with *R* as a center cut line *R-S* at *S*, locating point *S*. Now with 5 as a center, cut line 5-6 at 6, locating point 6. We have now located seven points on the large end *A*-7-*B-R-C*-5 and *D*, and seven points on the small end *E*-8-*F-S-G*--6 and *H* for the camber to pass through. However, since this problem has more tapper than Problems I. or II., making it necessary to establish more points, which may be done as follows: Bisect 5-*D* with the tram points and draw the line *a-b*. Now locate point *Y*. Then with point *Y* as a center and radius 5, cut the line *a-b* at *a*. Next with the trammels set equal to *H-a* or 6-*a*, and using point 6 as a center, draw an arc at *c*, as shown. Now with the same radius and *G* as a center intersect the arc at *c*, locating point *c*. In like manner points *e-f-h* are located, which are all the points necessary for drawing the camber on the large end. Now locate the intermediate points on the small end as follows: Bisect *H*-6, 6-*G*, *G-S*, *S-F*, *F*-8, and 8-*H*. Now with the trammels set equal to *B-F* or *C-G*, and using point *h* as a center, cut the arcs at *v*, as shown, locating point *v*. Continue this way until all the intermediate points on the small end are located. Now draw a smooth curve through the points on the large end. Do the same on the small end. Check up the pattern from the center line. Next draw the horizontal rivet lines *A-E* and *D-H*. Now space in the rivets, mark the lap for trimming and the pattern is complete for Problem III. in one sheet.

Since the layout of this course in four sheets would be developed the same as Problem II., this has been omitted.

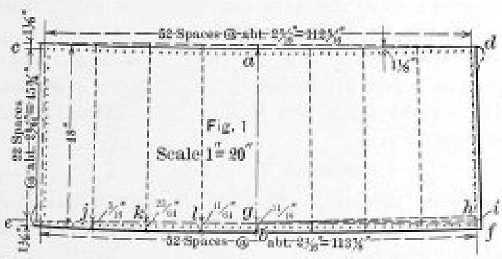
Edgar A. F. Wotring, Belfontaine, Ohio, submitted the following solution:

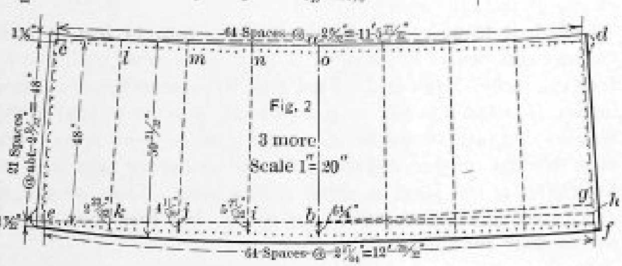
PROBLEM I.

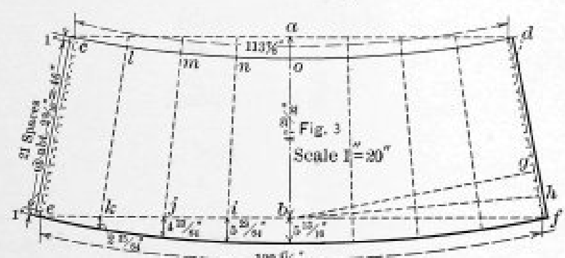
Square up the sheet, Fig. 1, *a b*; perpendicular to *a b* draw *c d* 35.25 × 3.1416 = 112 5/16 inches long. The slant height or the width of the sheet is equal to the square root of the sum of the square of the height and the square of one-half the difference of the diameters of the two bases, which is equal to ½ (36¼ − 35¾) = ¼, hence the width of the sheet equals $\sqrt{48^2 \times 25^2} = 48.0016''$. Parallel to and 48.0016″ from *c d* draw *e f* 36.25 × 3.1416 = 113.883 = 113⅞ inches. To find the height of the camber at *g*: with a square and straight edge square the center *e f* to *d f*; locating the point *h* with the trams set *g h*, draw an arc from *h* to *e f*, divide the arc from *g*, draw a line through the center of the arc to *d f*, locating the point *i*, then *i f* is the height of the camber, which is 11/16 inch; divide the line *c d* and *e f* in eight equal spaces, then to height at these points, as *l j k* divide 11/16 by 16 and multiply by 15, 12 and 7, making *l j* and *k* 41/64 inches, 23/64 and 5/16, respectively. The horizontal rivet lines are 112 5/16 inches at the small end and 113⅞ inches at the large end, measuring on the curve and added 1⅛ inch for lap. The girth seams are set in 1⅛ inches, or 45¾ inches from *c* to *c*. In spacing the rivets in the girth, we get 52 spaces at about 2 3/16-inch pitch on *e f* and 2 5/32-inch pitch on *c d*. In spacing *c e* and *d f* we get 22 spaces at about 2 5/64-inch pitch. The corners *e* and *d* should be scarfed as shown.

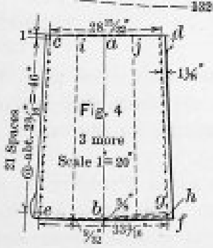
PROBLEM II.

Square up the sheet, Fig. 2, *a b*; perpendicular to *a b* draw *c d* (15 — ⅜) 3.1416 ÷ 4 = 11′ 5 27/32″ long; draw *e f* 48 inches from and parallel to *c d* (15 + ⅜) 3.1416 ÷ 4 =









12′ 29/32″ long; draw *c e* and *d f*, which is equal to ½ (180.375 = 1179.625) = 375; then $\sqrt{48^2 + 375^2} = 48.0015$, say 48 inches. With a square and straight edge, square the center *e f* to *d f*, locating the point *g* from *b* as a center; and, the trams set *b g*, scribe an arc from *g* on *e f*, divide the arc from *b*, draw a line through the center to *d f* locating the point *h*; then *h f* is the height of the camber, which is equal to 6¼ inches. To get additional points, as *i*, *j* and *k*, divide *e f* and *c d* in eight equal spaces; connect these points with radials, divide 6¼ by 16 and multiply by 15, 12 and 7, which gives 5 27/32, 4 11/16 and 2 23/32, respectively; with the trams, etc., to the slant height and the points computed for centers *l*, *m*, *n*, *o*, act draw a curve through, computed and located, which are the rivet lines, measuring 11′ 5 27/32 on *c o d* and 12′ 29/32 *e p f*.

In stepping off *c o d* we get 64 spaces at about 2 5/32, and on *e p f* we get 64 spaces at about 2 17/16. There are 21 spaces on *c e* spaced at about 2 9/32 inches; add 1 7/32 all around for lap, scarf the corners *e* and *d*. This can be used for a pattern for the complete layout.

PROBLEM III.

Square up the sheet, Fig. 3, *a b*; perpendicular to *a b* draw *c d* (36 + ¼) 3.1416 = 113⅞ inches long, the height of the frustum is equal to the $\sqrt{48^2 - 3^2} = 47\ 29/32$; draw *e f* 47 29/32 inches from and parallel to *c d* (42 + ¼) 3.1416 = 132 47/64 inches long; draw *c l* and *d f*. With a square and straight-edge, square the center of *e f* to *d f*, locating the point *g*; set the trams to *b g*, divide an arc from *g* on *e f*, divide the arc and draw *b h*; then *h f* is the height of the camber, which is equal to 5 13/16 inches. Divide *c d* and *e f* in eight equal spaces, draw the radials, divide 5 13/16 by 16 and multiply by 15, 12 and 7, which gives up 5 29/64, 4 23/64 and 2 35/64, respectively. With the trams set 48 inches and the points computed for centers, locate the points *l m n o*, etc. Stepping off *c e* and *d f* we get 21 spaces at about 2 3/16-inch pitch, equals 46 inches, leaving 1 foot at each end, for lap. The corners *e* and *d* should be scarfed as shown by dotted lines. The layout for one-fourth of Problem III. is shown in Fig. 4. Square up the sheet, Fig. 4, *a b*; perpendicular to *a b* draw *c d* 113⅞ ÷ 4 = 28 15/16 inches long; draw *e f* 47 29/32 inches from and parallel to *c d* 132 47/64 ÷ 4 = 33 3/16 inches long; with a square and straight edge, square the center of *e f* to *d f*, locating the point *g*; with the trams set *b g*, draw an arc from *g* on *e f*, divide the arc and draw *b h*; then *b f* is the height of the camber, which is equal to ⅜ inch; divide *c d* and *e f* in four equal spaces, draw the radials, divide ⅜ by 16 and multiply by 12, equals 9/32; with the trams set to the slant height of the frustum 48 inches and with the points computed locate the points *i j*, draw a curve through the points computed and located. In stepping off *c e* and *d f* we get 21 spaces at about 2 3/16-inch pitch, equals 46 inches, leaving 1 inch at each end for lap. The corners *c* and *d* should be scarfed as shown by dotted lines.

Following is the solution submitted by Robert M. Reay, Massillon, Ohio:

PROBLEM I.

Thirty-six inches at center makes 36¼ inches at large end and 35¾ inches at small end. But we must take into consideration the thickness of the sheet, which is ¼ inch, and add this to 36¼ inches, making 36½ inches and 35¾ + ¼, making 36 inches. The center length to figure will be:

On large end 36.5 × 3.1416 = 114.668 length of arc.
On small end 36. × 3.1416 = 113.097 " "

1.561 ÷ 2 = .78.

On all sheets with such a large radius I first find the camber and draw the arc in the following manner: To find the camber. If 45.5 inches gives ¾ inch what will half the difference be in the length of each side of the sheet? What will

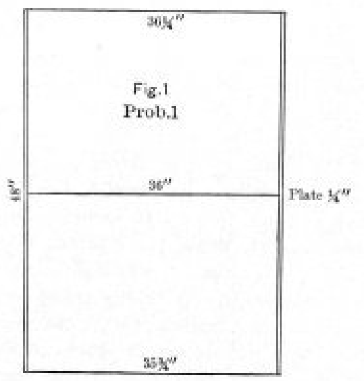
57.344 give? It will give more, so that the least term is the divisor:

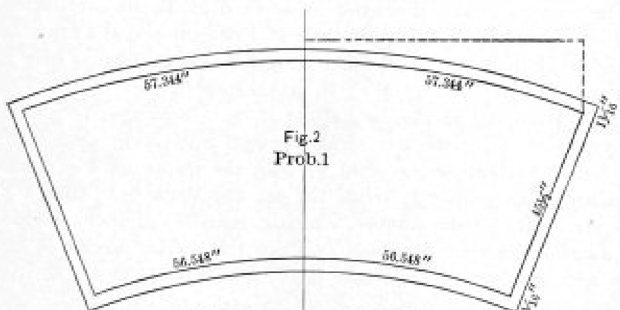
$$45.5 : .75 :: 57.344$$
$$\times 75$$
$$286720$$
$$401428$$
$$45.5)4301000(.9452$$

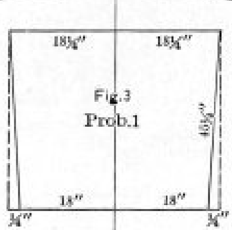
The rule is to take 4/9 of this for camber.

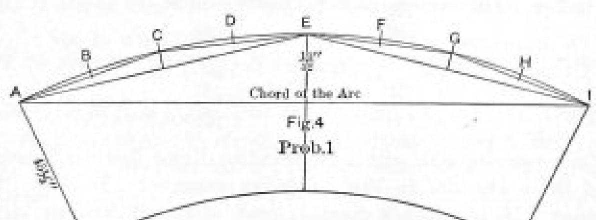
$$.9452$$
$$\times 4$$
$$9)37808$$
$$.4201$$

or 13/32 camber.









The radius is very great, as if 45½ gives ¼ what will 18¼ give? Answer, ¼ is contained in 18¼ 73 times, so 45½ × 73 = the radius = 3321½ inches, or 273 feet 5½ inches, which is too long a pole to use, so I do as follows, which is about as correct a way as any, on a large radius:

Draw the chord of the arc *A I*, raise camber in center of line 13/32, call it *E;* then draw a line from *A* to *E*, and raise a camber in center of this line ¼ of 13/32, call it 3/32 point *c;* then draw a line from *A* to *C* and from *C* to *E;* then in the center of these lines at *B* and *D* raise a line ¼ of 3/32 = 1/64 strong, and draw lines from *A* to *B*, *B* to *C*, *C* to *D* and *D* to *E*. Draw up the other side of the arc in the same manner, and then measure over 45½ inches on the radial line to form the arc on the short side of the sheet. Be sure and raise a good line at right angles on the center of the sheet, so as to get each side alike; measure your length on each side of the center on the arc line; that is, 57.334, or 4 feet 9 5/16 inches, and on the arc line on each short side 56.543, or 4 feet 8 17/32 inches, and allow 1 1/16 inches on each side of all these lines for the edge of the sheet. Spacing will be 54 spaces of 2⅛ inches, or very near, on each side of the sheet, as both ends must have the same number of spaces, and on the vertical seam 45½ inches, say 22 spaces. I generally add on the large end one-eighth more than it figures, so as the large end will go in easy. This allows a little for the lap of the sheet.

Order for the sheet would be 45½ + 2½ + ⅜ = 48 inches. Length of sheet = 9 feet 6¾ inches + 2½ = 9 feet 9 inches; so that it takes a sheet 117 inches × 48 × ¼ to make this, as we are tied to width.

PROBLEM II.

This is somewhat similar to Problem I., only it has four sheets. We figure for one sheet and divide it by 4 to get length of one of the four sheets.

Length is to be 15 feet inside at small end, 15 feet ¾ inch at large end, center line will be 15 feet 0⅜ at small end, and 15 feet 1⅛ inches large end. Find now the circumference, 181⅛ inches × 3.1416 = 569 ÷ 4 = 142.25 ÷ 2 = 71.125; 180¾ inches × 3.1416 = 566.66 ÷ 4 = 141.66 ÷ 2 = 70.83. We now find the camber and draw the arc as before described, as the radius is too large to draw with a pole. Then we say, if 45.25 gives 5/16 what will 71.125 give? We then take 4/9 of the produce for the camber.

$$45.25 : 325 :: 71.125$$
$$325$$
$$45.25)23.115625$$
$$.5108$$
$$4$$
$$9)20436$$
$$.2270 = 7/32$$

is the camber. Or, if you like, you can draw it in with the square, by placing the square on the short side and crossing on the center line and taking 4/9 of this for the camber, is very near on large radius.

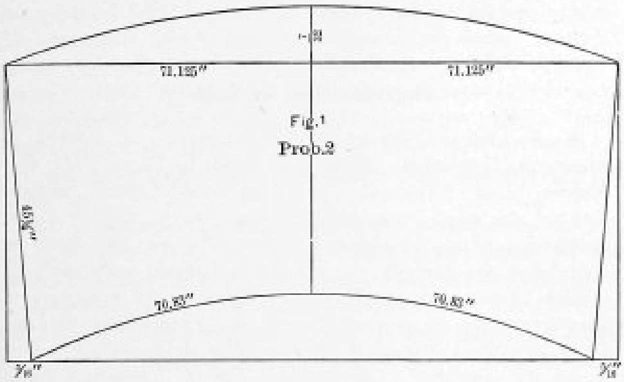
To develop this sheet proceed as in Problem I. Raise a camber in center of line *A*-1 7/32; then draw a line from *A* to *E;* raise a camber at *C* ¼ of 7/32 = 1/16 about; draw lines from *A* to *C* and from *C* to *E*. Then raise camber in the center of these lines, marking points *B* and *D*, which will be ¼ of 1/16 = 1/64. Draw lines from *A* to *B*, *B* to *C*, *C* to *D*, *D* to *E*, and do the same on the other arc, and you will have a true curve. Then measure over 45¼ for the other arc; space off on each side of the line on the arc 5 feet 11⅛ inches and 5 feet 10 27/32 inches, and allow 1¼ inches all around on your sheet for edge distance. Space off your holes as directed.

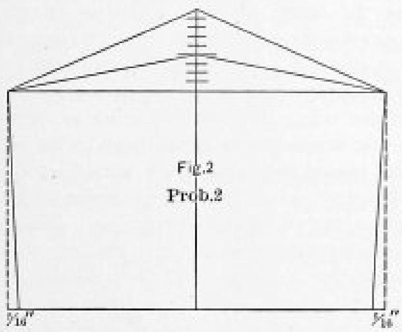
Spacing 2¼, say 63 spaces, to run 11 feet 10⅛ inches on long side.

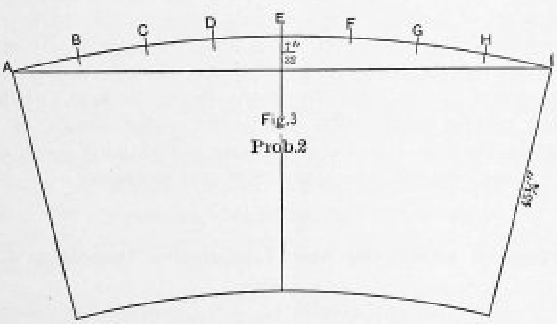
Spacing 2¼, say 63 spaces, to run 11 feet 9 11/16 inches on short side.

Seam 2¼, say 20 spaces, to run 3 feet 9¼ inches.

Size of each sheet will be 11 10⅛ + 2½ for edges = 12







feet ⅝ inch by 3 feet 9¼ inches + 2½ for edges and ¼ for camber = 4 feet.

The sheets would be ordered—four sheets 144⅝ × 48 inches × ⅜ inches.

PROBLEM III.

This is a different proposition from preceding problems. I will lay it out in the only correct way and the way Problems II. and III. should be laid out.

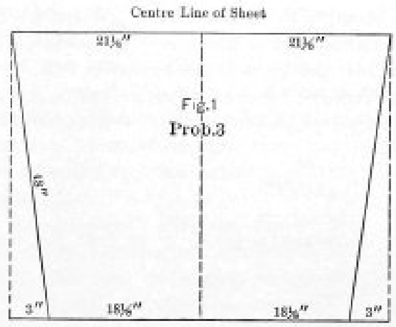
The problem has a very large taper, which makes a large camber, and if we were to lay it out as we have in Problems I. and II. we would, after projecting the sheet or sheets, move in the side lines when we measured them on the arc, the difference of the arc and the chord being so much that it must be laid out scientifically to have it right.

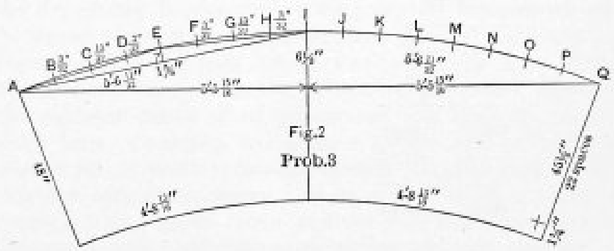
You can mark off No. 1 and No. 2 in the same way if you choose, but as the plan given is good and close for small cambers, it saves time in figuring and is easily projected.

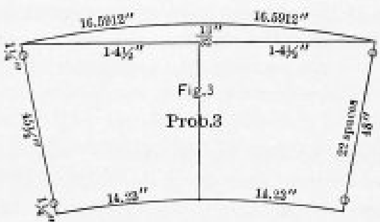
The problem is: mark off the frustum of a cone in one sheet, also in four sheets ¼ inch thick.

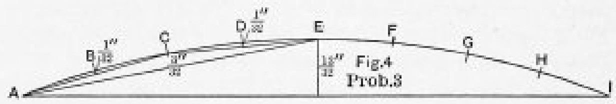
The frustum is 42 inches inside at one end and 36 inches at small end. Therefore, the center line is 42¼ on one end and 36¼ on the other end, and the sheet is 48 inches wide.

There will be no holes except on the vertical seam, as no connection is mentioned as being made to other sheets, but the development of the two sheets is the initial point and the cambers. If it were necessary to use holes in the ends it would









be a small matter to allow for them after knowing how to lay out the sheet.

We will consider the length of sheet if one sheet is used:

42¼ × 3.1416 = 132.732 arc line ÷ 2 = 66.366 inches = 5 feet 6 11/32 inches.

36¼ × 3.1416 = 113.833 arc line ÷ 2 = 56.916 inches = 4 feet 8 15/16 inches.

As we find the radius, if 3 inches, gives 48, what will 21⅛ inches give? 28 feet 2 inches × 2 = 56 feet 4 inches, or 676 inches diameter.

3 : 48 : : 21⅛
48
―――
3)1014
―――
338 = 28 feet 2 inches.

To do this we find out what part of a circle this sheet is. The diameter 676 inches × 3.1416 = 2123.7216 inches ÷ 132.732 = 16.00007, or about 1/16 of a circle. We then divide 360 degrees by 16 = 22½ degrees ÷ 2 = 11 degrees 15 seconds, which product we need, and is half of the angle of the arc of the circle.

We now go to our logarithm table and find the log of 11 degrees 15 seconds = 9.29023. The radius log, 28 feet 2 inches = 1.44974

———. We find the log = 5 feet 5 15/16 inches, the length 0.73997

of half the chord of the arc × 2 = 10 feet 11⅞ inches the chord.

The camber we want is quite easy, as we now have the two sides of the triangle to find the third. When we find this take it from the radius and it gives us the camber, 6½ inches. I will explain this, and we will see how easy it is.

Square the radius 28 feet 2 inches, or $338^2 = 114.244$. Square half the chord 5 feet 5 15/16 inches, or $67\ 15/16^2 = 4347.687$.

```
  114244
    4347.687
  ──────────
  109896.313(331.5, or 27 feet 7½ inches
   9
   ─
 63|198
  3|189
 ──────
 66|  996
   |  661
 ───────
6625|  33531
   5|  33125
 ───────
6630|  40630
```

Subtract the last square from the first, then extract the square root of this number, and it gives us 27 feet 7½ inches. Take this from 28 feet 2 inches

```
   27     7½
  ──────────
        6½ camber.
```

The best way to develop the sheet is with a pole, point 28 feet 2 inches centers; then move the point in 48 inches, leaving the other end at the same place, making the radius 24 feet 2 inches and scribe the two circles. Then add 2⅝ to length of sheet, or 11 feet ¾ inches + 2⅝ = 11 feet 3⅜ inches long. Forty-eight inches + 6½ for camber = 4 feet 6½ inches wide. Order for sheet would then read: 135⅜ × 54½ × ¼.

If you have no pole proceed as before to get the points to draw the arcs.

Steam Boiler Inspectors Organize.

The steam boiler inspectors employed in and around New York City have organized a society which has adopted the name of the American Institute of Steam Boiler Inspectors. A constitution has been adopted and the following officers elected: President, T. T. Parker; vice-president, J. N. Winter; secretary, Robert A. Thomson; treasurer, T. McGowan.

An executive committee of five was chosen, and the organization will be completed at an early date. The list of charter members contains thirty-six names, but it is expected that when the purposes of the society are fully understood by the inspectors not present the membership will be greatly increased and embrace practically all those in the immediate vicinity of New York. The society is for steam boiler inspectors employed by Federal, Dominion, State and city governments and the insurance companies of the United States and Canada, but the charter list is open to actual boiler inspectors only. The object of the institute is to promote the educational and social interests of its members, and, to this end, meetings for presentation and discussion of papers will be held at regular intervals. This is the second society of this nature formed in this country, but owing to the success of the Boston organization steps are being taken to make the institute one which shall include in its membership all of the reputable boiler inspectors in North America. The address of the secretary is 1 Madison square, New York, N. Y.

Deterioration in Boilers.

In discussing "Causes of Deterioration in Boilers and Measures Tending to Prevent or Remedy Them," Mr. C. G. Nelson stated: "Corrosion is caused chiefly through the oxidation of the steel by acidulated boiler water, and by electro-galvanic and thermo-galvanic action. Where the water was acidulated the remedy was to use an alkali, preferably carbonate of soda or caustic lime. Chloride of magnesia was always present in sea-water, and was exceedingly injurious. It attacked iron or steel, with or without the presence of air, at about 212 degrees F. Ammonium, sodium, potassium, barium and calcium only attacked in the presence of air, the order given being the order of their corrosive power. Zinc salts acted as a preservative in boilers, and mercury salts was also known as an effective protector against rusting. He advocated the use of filters for feed water, to arrest solids and oils, the presence of the latter very often leading to overheating. Impurities in the metal had a great deal to do with corrosion. Pickling the plates had been tried with partial success. He submitted figures to prove that the occlusion of gases by metals did take place under certain conditions. Zinc was put into boilers to prevent corrosion, but zinc put into boilers to absorb galvanic action was a fallacy, and the polishing of contacts insisted upon was, in his opinion, a waste of time. Thermo-galvanic action was caused by unequal heating in the plates, but he did not think this action exerted much influence in the corrosion of boilers. The action of stray electric currents also was blamed for a good deal more than it deserved. He recommended that those in charge of boilers should see that steam was raised slowly; that the water should be kept circulating when raising steam; that the boiler water should be kept slightly alkaline, and that scumming and blowing down might be resorted to, but with great care and attention.

Inspectors under the New Locomotive Inspection Laws.

The President has nominated, and Congress has confirmed, the following inspectors under the new locomotive inspection law: John F. Ensign, of Colorado, chief inspector; Frank McManamy, of Oregon, assistant chief inspector; G. P. Robinson, of New York, assistant chief inspector. These were appointed in accordance with the recent act for the inspection of locomotives, as approved Feb. 17, 1911. The text of this act was published on page 57 of our February, 1911, issue.

It is reported in the daily press that the New Haven road is planning to try oil-burning locomotives on a more extensive scale than has been attempted by any other railroad in the East. One locomotive has been transformed and the directors of the road will consider at their next meeting the project of converting twenty-two more locomotives. The road has been quietly running an oil-burning locomotive daily from Boston to Provincetown, Cape Cod. The experiments show a saving of $12 a day and a speed fully as great as that of coal-burning engines.

LOCOMOTIVE BUILDING IN EUROPE.

BY CAPTAIN GODFREY L. CARDEN, U. S. R. C. S.*

The past ten years have witnessed signal advances in locomotive building in Europe. This is especially true in Germany, Sweden, Belgium, France, Italy, Austria-Hungary and Russia. There was a time when American locomotives were necessary to the continental market; that time has passed. To-day Europe buys from us when her own shops are unable to meet the demands. In the course of two years' inspection work abroad the writer has visited many locomotive building plants. Practice, it was found, differed in different countries, but without exception the standards maintained are very high. These standards are generally indicated by State railways' authorities, which, in turn, means government plans and government inspection.

The question of whether American locomotive works can successfully compete in Europe to-day rests largely on our ability to construct European designed locomotives at a profit in American shops. On all orders emanating from Europe the foreign railway authorities may be depended on to insist on their own designs and to supplement the designs with specifications of an exacting character.

The greater part of the machine work on European locomotives can be handled by American tools. At the same time there are a number of special tools in service abroad which possess merit. The latter machines are of foreign origin and appear to have been built especially for the locomotive trade.

BORSIG WORKS, GERMANY.

The Borsig Works, at Tegel, on the outskirts of Berlin, employs about 5,300 men, and is one of the best all-round machinery works in Germany. Borsig is turning out 300 locomotives per year; the greatest number built in any one year was approximately 350. It is doubtful if any other works except those at Cassel, Germany, are exceeding this output. Few of the European locomotive works find it possible to devote their entire attention to locomotive building; in other words, to specialize. The Borsig shops, for example, are engaged in building hydraulic presses, steam engines, ice machines, boilers, compressors and locomotives, and yet the tendency at Borsig's is to specialize, for not long ago it dropped the building of gas engines. However, there was no work in hand more important than the locomotive orders. The Borsig shops are building for Russia, Sweden, Chile, Argentina and the far East. For Argentina, American type locomotives are furnished. By that, I mean the general type of the locomotive is American.

Practically all the locomotives built at Borsig's are of the plate-frame type of construction. These plates are cut out by oxygen-gas tools, the work being done quickly and in a most economical manner. The oxygen-gas tools are obtained in Berlin. At the Breslau shops in Germany hydraulic presses stamp out the plates. The general practice, however, in the German shops is to punch out the plate frames and to finish off with special types of milling machines. Chemnitz and Offenbach machine tool makers are offering special lines of milling machines for this plate frame work. The opinion was expressed by a director of one of the foreign locomotive shops that there did not appear to be available a good American line of heavy vertical millers.

At the Borsig shops and elsewhere in Germany copper fireboxes and copper stay-bolts are the rule. These are specified by the Prussian State Railways' authorities.

Building French Locomotives at Borsig's.—At the time of writer's visit, Borsig was building French locomotives for 1 mark 10 pfennigs (26.2 cents) per kilo (2.2 pounds). Borsig officials declared that they were losing money at this rate. At the same time they were advised that an order for French locomotives had been taken by the American Locomotive Works at a rate which amounted to 85 pfennigs (20.2 cents) per kilo. It is since understood that the American Locomotive Works was only inconvenienced in respect to receiving essential elements from abroad which the designs specified should be incorporated in the locomotives.

Wages.—At the Borsig works, good tool men are expected to make at least 85 pfennigs (20.2 cents) per hour. Two workmen picked out at random were questioned by the shop manager for my benefit as to wages they were earning. One man received five marks ($1.19) per day on an eight hour basis, while the second said he was making about seven marks ($1.66) per day. The manager declared that the first man was not earning as much as the shop permitted. In other words, it is possible to earn seven marks per day if a man puts forth the effort.

Fireless Locomotives.—Fireless locomotives form an important part of the construction work at Borsig. So far as the writer knows, this type of engine is practically unknown in America. The fireless locomotives use superheated water and when leaving a charging station the pressure is 170 pounds. At the Borsig Works one of these fireless locomotives was in almost constant service throughout the day and I was informed that it was only necessary to connect up twice during the working hours with the boilers of the power plant—in the morning before work commenced and again during the noon hour. Conection was made with the plant to the front end of the locomotive through flexible pipe and about fifteen minutes sufficed to charge. These are in much demand in Scandinavian logging camps and are especially recommended where insurance might be prejudiced through the use of electric or fuel-fired engines. It was found in practice that even at pressures of one or two atmospheres considerable work could be accomplished and at a pressure of one-quarter to one-half an atmosphere the engine was still able to go to the filling tank. The Borsig engine which I had occasion to examine while in service seldom required to be filled oftener than once in four hours.

HANOVER LOCOMOTIVE WORKS.

The Hanover Locomotive shops employ about 3,300 men. These works have built more than 5,000 locomotives, and their latest type of high-speed passenger engine is specially well spoken of. It is known as the Atlantic type and resembles closely the American locomotive of the same class. In this type one observes the bar-frame construction, but, generally speaking, the plate frame form is adhered to. The Hanover shops apparently build as many bar frame engines as they do plate frame, while Borsig's build more plate than bar. Borsig, however, supplies bar frames when his customers prefer them, but says that he has not found it necessary to provide special tools for the purpose of making bar-frames, which would indicate that plate-frames can be made with the same tool equipment as bar-frames.

The Hanover shops are sending about 30 percent of their locomotive output abroad. To the year 1907, when locomotive No. 4800 was completed, 22 percent of this company's output was for foreign countries.

Lentz Poppet-Valve Gear.—For all high-speed engines for the Prussian State Railways the poppet valve gear of the Lentz type* is used. I was assured by the Hanover Works that there was a saving of not less than 20 to 25 percent when a comparison is made between the poppet valve gear using

* "Railway Age Gazette.

* The Lentz poppet valve gear has four valves; two on the inside for admission, and two on the outside for exhaust. They are actuated by a cam rod and are weighted by springs. They have given good service at high speeds, working safely and exactly at 300 revolutions per minute.

superheated steam and slide-valves operating with saturated steam. One high-speed locomotive of the Prussian State Railway had already run 60,000 miles using this type of valve gear. Twenty-three engines of the International Works at Vienna had this type of gear installed on all the high-pressure cylinders, and in one year's time the entire cost of the change was saved in coal consumption. The management of the power plant of the Leipsic Street Car Railways not long ago, it was stated, converted four steam engines and equipped five boilers with superheaters; as a result of the utilization of the poppet valve gear with superheated steam 48,356 marks (about $12,000) was saved per year.

The Hanover shops are using the Pielock type of superheater with the Lentz poppet valve gear. It was stated that the introduction of this type of poppet valve was brought about largely because of the obstacles arising from using superheated steam. The Prussian State Railways are not using superheaters with compound arrangements. This is, however, at variance with the views of the engineers at the Hanover shops. From what I can learn, the success of the poppet valve gear has proved so great from an economical standpoint that it is now quite common for locomotives in service to be altered and provided both with superheaters and poppet valve gears. The change necessitates a new cylinder, as well as valve chest, since the poppet valve box and cylinder are cast in one piece.

Wages.—At the Hanover shops expert men at the machine tools receive on an average 70 pfennigs (16.6 cents) per hour, which is about 15 pfennigs (3½ cents) less than the men at Borsig's are paid. The Hanover shops own about 150 houses, which are rented at an average of 15 marks ($3.57) per month. The income is sufficient to keep up repairs, and no attempt is made to derive a profit.

OTHER GERMAN LOCOMOTIVE WORKS.

The Hohenzollern A. G. Locomotive Works are located near Düsseldorf and employ about 1,400 men. The plant is turning out about 140 locomotives a year. These shops employ plate-frame construction almost exclusively, and all plates are cut out by punching machines. Pielock and Schmidt superheaters are used, but I could not learn of any special valve gear being employed. This firm is building for Scandinavian and Indian railways.

Still other locomotive shops in Germany are those at Cassel, Breslau, Altoona and Munich. The Schwartzkopff shops are not far from Berlin and the general practice there resembles closely that at Borsig's.

Wages.—At the Hohenzollern Works expert tool men receive about 70 pfennigs (16.6 cents) per hour. The rate paid in the Berlin territory is higher than elsewhere in Germany. The lowest rate paid is in the Chemnitz district, where expert machine men seldom receive over 50 pfennigs (11.9 cents) per hour. The rates in the Rhine territory and in the Hanover district are about equal, namely, 70 pfennigs (16.6 cents) per hour for good machine tool men.

LOCOMOTIVE DEVELOPMENT IN GERMANY.

During the past five years locomotive development in Germany has tended toward the higher speeds and greater economy. The general increase in the size and power of locomotives is due to continental traffice conditions. Superheaters appear to be coming more and more into use. On the Prussian State Railways the authorities have limited the maximum steam pressures to 170 pounds. In Saxony and Bavaria, four-cylinder compound locomotives are much in vogue, and some of the lines have been experimenting with this system in connection with superheaters. Balanced compounds are much liked abroad, due to ability to construct a stronger engine frame.

There has been little change in the matter of finish and form on the continent for a number of years, and the opinion is general that the standards exacted are onerous. The German locomotive builders found the recent French contracts especially hard. Many of the parts were required to be case-hardened and the designs called for slide-valves of a particular kind of bronze. The standard metal which could be supplied readily and easily, and which the experience of years had indicated was excellent, would not suffice. It was almost a universal comment in Germany that the French, when they prepared their designs, had plenty of money to spend. Where a standard German design would require only one slide bar, the French, it was pointed out, had managed to incorporate four slide bars. I asked one German director if his firm expected to make much money on these contracts. His reply was: "We shall at least gain considerable experience and shall know what to expect when we take a second contract." There is no question that the finish and form demanded abroad are expensive, but the trade apparently demands it.

It was my practice whenever opportunity presented to chat with the engineers of the high-speed locomotives of the Prussian railways. These men are, for the most part, clever and intelligent, and exhibit a certain self-reliance which may be expected of men in their calling. They invariably praised the poppet valve gear and declared that it gave no trouble and where used with superheated steam was a great saver of coal. The Prussian engineers regard briquettes as poor fuel for high-speed locomotives, declaring that they pack too hard on the fires and do not permit of the spread which can be obtained with loose coal. The Metcalf feed-water heater seems to be in general service throughout Germany. The Hanover shops, however, are developing a new type of feed-water heater, from which much is expected.

In counter-distinction to the German practice, the Belgians seem to favor non-compound engines with superheaters, and this form of engine is common in the express locomotive service. For freight engines the Belgians are utilizing the two-cylinder non-compound engines with superheaters.

Germany is exporting approximately 400 locomotives per year. In 1907, for example, Germany exported 395 locomotives. This number was absorbed by Belgium, France, Italy, Russia-in-Europe, Turkey-in-Asia, Southwest Africa, Prussia, Egypt, India, East Indies, Argentina and Chile. For 1907, France took 555,500 pounds; Italy, 504,460 pounds; Egypt, 594,600 pounds; Chile, 449,460 pounds, and Argentina, 446,160 pounds. Egypt took more than any other country, followed in order by France, Italy, Chile, Argentina and Russia-in-Europe.

FRANCE.

At Le Creusôt in France, Schneider & Company are building some of the best engines of French design. This firm is to France what Krupp is to Germany, that is to say, Le Creusôt is the great ordnance establishment of France. In addition to building guns, these works also construct both marine and stationary engines, railway equipment and locomotives. The shops at Belfort will turn out more locomotives in a year doubtless than Le Creusôt, but for high grade work there is nothing finer in France than is produced by Schneider & Company.

SWITZERLAND.

The Swiss Locomotive Works at Winterthur employ about 1,800 men. This is one of the best locomotive shops in Europe. Its engines are sent to all parts of the world, and it is doubtful if there is a higher finish to be found on any European locomotive. This firm is about to undertake bar frame construction, and at the time of my visit the first set of bar frames had just been received. These frames were of forged steel and were received from Germany. Among the engineers in charge of departments was one gentleman who saw service in the Baldwin Locomotive Works for several months and whose observations on the general locomotive situation were among the best I have heard in Europe. In fact, those engineers whom I met at the Swiss Locomotive Works impressed me as being of very high order. A large number of American machine tools were in use in the Winterthur shops. I also observed a number of the heavier types of English tools. English tools ten years ago formed the major complement of most of the continental locomotive works, but in recent years few English tools are going into these shops. When new tools are obtained, they are almost invariably of German or American origin. There are a few English tools which are offering sharp competition to American machines. I refer particularly to Herbert, of Coventry; Smith & Coventry, of Manchester; Darling & Sellers, of Keighley; Kendall & Gent, of Manchester, and Richards, of Broadheath.

The three-cylinder compound engine has not been tried to any great extent on the continent, although the Jura-Simplon Railway, which is now the Swiss Federal Railway, has several mogul engines of the three-cylinder compound type at work. This same railway has mogul engines of the four-cylinder compound type. The special three-cylinder compound type of engine which was in use in the United Kingdom for a number of years has now entirely disappeared. So far as could be learned, superheaters have not been applied abroad to Mallet locomotives.

ITALY.

At the Breda Locomotive Works in Milan the force employed numbers approximately 4500; of this number about 2000 are engaged in the locomotive department in Cittá. Breda is turning out a new high-speed locomotive, designed for a speed of 120 kilometers (74.5 miles) per hour. It is a beautiful four-cylinder machine working compound and operating four cranks. The compounding is independent for each side. Superheat is not used. About 40 of these engines have been turned out for the Italian State Railways. Krupp and Bochum furnish practically all the wheels and axles used. As elsewhere in Europe, copper fireboxes and copper stay-bolts are the rule. Here, as in German shops, one is impressed with the great amount of unnecessary work. In the finishing shops no less than 12 applications of paint and varnish follow filling. All this filling, varnishing and painting, that is to say, the exact number of applications, are fully prescribed by the State engineers in the specifications.

Breda bores all six cylinders on the new passenger locomotives simultaneously. He makes his own boring tools and turns out a gang of horizontal borers designed, as above stated, to take the two high-pressure and two low-pressure cylinders and piston-valve chamber simultaneously. All the plate-frames at Breda's are worked with triple slotting machines. I observed no oxygen-gas cutters or hydraulic presses in use for stamping out frame parts. I saw but very few German tools in these works. The foundry is turning out especially fine cylinder combinations, readily made and in one casting. Only plate frame form of construction is used and the steel comes both from Germany and Italy. The Breda firm is representative of modern and progressive Italy. Workmen receive about 40 centimes (7¾ cents) per hour on an average throughout the year, ten hours comprising the working day. The men are working fast, and there is a care and attention bestowed on the locomotive work in keeping, almost, with some of the best work I have seen in automobile shops. No superheaters are used. Breda builds almost entirely for Italy, as the firm finds it difficult to compete abroad with the Germans. A few locomotives, however, have been built for Denmark and Roumania. The new engines for the Italian State Railways are using the highest steam pressures on the continent, 235 pounds.

A NEW HIGH-SPEED BOILER.

BY H. C. HODSON.

A new departure in commercial boiler practice, which may interest readers and calls for serious consideration of both boiler makers and users, is detailed below. Theorists, both English and foreign, can scarcely be said to have been very conspicuous in the past in giving prominence to their ideas; they have generally confined themselves to criticising manufacturers and practical engineers for rule-of-thumb working and their unscientific attitude to theory; an attempt has now been made to supplement boilers of the existing types by one based on radically new ideas. It may be described as the Hurricane or Nicholson boiler. The essential features of the theory on which the new type is based are, briefly, as follows: As far back as 1874, Prof. Osborne Reynolds, one of the professors of Owens College, now the Manchester Victoria University, described in an important article his theory that the quantity of heat absorbed by a boiler from the hot gases which passed through the internal flues were practically in direct proportion to the weight of hot gases which passed in a given time, or, in other words, to the velocity of the gases in the flues. It should be stated, by-the-bye, that an increase in the gas velocity does not affect the efficiency of the boiler to any appreciable degree, and no lengthening of the flues are required. More recently, in 1897, the soundness of this theory was verified, so far as currents of water are concerned, by Mr. Stanton, of the same university, and some years ago the theory was discussed and approved by Prof. Perry, who suggested a boiler designed with small bore tubes combined with a high-speed gas flow. Now Prof. Nicholson, of Manchester, by means of noteworthy experiments with a modified Cornish (or one flue) boiler has made the theory of practical importance to the manufacturers and users of boilers. These experiments and the theories on which they are based have been tested by practical engineers and verified, and boilers constructed in accordance with the new ideas are to be placed in the market.

Three essential questions of importance suggest themselves in making a new departure of such magnitude: First, whether the principle is really in practice what it claims to be; secondly, whether the theory can in fact be embodied in a working and convenient form, and, thirdly, whether the new theory will result in increased economy or a corresponding commercial gain.

These points may be answered without hesitation. The available results so far obtained amount to a reasonable proof as to the reliability of the theory that the rate of heat transmission in boilers is substantially proportional to the speed of the gas flow; the second and third points cannot be definitely affirmed until a number of high-speed boilers have been practically worked for a number of years and the results obtained have been critically examined and compared with those of boilers now in use of the ordinary types. The point relating to commercial advantage includes a saving in bulk; increased economy is also claimed. The high-speed principle, it should be pointed out, does not increase the amount of heat in coal which can be transferred to the water and steam; on the other hand, it undoubtedly results in a very decided low final gas temperature, and consequently in a very considerable evaporative efficiency. The ordinary chimney may be dispensed with, as fans are substituted and required. It is true that a somewhat similar high evaporative efficiency could be obtained from boilers and economizers of ordinary types with very largely increased heating surfaces and by substituting fans for the chimney now used to create the draft required. It follows that for practical purposes the new high-speed boiler type should yield an increased evaporative efficiency. Critics of the new type have expressed themselves as follows to place both views before readers:

"The essential point is the net available efficiency; in high-speed boilers it is probably very considerably less than the evaporative efficiency. To take a typical case from recent trials of Prof. Nicholson's one-flue or Cornish boiler the evaporative efficiency was 76 percent, while the net efficiency, after deducting steam for the fan, was 66.8. It should be noted, however, that there was a loss of heat due to radiation and unaccounted for equal to 15 percent. It is suggested that a portion of this loss may have been due to coal dust being swept unburnt through the flues owing to the undesirably high rate of combustion; namely, 38 pounds per square foot of grate per hour. But even after this allowance has been made the net efficiency would by no means create a record." As described below, the reduction in weight and bulk of the new type of boiler, if fitted in a large steamer, instead of the ordinary marine boilers, would be such that the cargo space would be increased by several thousand tons. Such a very considerable saving would be an advantage of very considerable commercial importance. In extensive electric power stations the same point may also be of consideration, but in the case of textile factories and ordinary machine shops it will not be one.

The turbo-fan and the circulating pump, essential features of the new boilers, are not in themselves very complicated mechanisms to maintain in working condition, but when the efficiency of an entire plant depends on them they become all important. In a small plant of only two or three boilers they become disproportionately essential, and they would require to be duplicated at a very considerable outlay to prevent a break-down due to defects in the fans or pumps. It may be said, therefore, that for many relatively small plants the new high-speed boilers do not, in the opinion of some experts, appear to provide any great commercial advantage over existing boiler types. But in the case of a large range of boilers, with ample skilled supervision, the pumps and fans are of proportionately less importance, and the new boiler type undoubtedly possesses unmistakable advantages, more especially in those cases where the load has sustained peaks. With the existing boilers these sustained peaks are generally met with the aid of banked boilers in reserve; but high-speed boilers with ample grate area could be worked normally at reduced output as a medium-speed boiler and when required as a high-speed boiler. No doubt existing boilers can be forced, but the furnaces are not designed for the additional strain, and the necesary mechanical flexibility is wanting, which may result in overheating and priming.

The construction of the new boilers will have to combine rigidity and flexibility; difficulties of design will be equally great in the high-speed boilers as in the ordinary type. Rigidity will be necessary in the tube plates, where straight tubes enter, failing which the so-called "breathing" of the plates will very probably result in the tube joint leaking. As a rule, tubes of moderate section should enter the tube plate squarely; should they be straight and grouped in several rows the tube plates should be flat; but flat tube plates are not easily kept tight when boilers are forced, should they, on the other hand, be curved there is a difficulty of cleaning and inspecting. It has yet to be ascertained from practical experience whether with high gas and water speeds the flues and water spaces can be kept clear of deposits; the maintenance of open passages for both gas and water are of the utmost importance, as there can be no doubt that even a small amount of deposit in small bore tubes would be a serious consideration. Even should prolonged working show that with high speeds deposits need not be feared, special arrangements will have to be devised to make deposits impossible when the boilers are under banked fires or subject to light loads. The opinion has been expressed that high-speed boilers could be more suitably constructed with tubes of moderate size and with lower water speeds combined with high gas speeds. It is probable in that case that the practical difficulties which arise would be diminished, but the saving in weight and bulk would also be reduced, and it has yet to be ascertained which of these factors would be the more important. Experts prefer boilers of the watertube type for electricity stations, under the impression that those boilers can be forced, an opinion not always justified. A form of boiler, therefore, specially designed for high-speed conditions, combined with the simplicity and reliability of the Lancashire boiler, may have an important future and create a market of its own.

As already indicated, the principle of the invention depends upon the physical fact that the rate of heat transference from hot gas to water in a boiler increases in almost direct proportion to the speed of the gas through the flues. In boilers now generally in use that speed averages about 25 feet per second, whilst the heat transmitted is sufficient to evaporate not more than about 6 pounds of steam per square foot of heating surface per hour. In the proposed new type of high-speed boilers made in accordance with the new invention, on the other hand, the gas speed is increased from 25 to 100 to 200 feet per second from four to eight times, consequently the steam generated per square foot of heating surface is increased to 20 or 40 pounds per hour. It follows that a very material reduction of the amount of the heating surface necessary to produce a given horsepower can be made, and that there is a corresponding decrease in the weight of the boilers and in the space they occupy. To give an instance: In a large mail steamer, such as those crossing the Atlantic, say well over 5,000 tons, or about 30 percent of the boiler-hold displacement can be saved and rendered available for cargo space by the replacement of the present boilers by others of the new type. In a man-of-war such as the Chilian battleship *Libertad,* which was fitted with twelve boilers of the so-called "express' type, each of 1,200 horsepower, so much more boiler power could be installed in the stokehold by the new system that a 10 percent increase of speed could be obtained.

The high gas speed, the essential basis of the new system, is produced by a fan driven by a steam turbine, which, by creating a high vacuum in the uptake, induces the strong draft required. The turbine also drives the feed and circulating pumps, and as its speed is very easily changed, and with the changed speed the boiler power may be varied from nothing to 50 percent overload, almost instantaneously, all the advantages accompanying artificial draft, in regard to meeting sudden demands for steam without the disadvantages of either a closed stoke-hold or a closed ashpit are obtained with this new system. The steam required to drive the turbine is more than made good by the high-speed counter-current economizer, which is the second feature of the invention. In the last-mentioned apparatus, by causing the gases and the feed-water to traverse flues or small bore pipes in opposite directions the temperature of the water gases is lowered to about 200 degrees F. when the feed enters at 60 degrees F.

The additional amount of heat thereby extracted from the products of combustion over and above that now obtainable is sufficient not only to provide all the steam required for the fans but also to leave a balance considerably in favor of the economy of the new type of boiler. The invention covers the application of the principle to both smoketube and water-tube boilers. For application to central station and marine work, however, the boiler is of the watertube type. The increasing popularity of this type is evidenced by the large sales and profit secured by the leading watertube companies during the last ten years. The advantages claimed for the type of boiler may be summarized as follows: (*a*) A considerable saving of weight of and space occupied by the boilers; (*b*) a reduced initial capital outlay; (*c*) increased economy; (*d*) great adaptability for working with suddenly varying loads; (*e*) a more rapid attainment of full steam pressure from cold than any system now in use. Owing to the novel construction of the new boiler type, with their very small bore watertubes and the correspondingly small weight of water to be heated up, steam can be got up in from ten to fifteen minutes from dead-cold water, provided, of course, either stand-by steam or electric current is available to run the turbine or motor which drives the fan. This is a specially valuable feature in central power stations and in men-of-war. (*f*) The new boilers are self-scouring, both on the water and the gas side, special cleaning is not therefore necesary; (*g*) both safety and suitability under the highest pressures; (*h*) there is no straining of shells due to unequal heating—thorough circulation; (*i*) greater certainty of anticipated output on account of better application of the theory of heat transmission; (*k*) effectual prevention of the corrosion which commonly accompanies low waste gas temperatures in economizers. The flue surfaces are covered with a thin, hard coating of sooty coal dust, which absolutely prevents contact between the corroding gases and the metal surfaces, while at the same time, owing to the active heat-transferring power of the high velocity, the hot gases can transmit their heat to the water at much greater rates than in ordinary boilers, even when their surface is clean; this latter is a most important feature of the new boilers.

This new type of boiler is peculiarily well adapted for the burning of oil or other liquid fuel; the inventor believes that there is a great future before it in this direction. The strong draft available and the absence of a closed stokehold or ash-pit render it possible to use a sprayer of exceptional simplicity. No steam need be wasted in inducing a current of air to mix with the sprayed fuel, as the high vacuum produced by the fan is always available for this purpose. It is important to note that no smoke is produced by these boilers even when burning small coal of the cheapest grade. This is due to the zone of high temperature through which the products of combustion are made to pass. A brick-lined combustion chamber is interposed between the fire-bridge and the first nest of evaporating tubes. Several severe tests have been made; the following may be mentioned: A sixty days' steaming of an experimental boiler in large English works has conclusively proved the self-scouring properties of the high-speed gas flow. A six days' test was made without cleaning the boiler inside or out after fifty-one days' running.

Arising out of the high gas speeds and the forced water circulation the grate of the boiler is followed by a length of firebrick-lined flue, in which the combustion is completed. It may be noticed that the furnace proper is not brick-lined, so that as much radiant heat as possible may be transmitted through the furnace plates to the water. Following the combustion chamber, the last length of the internal flue is all but filled by a firebrick plug; through the narrow space between which and the boiler flue plates the gases are drawn by a fan revolving at a very high velocity. After leaving the internal flue the gases pass through, first, an evaporator and then an economizer. These two are similar in construction, and are arranged for high-speed countercurrent gas and water flows, the gases being finally discharged into the chimney by a fan. A pump forces the feed-water through the economizer and the evaporator, and in passing through the evaporator it is joined by water taken from the main boiler and circulated by way of the evaporator back into the boiler again. It is essential to note that the ratio of surface to the cross-sectional area of the high-speed portions of the boiler must not be less than 750 to 1; as by this means it is expected to reduce the final temperature of the gases to a very low figure, and in that way to increase the efficiency of the boiler.

THE ARRANGEMENT OF LOCOMOTIVE REPAIR SHOPS.

Some general opinions concerning the layout of locomotive repair shops were given at a meeting of the New York Railroad Club in January by Mr. H. H. Maxfield, master mechanic of the Pennsylvania Railroad at Trenton, N. J. At the outset he expressed a preference for the longitudinal as compared with the cross type of shop, because of its greater flexibility, more economical use of track space and greater output from a given amount of track space. In his paper it was assumed that a longitudinal shop was decided upon.

The machine shop should house, not necessarily under one head, besides the machine department proper, the vise, air brake and brass, sheet iron, tin and copper and pipe departments. All are intimately connected with the erecting department in their work.

The blacksmith department is principally a feeder of the machine department. It, therefore, should be close to it. It should also be close to the power house, for it is a heavy consumer of steam, and practically the only consumer of steam in an electrically-driven shop. It should, consequently, be located between the machine department and the power house.

As there is a great deal of boiler and tube work done in the erecting department, the boiler department, if for no other reason than ease of supervision, should be close to the erecting department. It should also be so located as to avoid unnecessary time and labor in transferring boilers and tubes between it and the erecting department. The most convenient location would be as a continuation of the erecting shop, but should not be under the same roof on account of the incessant din The middle track of the erecting shop should be continued through the boiler shop, in order to afford an easy method of handling boilers and tubes between these departments. A large part of the work of the boiler department consists of repairs to tender cisterns, tender frames and tender truck bolsters. It therefore would seem reasonable that the tender and tender truck repairs should be handled in the same building.

The woodworking end of a purely locomotive repair shop is one of diminishing importance, but there is still enough left to warrant a small mill under the same roof and jurisdiction as the carpenter or cab department. This department would undoubtedly be under the supervision of the foreman of tender repairs. A considerable proportion of the work of this department is done in the erecting shop. There is also considerable traffic between it and the smith shop. It should therefore be located as conveniently as possible with reference to these other departments, which can best be accomplished by placing it alongside the boiler shop, opposite the smith shop.

The paint department is another which in the rush of repairing locomotives is not given much consideration. Practically all locomotive painting is done in the erecting shop, and a large proportion of the tender painting, other than varnishing, is done in the boiler shop. It does a good deal of work in connection with the wood department, especially as regards cabs, pilots and miscellaneous work. It should therefore be adjacent to the wood department, and reasonably near the boiler and erecting departments. This can best be accomplished by housing the paint and wood departments under one roof, and placing a fire wall between them.

The power house has already been located in connection with the smith shop.

The stores department should be convenient to every other department, but as this is practically impossible it will have to be located with reference to the largest consumers of material stored in it, which are the erecting, machine, vise, air brake and brass, sheet iron and tin and copper departments. It will be best located by placing it alongside the erecting and machine shop building on the opposite side from the smith shop. The casting sheds, boiler tube racks, iron and pipe racks, boiler steel yard, lumber yard, etc., all of which are under the jurisdiction of the storekeeper, will be located so as to be convenient to the points of consumption. The paint, oil and waste storehouse will naturally be located near the paint shop.

The location of the scrap bins will depend to a great extent upon the size and shape of the property available. At its best it is an unsightly proposition, and for this reason the scrap bins should be located outside the area bounded by the main buildings. They should be reasonably accessible and should be reached by trucks and cars from either end of the shop yard.

In the location of the office building, if a separate one is provided, the main essential is that it should be reasonably accessible to all the shop departments, and as convenient as possible to the main entrance of the plant, so that visitors and applicants for work can, if desired, be kept out of the plant proper. It should also be located so that the private office commands a fair view of the plant in general. These conditions can perhaps best be met by placing it in line with the storehouse and about 25 feet in advance of the line formed by the ends of the boiler, wood and paint and oil house buildings.

After the repairs to a locomotive have been completed, it is necessary to fire it up and thoroughly try it out in order to develop minor defects. If an engine house is available, this work is generally taken care of at that place. In the case of the central shop, however, it is possible that the nearest engine house is too remote to allow this being done, and, furthermore, it may be under different jurisdiction. Assuming the above to be the case it becomes necessary to provide for this after-trial work at the shop proper.

To bring the locomotive back into the erecting shop involves a serious delay to the legitimate work of that department, it being necessary to hold track space in reserve, which prevents bringing other locomotives into the shop, which not only reduces the efficiency of the department but reduces the earning capacity of the men. Furthermore, the escaping smoke and gases are very objectionable. The only satisfactory way to handle this after-trial work is to provide a separate building for this purpose, making it an auxiliary of the erecting shop, and under the supervision of that department. This auxiliary or after-trial shop should be reasonably close to the erecting shop, and yet far enough away to prevent the escaping smoke and gases from flooding the other buildings. It should be adjacent to the track upon which engines are tried, and also adjacent to the track over which incoming engines pass. Alongside of this building should be a coal platform and an ash pit.

Ample locker and toilet facilities should be provided for all departments. These facilities should be provided in or attached to the various buildings, so as to obviate the necessity of employees exposing themselves going to and from same.

The space formed by the side of the erecting and machine shop and the boiler shop on the one hand, and the storehouse and office building on the other, should be served by a traveling crane for the purpose of handling material. This space should be not less than 90 feet wide to allow for the necessary tracks, platforms, etc. Between the erecting and machine shop and smith shop buildings there should be a space of 80 feet to allow of tracks, storage of material, etc. The same distance should be allowed between the boiler shop and wood and paint shop. At least 70 feet will be required between the wood and paint shop and the oil house.

The width of the various buildings should be about as follows:

1. Erecting shop, 90 feet center to center of columns. This allows three tracks spaced 30 feet center to center, upon all of which locomtives can be repaired, and, in addition, locomotives can be carried between these tracks without danger of interference.

2. Machine shop bays, 60 feet center to center of columns. This allows ample aisle room and a sufficient crane runway space between the machines.

3. Boiler and tank shop building. This, being in a sense a continuation of the erecting and machine shop building, will be of the same cross section.

4. Smith shop, 90 feet center to center of columns.

5. Paint and wood shop building. This building should be 180 feet deep, which will allow ample space for six tenders on each track.

6. After-trial shop. This shop will require a maximum space 75 feet in width, while the coal platform and ash pit, etc., will require practically the same.

7. Storehouse, 60 feet center to center of columns. This will allow adequate bin and aisle space.

8. Office building. This building should have a width of 50 feet.

9. Scrap bins. These will require a space of 90 feet in width, making due allowance for necessary tracks, platforms, etc.

The machine department should be sub-divided into at least two parts, thus separating the heavy machinery, which should have full overhead crane service, and the light machinery, which requires only partial crane service, and which may be advantageously laid out, partially at least, in groups of machines driven from countershafts, they, in turn, being driven by suitable motors. In these machine bays can also be located the other departments of the erecting shop.

The question arises as to whether the erecting bay should be in the center and the machine bays on either side, or whether the erecting bay should be on one side and the two machine bays follow in order. In the latter case there is the advantage of having the entire machine department under, as it were, one roof, thus making the supervision somewhat simpler. The advantages of the other scheme are:

First, symmetrical design of building; second, division of movement of material removed from locomotives, thus avoiding congestion in passageways; third, more advantageous storage of rough material outside of buildings in order that heavy material will not have to pass through the light machine department, and *vice versa*. There is no doubt but what the weight of evidence is in favor of the erecting bay being in the middle with the machine bays on either side. Experience with such an arrangement confirms this.

It was stated above that the light machine department required only partial crane service. This is not only true, but it is advantageous, for it allows a gallery being put in this bay, running the full length of the building, the width of the gallery being somewhat less than one-half the width of the bay (in the present case say 25 feet). This allows grouping under the gallery the machines working on material light enough to be put in and taken out of the machines by hand and driving them from the countershafts attached to the gallery. It also provides floor space in the gallery for the air brake and brass department, the tool manufacturing department, the tin manufacturing department and the department for repairs to electrical equipment.

That portion of this bay not covered by the gallery should be served by a traveling crane. On the ground floor of this bay, in addition to machinery, will be located the vise, pipe and sheet iron and copper departments.

In the heavy machine bay will be found sufficient floor space for the repairs of engine trucks, thus relieving the erecting bay to this extent.

The character of the work to be done in the boiler shop building lends itself very nicely to the same general design as

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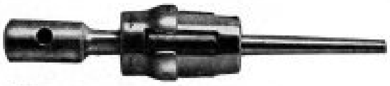
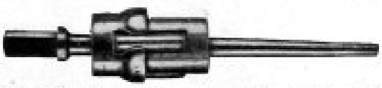


"Boss" Roller Expander (Hand Use)



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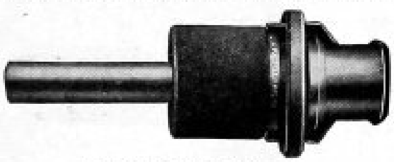

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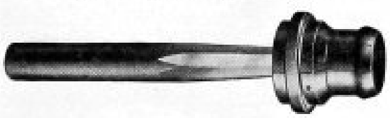

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the erecting and machine shop. The center bay will be devoted to the repairs of boilers, tender frames and cisterns. In one of the side bays will be located the strictly boiler working machinery, flanging fires, laying off tables, etc., while in the other bay will be located the tender truck, boiler tube and ash pan departments. A gallery is not necessary.

The after-trial shop should be rectangular in shape, and should have three tracks running through it, each long enough to accommodate two engines with their tenders. This building should be equipped with wheel pits and an overhead traveling crane.

The storehouse should consist of two stories and basement, should have at least one fireproof vault for the storage of combustible material, one or more freight elevators, and by all means should be divided into at least two parts by a fire wall. —*Engineering Record*.

Preventing Scale in Boilers by Aid of Aluminum Plates.

A paper upon the above subject, which created considerable interest, was read at the last meeting of the New York Section of the Society of Chemical Industry by Thomas R. Duggan, F. I. C., F. C. S., of 20 Beaver street, New York, and was listened to by some 300 chemists and engineers.

After reviewing the necessity of a pure water for boilers and technical purposes the author went on to describe the method by which some most interesting results have been obtained in practice, and stated:

"After a long period of experimenting and after many trials, an inventor, a German scientist, one Herr Brandes, discovered an apparatus—'The Luminator'—which gave to ordinary water, after simply flowing over it, certain remarkable properties. For instance, when used in steam boilers, much less scale was deposited, old scale was softened and detached from the plates, especially the flues, steam was dryer, and less coal was required in steam raising, and generally the salts were found as a powder in the bottom of the boiler, whereas otherwise they would have formed hard scale.

"The treatment consists simply of allowing water to run down an aluminum plate of special dimensions, with corrugations of a particular size, according to the character of the water to be treated, as per apparatus illustrated.

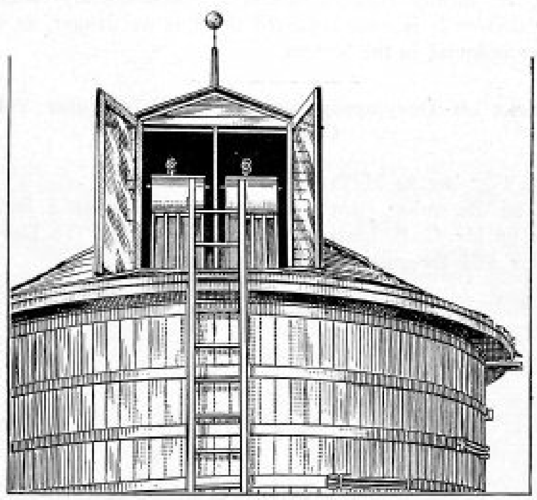
"No chemicals are required; it is only necessary to brush well the corrugations to keep them clean and free from deposit. No scale chipping hammers are required where this apparatus is used, nor drilling machines required to drill out tubes of watertube boilers or economizers. In most cases where this method has been used the smooth and enamel-like appearance of the flue plates and surfaces has been remarked after brushing away the powder formed.

"When storage tanks and mains are far from the boiler it is necessary that they be coated with a non-conducting composition—any bituminous varnish will do—and that water reach the boiler as soon after treatment as possible. To get the maximum effect the water must be used within seven days after its treatment; hence storage tanks should not be too large. Where water is used continuously night and day, it may be found necessary to give the apparatus about one day per week rest, as the plates under certain conditions become polarized. This only happens under very unfavorable conditions, and in most cases may be neglected altogether.

"The action of the 'Luminator' is that, by the passage of water over the metal channels at certain speeds, a current of electricity is induced, the water being negative and plates positive, ionization of the salts takes place, and they do not take a crystalline form but become amorphous; at the same time a new and particular action goes on; that is, aluminum is by friction and electrical action abraded from the surface as a colloid, which after a period undergoes change in the water. This action was investigated by Professor Donnan at the Liverpool University, who found that aluminum hydroxide was not present in water treated by the apparatus to any extent, but on turning to the ultra-microscope he was enabled to see that the aluminum was in the colloidal form mixed with hydroxide and remained so for several days.

"It has been found that the best results are obtained when the 'Luminator' is facing either north or south and exposed to direct light, and that if closed in entirely from light and air the apparatus becomes almost inoperative. From observations made by the inventor, who had met with some failures of the apparatus when placed facing certain directions, he assumed that the earth's magnetism had some effect; therefore it occurred to Professor Donnan that if the plane of the aluminum sheet was set so that the earth's magnetic field cut across it, there would be produced, when the water flowed down the apparatus, a small electromotive force at right angles to the longitudinal grooves of the aluminum sheet, with the result that a slight electrolysis would occur, precipitating aluminum hydroxide in the solution.

"Professor Donnan is of the opinion that the local electricity, the existence of which his experiments have demonstrated, together with a certain amount of chemical action, due to the



NEW TREATMENT FOR BOILER SCALE.

heterogeneous nature of the metal, is sufficient to explain the surprising and hitherto unknown disintegration of the aluminum.

"The action within a steam generator is somewhat obscure, but in all probability the colloidal aluminum will act as nuclei or active centers for the evolution of CO^2 and the crystallization of salts; also the aluminum particles will combine with the dissolved oxygen of the water, thus causing a marked de-oxygenation.

"As the corrosion of boiler plates is supposed to be essentially dependent upon the presence of free oxygen in the water, it is clear that water treated by this process will greatly diminish the corrosion of boilers, and such is found in practice to be the case. One instance might be mentioned: A boiler which was usually red with Fe_2O_3, at what could be called the steam and water line, a belt of about 12 inches wide throughout the boiler became purple-black like new plates after using water treated by this process. This action is not confined to the steam and water junction, but goes on all over the boiler until it becomes coated with a smooth adherent semi-metallic coating of magnetic oxide of iron, which undoubtedly results in preventing centers of crystallization upon the plates, transferring these centers to the aluminum colloidal metal and hydroxide, and precipitating the salts as a powder.

"The following are, briefly, the advantages of 'Luminator' water treatment:

"1. It prevents entirely the formation of hard scale adhering to plates and tubes.

"2. Its action is automatic, continuous and uniform, requiring no chemical supervision even when treating waters of variable composition.

"3. No chemicals are used, the action being purely physico-chemical.

"4. The metal of the boiler is absolutely unaffected, and the treatment is eminently suitable for locomotives of steel or copper-steel make.

"5. Corrosion and pitting are prevented.

"6. Saving in coal bills, repairs and cleaning-out costs; increased boiler efficiency and life.

"7. Free steaming and very dry steam.

"8. No precipitation, filtration or subsidence plant of any kind required.

"9. Costs much less than any other treatment."

It has been found in practice of the utmost importance that boilers should be regularly blown off, particularly when the apparatus is first installed, as the old scale comes down so rapidly that there is danger of burning the boiler under the accumulation of this scale unless quickly removed. After this scale is once removed there is no danger, as only powder is found in the bottom.

Remarks on Developing Regular and Irregular Y-Pipe Connections.

Editor The Boiler Maker:

In the December issue of The Boiler Maker I find an article by Mr. C. B. Linstrom page 365, entitled "To Develop Regular and Irregular Y-pipe Connections."

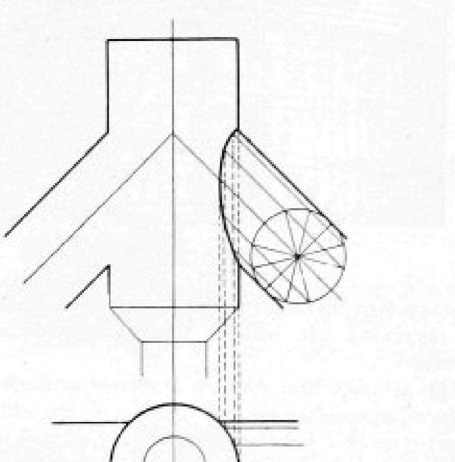


Fig. 1A.

I beg to make the following remarks in connection thereto: As the development of such piping is often met with in boiler work, how to lay it out correctly is of interest. Mr. Linstrom's constructions as shown by his figures 1 and 2 are correct, and can be universally used, but the construction as shown in his figures 3 and 4 cannot be satisfactorily used.

Referring to his Fig. 3 it will be seen that the intersections of the cylinders *A* and *B* and *B* and *D* are not correctly drawn.

In Figs. 1A and 1B, this issue, I show the intersecting line correctly drawn, as it is, of course, never a straight line but a curve, as every layer-out should know, and as Mr. Linstrom makes no allowance for this some may be misled and trouble follow. My Figs. 3 and 4 show clearly how this work should be done, which is as follows:

Divide the circle, Fig. 4, in a number of parts, this circle being equal in diameter to the cylinder *B*. Then draw lines parallel to the axes *x x*, and do likewise in Fig. 3-B.

The parallels in Fig. 4 will intersect a circle equal to *B*, and the intersecting points can be projected as in the elevation. The body *A*, Fig. 2A, is never a true cylinder, but it is an

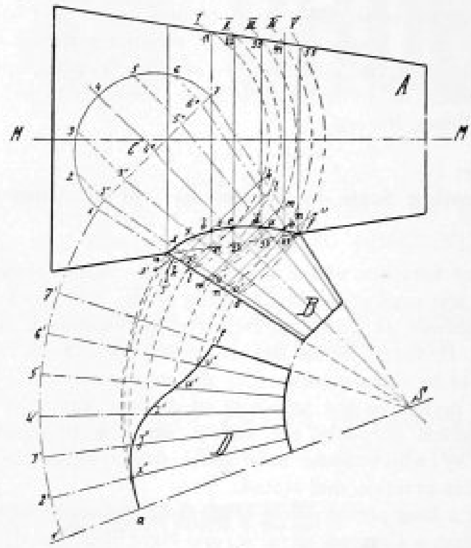


Fig. 1B.

irregular cone, one side of which is a circle and the other an ellipse. This cone must be developed by triangulation, as has often been described in these columns.

The Figs. 5, 6 and 8 show these developments, and how this is done is so clearly shown by Figs. 3, 4 and 7 that no description is needed. I, of course, used the same cylinders as used by Mr. Linstrom.

In Mr. Linstrom's Fig. 4 his intersection lines are incorrect,

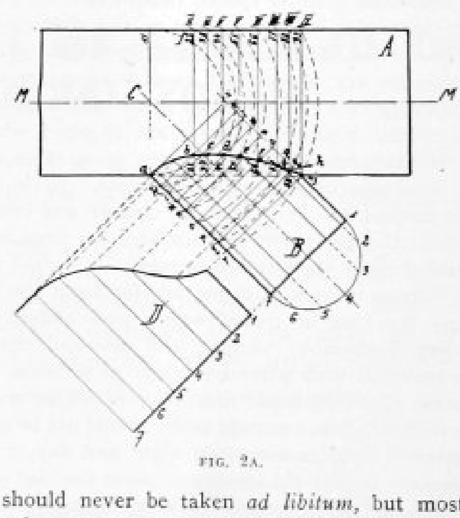


Fig. 2A.

as they should never be taken *ad libitum*, but most exactly constructed.

I give below a new way for finding the intersection of two bodies and laying out the work.

Fig. 4A shows the intersecting of a cone and a cylinder. To layout the cone it is necessary to find the intersecting line of the two bodies. This is usually found by a long and laborious method, as it is necessary to have two views and a projection from one to the other. This makes the work unhandy, and is more or less inexact. If the bodies are large it is almost impossible, in a shop, to draw two views, and the work of so doing is expensive. It is possible, however, to do this work with only one view quickly and cheaply.

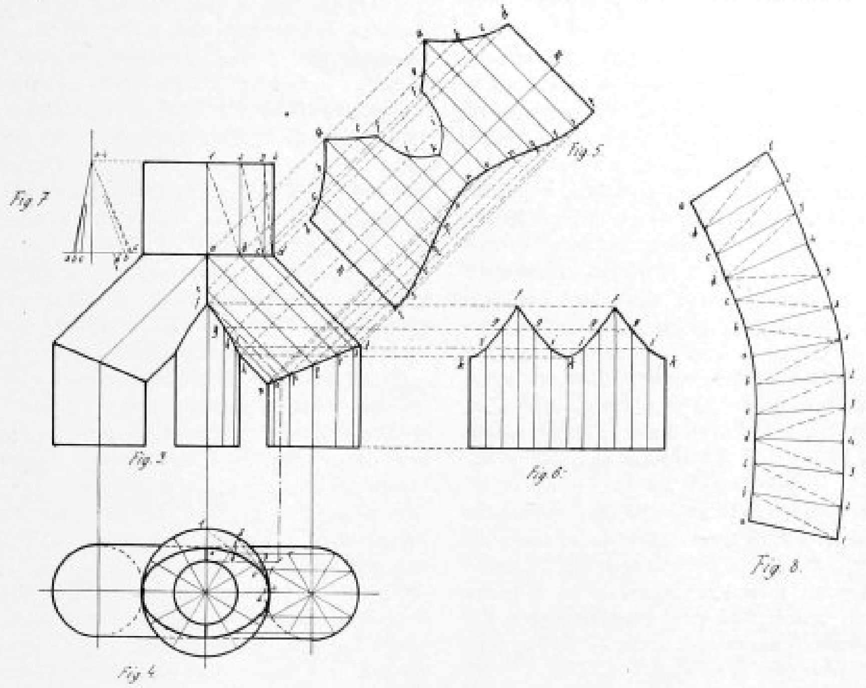


FIG. 2B.

If we look at Fig. 1B we will see that there are shown two conical courses intersecting each other. It is difficult to layout the cone *B* and find the line of intersection in the usual way, but it can be found quickly and easily as follows:

Take the intersecting point of the two center lines *S* and

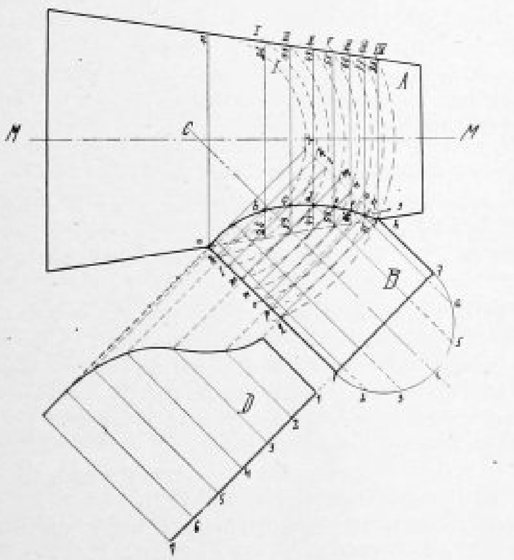


FIG. 3A.

M M as center lines, and draw a nest of circles *I* and *II* and *III*, and so on. These circles intersect the conical body *A* at 11-11 and 22-22 and 33-33, etc., and the cone *B* at *k-k* and *l-l* and *M-M* . . . Then draw lines connecting 11 with 11, 22 with 22, 33 with 33 . . . and *k* with *k*, *l* with *l*, *m* with *m* . . . Where these lines intersect at *b* and *c, d, e, f* the points of the intersecting lines are thus found; connecting these intersecting points by a curve the intersecting line is produced.

Graz, Austria. JOHN JASHKY.

SUPERHEATED STEAM IN LOCOMOTIVE SERVICE.

Two reports relating to research work on locomotive performance by Dr. W. F. M. Goss, under the patronage of the Carnegie Institution at Washington, have been published. The first related to the performance of a locomotive using saturated steam, and the second to that of a locomotive using superheated steam. Liberal extracts from these reports, dealing more particularly with the Purdue tests, were given in a paper by Dr. Goss which forms a part of the proceedings of the American Railway Master Mechanics' Association for 1909.

A more elaborate presentation of the facts in the second

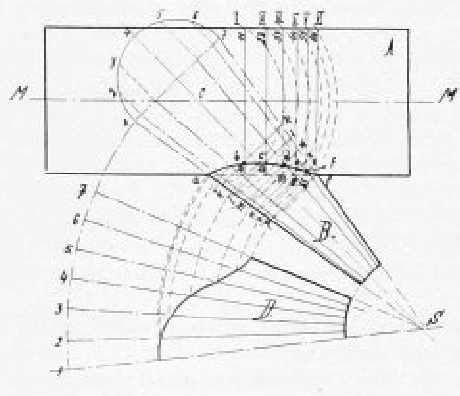


FIG. 4A.

report has recently been made in publication No. 127 issued by the Carnegie Institution of Washington. The various sections of the report relate to: First, foreign practice in the use of superheated steam; second, the American attitude toward the use of superheated steam in locomotives; third, tests to determine the value of superheating in locomotive service; fourth, performance of boiler and superheater; fifth, performance of the engine and of the locomotive as a whole; sixth, locomotive efficiency as affected by its running schedule; seventh, economy resulting from the use of superheated steam; the appendix contains all data and diagrams in detail.

Under foreign practice is given an interesting account of the development of the superheater for locomotives on the Prussian State Railway, commenced in 1898 by Wilhelm Schmidt and Robert Garbe. This also describes the special design of piston valve and piston rod packing used in Germany for superheater locomotives.

In the statement relating to the American attitude toward the superheater, Dr. Goss says: "These statements will serve to show that the ideal underlying practice in the development of the modern American locomotive has placed power-capacity and continuity of service upon a higher plane than thermodynamic efficiency. This ideal has, on the whole, not been misleading. It has produced locomotives of unprecedented power; it has satisfied a legitimate demand for service; and it has resulted in the development of a machine which must always be regarded as a mechanism of remarkable quality. This in itself has been a great achievement. It is, therefore, not discreditable to the railways of America that their interest in superheating has thus far been hardly more than academic, for the advent of the superheater brings complications of mechanism with it and introduces new problems in maintenance. .....The time is aproaching when, in the natural order of development, the railways of the United States will leave no stone unturned in their efforts to increase the thermodynamic efficiency of the American locomotive. Such an attitude involves no abandonment, but merely an enlargement of existing ideals. Progress in this direction means, in its ultimate analysis, the sacrifice of nothing already possessed, but the addition thereto of greater economy in the use of fuel and an extension in the amount of power developed."

The tests of the superheater locomotive on the Purdue testing plant were made November, 1906, to July, 1907, and during that time the locomotive performed a service equivalent to 4851 miles. "The interittent tests were designed to disclose the effect on its efficiency of certain conditions which enter into the normal operation of a locomotive. The writer long ago called attention to the fact that not less than 20 percent of the total fuel used by the average locomotive in this country was not utilized in advancing trains over the road, but was consumed in starting fires, in raising steam, in keeping the locomotive hot while waiting for its trains, while stopping at stations and at passing points, or remained in the firebox at the end of the run. Obviously, no embellishment in the design of a locomotive can effect a saving in that portion of the total fuel supply which is thus accounted for. The advantage to be derived from such an embellishment as a superheater must, therefore, be judged by the effect it can produce on not more than 80 percent of the coal consumed. If, for example, it were shown that the superheater can effect a saving of 20 percent in the amount of fuel used, the saving in total fuel which it will be necessary to supply will be 20 percent of 80, or 16 percent only."

The advantage of increased power obtained by the use of superheated steam is explained as follows: "It has been shown that for the development of equal amounts of power the combined boiler and superheater of the superheating locomotive have an efficiency which equals or exceeds that of the saturated-steam boiler; hence the boiler-power which it may be made to deliver as a maximum equals or exceeds that which the boiler of the saturated-steam locomotive can be made to deliver. But each unit of power delivered from the boiler in the form of superheated steam is more effective in doing work in the cylinders than a similar unit of power delivered in the form of saturated steam; hence, at the limit, the superheating locomotive is more powerful than the one using saturated steam, and the difference is that which measures the difference in the economy with which the cylinders use steam. The same question may be dealt with through another series of facts, as follows: It can be shown that the power of any locomotive is limited by its capacity to burn coal, and coal-burning capacity is a function of the draft. The data show that for the development of a given cylinder power the draft values of *Schenectady No.* 3 (superheating) were in all cases less than those of *Schenectady No.* 2 (saturated). Tests at 160 pounds show that the power developed in return for a given draft is from 10 percent to 16 percent greater for the superheating locomotive than for the saturated-steam locomotive. Obviously, there is no reason why the draft for the former should not be increased to limits practicable with the latter, and when this is done the power developed by the superheating locomotive will exceed that which is possible with the saturated-steam locomotive."

The possible economy resulting from the use of the superheater and its relation to the degree of superheat is discussed as follows: "The Purdue tests dealt principally with steam superheated to approximately 150 degrees F. The gain in any service resulting from superheating is a function of the degree of superheat employed. The Prussian State Railway prescribes a boiler pressure of 180 pounds, and a degree of superheat of 190 degrees F. is regarded as satisfactory, while the maximum limit never to be exceeded is 280 degrees F. Under normal conditions in Prussian State Railway practice, the superheating is considerably above 200 degrees F. Comparing this with the Purdue locomotive working under a pressure of 180 pounds, the temperature of the steam in those tests may have been increased by 33 percent without exceeding the limit which has proved practicable in the every-day practice of the German railways. The saving in water and fuel resulting from this increase would be proportionate to that increase."

The whole question of the economy of superheating, as far as fuel is concerned, is thus summarized: "The actual net reduction in the amount of fuel needed for locomotive use by a railway having all of its locomotives equipped with satisfactory superheaters, over that which would be necessary if all required saturated steam, will not be far from 10 percent. This value is not to be accepted as of strictly scientific import, but merely as an estimate based on such facts as have appeared in the course of a rather careful study of the problem."

A summary of conclusions relating to the whole investigation is given below:

SUMMARY OF CONCLUSIONS.

1. Foreign practice has proved that superheated steam may be successfully used in locomotive service without involving mechanism which is unduly complicated or difficult to maintain.

2. There is ample evidence to prove that the various details in contact with the highly heated steam, such as the superheater piping, valves, pistons, and rod packing, as employed in German practice, give practically no trouble in maintenance; they are ordinarily not the things most in need of attention when a locomotive is held for repairs.

3. The results of tests confirm, in general terms, the statements of German engineers to the effect that superheating materially reduces the consumption of water and fuel increases the power capacity of the locomotive.

4. The combined boiler and superheater tested contains 943 ft. of water-heating surface and 193 feet of superheating surface; it delivers steam which is superheated approximately 150 degrees. The amount of superheat diminishes when the boiler pressure is increased, and increases when the rate of evaporation is increased, the precise relation being

$$T = 123 - 0.265\,P + 7.28\,H$$

where T represents the superheat in degrees Fahrenheit, P the boiler pressure by gage, and H the equivalent evaporation per foot of water-heating surface per hour.

5. The evaporation efficiency of the combined boiler and superheater tested is

$$E = 11.706 - 0.214\,H$$

where E is the equivalent evaporation per pound of fuel and H is the equivalent evaporation per hour per foot of water heating and superheating surface.

6. The addition of the superheater to a boiler originally designed for saturated steam involved some reduction in the total area of heat transmitting surface, but the efficiency of the combination when developing a given amount of power was not lower than that of the original boiler.

7. The ratio of the heat absorbed per foot of superheating surface to that absorbed per foot of water-heating surface ranges from 0.34 to 0.53, the value increasing as the rate of evaporation is increased.

8. When the boiler and superheater are operated at normal maximum power, and when they are served with Pennsylvania or West Virginia coal of good quality, the available heat supplied is accounted for approximately as follows:

	Per Cent.
Absorbed by water	52
Absorbed by steam in superheater	5
Utilized	57
Lost in vaporizing moisture in coal	5
Lost in CO	1
Lost through high temperature of escaping gases	14
Lost in the form of sparks and cinders	12
Lost through grate	4
Lost through radiation, leakage, and unaccounted for	7

9. The water consumption under normal conditions of running has been established as follows:

Boiler Pressure, Pounds.	Corresponding Steam Per Indicated Horsepower Hour, Pounds.
120	23.8
160	22.3
200	21.6
240	22.6

The minimum steam consumption for the several pressures is materially below the value given. The least for any test was 20.29 pounds.

10. The coal consumption under normal conditions of running has been established as follows:

Boiler Pressure, Pounds.	Coal Consumed Per Indicated Horsepower Hour, Pounds.
120	3.31
160	3.08
200	2.97
240	3.12

11. Neither the steam nor the coal consumption is materially affected by considerable changes in boiler pressure, a fact which justifies the use of comparatively low pressures in connection with superheating.

12. Contrary to the usual conception, the conditions of cut-off attending maximum cylinder efficiency are substantially the same for steam superheated 150 degrees as for saturated steam. With superheated steam, when the boiler pressure is 120, the best cut-off is approximately 50 percent stroke, but this value should be diminished as the pressure is raised, until at 240 pounds it becomes 20 percent.

13. Tests under low steam pressures, for which the cut-off is later than half stroke, give evidence of superheat in the exhaust.

14. The saving in water consumption and in coal consumption per unit power developed which was effected by the superheating locomotive *Schenectady No.* 3 in comparison with the saturated-steam locomotive *Schenectady No.* 2 is as follows:

SAVING IN WATER CONSUMPTION.

Boiler Pressure, Pounds.	Saturated Steam, Pounds.	Superheating, Pounds.	Gain, Per Cent.
120	29.1	23.8	18
160	26.6	22.3	16
200	25.5	21.6	15
240	24.7	22.6	9

SAVING IN COAL CONSUMPTION.

Boiler Pressure, Pounds.	Saturated Steam, Pounds.	Superheating, Pounds.	Gain, Per Cent.
120	4.00	3.31	17
160	3.59	3.08	14
200	3.43	2.97	13
240	3.31	3.12	6

15. The power capacity of the superheating locomotive is greater than that of the saturated-steam locomotive.

16. Tests involving intermittent running show that the steam consumption per unit work delivered is increased when the program of operations is made to involve intervals of rest, due doubtless to the cooling of the cylinders and the connected parts. This loss increases with increase of steam pressure. When the program of operations involves equal periods of rest and running it amounts to from 5 to 10 percent of the consumption under constant running; adding to this the losses resulting from low efficiency when starting and the radiation and stack losses during the periods of idleness, the total loss resulting from such intermittent running, as compared with constant running, is approximately 20 percent.—*Railway Age Gazette.*

The Federal Locomotive Inspection Law.

A Washington dispatch says a preliminary meeting of the new Board of Locomotive Boiler Inspectors has been held. This board is directed to divide the United States into fifty locomotive boiler inspection districts. After such division fifty inspectors of locomotive boilers are to be appointed, who are to make periodical examinations of all locomotive boilers in their districts, and to see that the railroads comply with rules and regulations promulgated by the board. Penalties are provided for failure of the carriers to comply with the rules and regulations. The inspectors are to be appointed by the commission after competitive examination according to law and the rules of the Civil Service Commission governing the classified service. These examinations must be held soon, as the law is about to go into effect. Inquiries about examinations should be addressed to United States Civil Service Commission, Washington, D. C. The board, which was named by President Taft, consists of John F. Ensign, chairman; Frank McManamy, both at present safety appliance inspectors under the Inter-State Commerce Commission, and G. P. Robertson, formerly boiler inspector for the Public Service Commission of New York.

Horsepower Capacity of Steam Pipes.

As an average for steam engine design, a velocity of 6,000 feet a minute in a steam pipe and 8,000 feet a minute in an exhaust pipe is used, and this gives about 0.14 square inch internal area per horsepower for steam pipes, and 0.2 square inch for exhaust pipe, says *The Practical Engineer.* Based on these values the accompanying table has been worked out, showing the engine horsepower that can be taken care of by different sizes of pipe when used for exhaust and for live steam:

ENGINE HORSEPOWER CAPACITY.

Size Pipe Inches.	For Exhaust.	For Steam.
½	1.52	2.18
¾	2.66	3.81
1	4.31	6.16
1½	10.18	14.55
2	16.78	23.95
2½	23.95	34.15
3	36.95	52.30
3½	49.45	70.50
4	63.65	91.00
4½	79.70	114.00
5	100.00	142.70
6	144.60	206.50
7	193.80	276.80
8	250.00	357.50

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

NOTICE TO ADVERTISERS.

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

The meeting of the International Master Boiler Makers' Association, which takes place in Omaha, Neb., May 23, 24, 25 and 26, should be made, and can be made, one of the most important meetings in the country. The lives of thousands depend on the craft of boiler making, and the master boiler makers are, in a measure, not only responsible for the designs, but the actual work on the boilers. Therefore, their responsibilities are heavy. The names of the officers are a guarantee of the association's standing, and it is safe to say that the time they so liberally give to its work and welfare is not as thoroughly appreciated as it should be by members in general. In order to make this meeting a success, every member should plan to set aside the special days in May and be on hand. Empty benches and a small attendance do not inspire those in charge, while a large, full meeting does wonders in bringing the loyalty and sentiment of the association to the point it should be. All should come, not only to listen to matters of interest, but to take part in the discussions of the papers. Such discussions always bring forth something of value. It is by the differences of opinion we learn, and we must not expect to always absorb and never give out knowledge. It is not fair or manly to be a human sponge. To meet our co-workers is always good, broadening our ideas, and sometimes results in lessening friction or preventing it. There is much of moment at the present for boiler makers to consider—better water circulation in boilers, better feed-water heating systems, and the question of superheated steam are all now to the fore. Also, much loose talk has been indulged in by some as to the saving which can be effected in work and in management, and we regret to say this has been done by those who do not seem to know that brains of the highest order have been constantly bent towards this question of economy for many, many years, and some very interesting remarks may be looked for on this subject of economy. Now let all members of the International Master Boiler Makers' Association make up their minds to be at this meeting and do their share in its good work.

It is pretty generally believed that boiler makers should possess considerably more strength than brains, and that their work calls for little or no mental effort. Now there is nothing wider of the mark than this. While the machinist, for example, makes use of much finer measurements and works far closer than the boiler maker, his work does not begin to demand the mental effort of the boiler maker in its preparation. Practically the machinist thinks in but one plane, while the boiler maker has to think in an infinite number of planes. Laying out the work for a boiler and its up-take, etc., requires a line of thought entirely unknown to the machinist and many other trades. The boiler maker must have, first, knowledge of what metals will do, or, more properly, what can be done with them when hot or cold; second, some knowledge of plain geometry; and third, a considerable knowledge of descriptive geometry, which has to do with the development of surfaces of solids. As we expressed ourselves in last month's issue concerning the drawing room in its relation to sending in drawings to the boiler shop, we consider a draftsman is better fitted to lay out work than a boiler maker. The boiler maker generally only receives a drawing of what is to be made, and he does not always get that, whereas he should receive a drawing which should clearly show how every piece is to be laid out. But as he does not, how to do this work in the simplest way is what is very interesting.

Five solutions of a problem in laying out sheet-metal work for which a prize was offered are given in this issue. Their study is very interesting, and we commend the solutions of these studies to our readers. We are giving them as they were received. It may be possible that of those who read The Boiler Maker some simpler method is known than has been described, and simplicity is what we desire to bring forward in the solutions of such work.

COMMUNICATIONS.

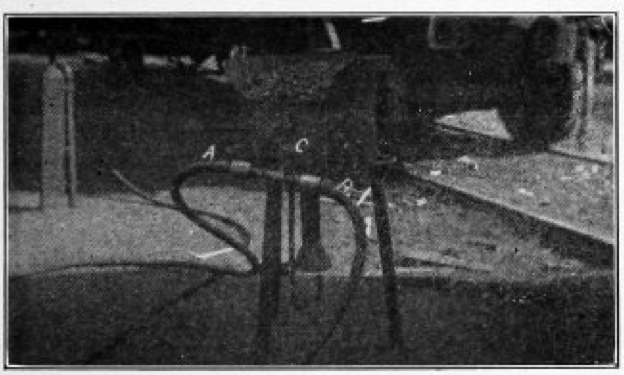
Careful Use of Compressed Air—A Rivet Heater.

Editor The Boiler Maker:

For some reason or other compressed air is not looked after as it should be in a great many shops. Since compressed air is getting used so extensively it should, and must, receive more attention as to the method of piping and arrangements for connections, etc.

Leaks are very expensive, as the slightest leak here and there and everywhere will in a short while ruin a good compressor by running it at its full speed from morning until night to keep up the proper supply of air. But the most costly part of the leaky pipes and air hose is the excess use of coal that is necessary to burn to furnish steam to keep the compressor or compressors at their maximum speed.

The accompanying picture shows a portable rivet heater for boiler and steel car work. This forge is very simple in its construction and economical in the use of air. A 2-inch pipe about 10 inches long, with a funnel at its lower end 4 inches in diameter and 4 inches long, is screwed into the bottom of the fire pot. The 3/8-inch air pipe is clamped, so that it discharges through a 3/16-inch nozzle in the end of the pipe directly up through the center of the funnel, the top of the pipe being



PORTABLE RIVET HEATER.

about on a level with the lower part of the funnel. With this arrangement a suction is set up, and air from the outside is forced up through the fire. It is possible to heat the rivets as fast as they can be driven in with the air valve opened only one-quarter of a turn. The method of connecting the compressed air line to the forge is also of interest. The hose *A*, which is connected to the air line, discharged through the end of the *T* to the hose *B*, which is connected to the air hammer, while the other connections from the *T* carries air to the blast pipe. The blast is controlled by the valve *C*. In this way it is possible to operate the forge and the hammer from one air connection, doing away with the use of a second connection from the main line.

The extravagant use of compressed air cannot be watched too closely. We realize it is impossible to keep the compressors standing still where air is used to any extent; but if the air lines are properly watched and the leaks followed up and repaired, it will mean a whole lot in keeping the speed of the compressor down and avoid a great deal of the extravagant burning of coal. W. H. Snyder.

Stroudsburg, Pa.

Who Has a Clamp of this Kind?

Editor The Boiler Maker:

It would be appreciated if any reader submits for publication sketches, photographs or description of a reliable clamp or device capable of lifting plates vertically or on edge by utilizing the weight of the plate to secure the grip of the clamp to the plate; *i. e.*, a clamp which does not require being made fast to the plate by means of a screw or other device before the lift is made, but will automatically create its own grip while the plate is suspended. John V. Petty.

Lebanon, Pa.

Boiler Inspection in Arkansas.

Editor The Boiler Maker:

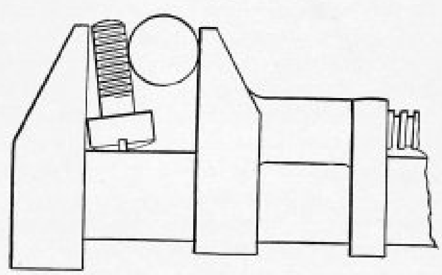
On January 31 Bill No. 167 was read before the House of Representatives, State of Arkansas, providing for a set of boiler rules and a board of inspectors, to be appointed by the Governor. The bill was read twice and referred to the committee on judiciary, and has a fair chance of becoming a law. One feature of this proposed law requires the inspectors to be practical boiler makers, with not less than ten years' experience.

A law of this nature would be a great help to owners of cotton gins, sawmills and other factories in the State of Arkansas. The bill will no doubt pass with little or no opposition. The bill provides for a small fee for the inspection of each and every boiler, together with a salary of $2,500 for the general inspector, $2,000 for the assistant general inspector, and $1,000 for a clerk, with traveling expenses of $1,000 per annum and 10 cents per mile, as paid other State officers in Arkansas. It is a well-known fact among men who are connected with the boiler making industries throughout the State that there are many boilers that are run with an excess of pressure, and there are boilers in cotton gins, sawmills, etc., that are twenty to thirty years old and have never been inspected. The proposed law does not arouse opposition of the owners of such boilers, as no doubt they realize the importance of inspection, as owners have done in other States.

McGehee, Ark. A Reader.

An Emergency Pipe Wrench.

How frequent is our need of a pipe wrench when one is not to be had! The substitute described herewith has helped out in many such a case. Perhaps the idea is old, but, nevertheless, a good thing bears repetition. The kink is to place



a hard short-head screw in the jaws of a monkey wrench, as shown in the sketch. The threads of the screw bite into the pipe with as good results as if a pipe wrench were used.—*R. A. Rudolf, in The American Machinist.*

A bill has been introduced in the Ohio State Legislature providing for the formation of a State department of boiler inspection. A chief inspector at $2,400 and six deputies at $1,800 per annum are authorized.

Test of Staybolt Threads.

BY C. J. MORRISON.*

The V thread was generally used on stay-bolts for many years, but recently the Whitworth thread has been attracting considerable attention. The difference between the Whitworth and the V threads is that the former has an angle of 55 degrees and its top and bottom are rounded, while the V thread has an angle of 60 degrees and its top and bottom are brought up sharp. The V thread is often called the American thread, while the Whitworth is English.

In order to ascertain the relative strength and life of stay-bolts with the two types of threads careful tests were made, and the following results obtained:

BOILER STAY-BOLT TEST.

Thread.	Dia. of bolt.	Area in inches.	Breaking strain in lbs.	Strain per sq. in.	Original length.	Percent of elongation in length of section.
Sharp "V"	.880	.608	32,139	52,870	8"	20.5
	.881	.610	32,910	53,960	8"	15.7
	.879	.607	31,140	51,310	8"	19.
Average..	....	....	32,063	52,713	8"	18.4
Whitworth	.882	.611	33,060	54,120	8"	27.5
	.889	.621	33,040	53,210	8"	27.75
	.887	.618	33,080	53,540	8"	27.25
Average..	....	....	33,060	53,623	8"	27.50

Vibration and bending tests were also conducted. In the vibration test, each bolt was screwed and riveted in a ½-inch steel sheet in the same manner as stay-bolts are fastened in boilers. Each bolt was given a vibration of ⅜ inch; the average number of vibrations withstood by the V thread was 1,485, while the average for the Whitworth was 3,437. In the second series of tests each bolt was given 10,500 vibrations through 3/16 inch and then vibrated through ⅜ inch to destruction. The V threads averaged only 791 vibrations, while the Whitworth failed at 1,932. One very noticeable feature of the tests was that the Whitworth thread bolts hold much tighter in the sheet than the V thread, and also showed no tendency to cut into the sheet. Bending tests were also made, and in these the V thread failed when bent over a 3-inch circle, while the Whitworth withstood a bend over a 2-inch circle, but failed at 1⅞ inches.

These tests show the theoretical superiority of the Whitworth thread, while the practical superiority has been demonstrated by the great decrease in broken stay-bolts on several roads which have adopted the Whitworth thread as standard.

After the adoption of a standard thread it became necessary to devise a cheap and accurate method of tapping. Many contend that taps and stay-bolts with continuous threads are necessary, but practical demonstrations have shown the weakness of their arguments. It is a very easy matter to get threads 1/24 out of being continuous, which is the worst they could possibly be when not continuous. It is also exceedingly difficult to get the taps for long, radial stay-bolt work continuous. If the tap is out .008 inch in hardening, which often occurs in a tap of that length, and the lead screw on the lathe is out the same amount, it is readily seen that the threads in the wagon top and crown sheet, after the holes have been tapped and the stays screwed in, are no more liable to be in line than had the holes been tapped with separate taps. In order to tap the holes in the top and crown sheets in line, extension sockets have to be used; the socket should fit the holes fairly well. The tap hos to be made so that an extension rod can be driven into its small end, and this rod must be long enough to pass through the lower or crown sheet hole in order to guide it. The second extension bar must have a socket to take the large or square end of the tap, and be long enough to reach up through the top sheet hole. Reaming should be done in the same way.

This method has been in use for several years and has proved to be very satisfactory.

* In "American Engineer and Railroad Journal."

Marine Boiler Repairs.

A paper on "Marine Boiler Repairs" was read before the Institute of Marine Engineers, from which the following is abstracted:

Boiler Shells.—In cases where the end plates are flanged outwards for the purpose of hydraulic riveting to the shell, it is not uncommon to find considerable corrosion through leaky rivets. At an early stage this defect can be overcome if the rivets are cut out and the holes countersunk on both sides and re-riveted. Where this is not done and the seam is neglected, the shell and end plates will require patching, a most difficult and unsatisfactory job.

End Plates.—Front plates in the steam space are sometimes found considerably corroded at and above the normal water line. This action can be stopped by making a clear air space between the uptake and the front top plate, and where such space exists by keeping it clean. When, however, the corrosion has gone so far that it is necessary to deal with it, riveted washers should be fitted to each stay outside, or a continuous doubling plate or strip riveted on outside, taking all the stays. In cases of grooving and cracking of the furnace front plate flange, to which the furnace is riveted, the front plate may be renewed, which means a renewal of the furnaces, or a repair may be effected by cutting out the rivets in way of the crack in the furnace connection to flange, and if the front plate is fitted on the inside of the front tube plate, to cut out the rivets connecting them together for a distance equal to the length of the proposed patch. The crack should then be studded at each end, a flanged angle plate about ½ inch thick should be carefully fitted and bedded close on the inside, taking in the seam of the tube plate and furnace rivets, also a number of tack rivets through same, here and there. After the angle patch has been riveted and caulked, it should be forced with red lead by means of a pump.

Furnaces.—Corrosion along the fire-bar line is more a question of treatment than of design or circulation. To avoid corrosion, if this part is kept well scaled and cleaned, and the water kept as free from acid as possible and soda used, and zinc plates should be hung on studs where the corrosion is worst, not intermittently, as is so often done, but continuously, the corrosion will be removed. The cracking of furnaces is, in every case, due to the accumulation of scale. To repair a crack, it is usual, in the case of corrugated furnace, to lock-stud it. This method of repair is at best only a temporary one, as it is necessary to renew the studs very often. When local distortion or a bulge forms on the furnace, it is almost better not to interfere with it other than to keep it clean. Girders are sometimes fitted with a bolt through the bottom of the bulge, but usually this only makes the bulge worse than before.

Tube Plates.—When a tube plate cracks in the nest of tubes, the plate should be cut through and a piece dovetailed in and clenched over on each side; the tube holes should then be filled out, and two new tubes (stay-tubes for preference) fitted. The crack should not be "lock-studded," nor should a spectacle plate be fitted on the fire side.

American Locomotives in South Africa.—Consul Edwin N. Gunsaulus, of Johannesburg, notes that American locomotives are having a large sale in South Africa, where upward of fifty different types are in use, and tenders were recently asked for thirty-five more of United States manufacture.

THE FAILURE OF LOCOMOTIVE CROWN SHEETS.

The enactment of a federal law for locomotive boiler inspection makes the subject of the causes of boiler failures of timely interest. The most complete and reliable statistics relating to locomotive boiler explosions, failures and casualties are found in the 1910 report of the Master Mechanics' Committee on the Inspection of Locomotive Boilers. They cover a period of nearly five years from January 1, 1905, and represent 75 percent of the locomotives of the country. When equated for the whole number of locomotives, estimated at 58,000, they will fairly represent the total number of boiler failures which are in the nature of an explosion. The equated figures show a total of 800 failures per year. It should be understood that the figures cover only those failures which resulted in personal injury or death, and the total number of failures, including those in which there was no personal injury, is still larger. Of these, 5 were due to explosions of boiler shells; 68 to explosions of fireboxes, and 700 to damage by burning. Those due to explosions of fireboxes and to damage by burning may be considered as crown sheet failures, since as a rule they are confined to the crown sheet. We therefore have a total of 768 failures of crown sheets per year causing personal injury, and an additional number not reported which did not result in personal injury.

The report shows that 98.3 percent of the failures were due to low water, and all of these, with the exception of 1.4 percent., were caused by the neglect of the men in immediate charge of the locomotive to maintain a proper supply of water in the boiler. The only real locomotive boiler explosions which may be charged to the weakness of the boiler are those classed as explosions of the boiler shell, and the average number per year for all the engines in the United States is 5.6, or less than 1/100 of 1 percent of the locomotive boilers in service, which is smaller than in any other service, stationary or marine.

The serious damage to locomotive boilers is, therefore, largely due to the failure of crown sheets and, including those which do not cause injury to persons, the average number in the United States per year is now probably 1,000, or about 2 percent of the locomotives in actual service, and the number is increasing. Over 98 percent of these failures are chargeable to the enginemen. It is found by experience that in some cases the water may be low and the sheet scorched or overheated without blowing down or doing any damage, and this leads to carelessness and willingness to take risks. The failure of crown sheeets is, then, as a rule, a personal matter rather than one connected with the construction of the boiler, its strength or its inspection, and the effort to reduce these failures should be directed to the cultivation of greater care and watchfulness on the part of the enginemen.—*Railway Age Gazette.*

PERSONAL.

MR. DANIEL CONNELLY, president of the D. Connelly Boiler Company, Cleveland, Ohio, died last month at the age of 57. Mr. Connolly spent his whole life in the boiler-making business in Cleveland, beginning in a modest way with the Cleveland Steam Boiler Works. This plant grew rapidly into one of the largest boiler plants in Cleveland. Only two weeks before his death he completed a large modern plant in East Cleveland.

At the annual meeting of J. K. Petty & Company, Philadelphia, Mr. D. O. Mader was elected president; Mr. J. K. Petty, treasurer; Mr. W. K. Petty, secretary, and Mr. John V. Petty, superintendent of the Lebanon Boiler Works. This plant is running full at present, completing a number of return tubular boilers and fabricating a large order of special plate work.

ENGINEERING SPECIALTIES.

Improved Kerosene Torch.

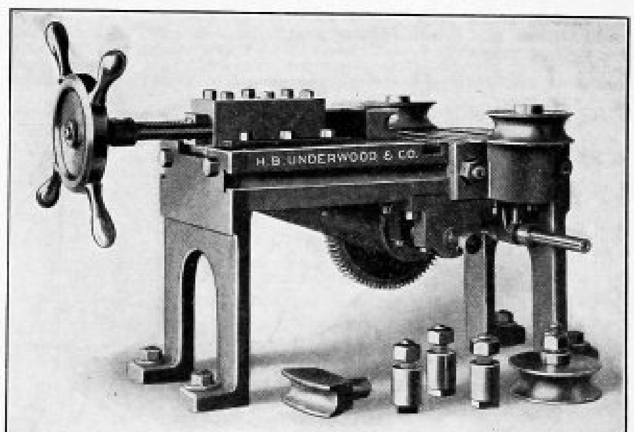
Oil as fuel for many purposes gains daily, and of all oil products kerosene is probably the most widely known and distributed. Taking advantage of this, as well as other points, the Hauck Manufacturing Company, 140 Livingston street,

NEW HAUCK KEROSENE TORCH.

Brooklyn, N. Y., has placed on the market a kerosene torch. Certainly the use of kerosene appeals to many on account of no insurance restrictions, the safety and ease with which it can be obtained and cheapness. The uses to which this torch can be applied are almost endless, in general shop work. The torch is so constructed as to keep the tank cool, and only small pressure is required to operate it.

Underwood's Bender and Straightener.

A most convenient bending machine is made by H. B. Underwood & Company, of Philadelphia, Pa., who have had great experience in this class of tool. Very few dies or formers are required; in fact, there are no real dies, but the bending is



UNDERWOOD PIPE BENDER AND STRAIGHTENER.

accomplished by means of a pair of rolls and block, of which are adjustable, but, of course, the rolls and blocks must meet the size of pipe or rods to be formed, thus saving a great amount of money.

In a boiler shop the machine can be most advantageously used to strengthen or bend angles or tees by making special rollers.

SELECTED BOILER PATENTS.

Compiled by
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Loan and Trust Building,
Washington, D. C.

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

984,205. STEAM-BOILER FURNACE. GEORGE S. GALLAGHER, OF NEW YORK, N. Y., ASSIGNOR TO HENRY GALLAGHER AND EMMA G. GALLAGHER, OF NEW YORK, N. Y.

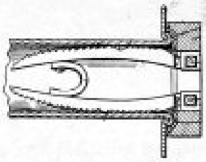
In a steam boiler furnace, a revoluble grate, means for supporting the same, means for continuously turning the said grate while in use and means connected to and moving with the said grate, whereby in its revolution currents of air are created and continuously conveyed from the space beneath the grate to approximately central points above the same.

980,696. STAY-BOLT. BENJAMIN E. D. STAFFORD, OF PITTSBURG, PA., ASSIGNOR TO FLANNERY BOLT COMPANY, OF PITTSBURG, PA.

The combination with a bracket comprising a base flange for attachment to the roof sheet of a boiler, a seat for the head of a stay-bolt and a web connecting the head and the seat, of a removable cap having projecting lips adapted to engage corresponding lips on the seat, the said cap adapted to cover and protect the head of the stay-bolt.

974,819. FLUE-PLUG. WILLIAM F. PETERS, OF WAVERLY, N. Y.

In an open end packing ring for flues, a pair of arms pivoted to said ring, a U-shaped spring connected to each of said arms for pressing the



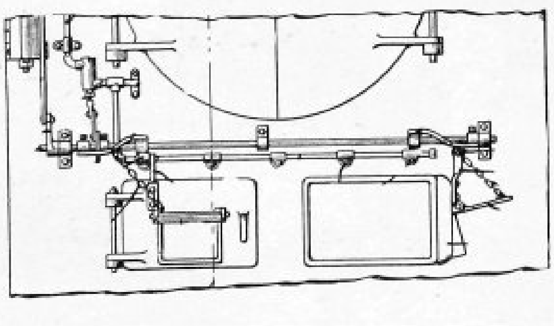
same in opposite directions, and means carried by said arms for preventing displacement of the same when inserted in a flue.

983,184. STEAM BOILERS. JAMES R. VANCE, GENEVA, N. Y.

A return-flue steam boiler comprising a main shell of uniform dimensions from one end of the boiler to the other, a fire-box, an ash-pit, a transverse partition extending from the top to the bottom of the shell, the upper portion of the partition forming the rear flue-sheet for the direct flues, and the lower portion of said partition forming the back wall of the fire-box and ash-pit, a combustion-chamber and an ash-trap formed by the space between said partition and the back-plate of the shell, the partition provided with an opening affording communication between the fire-box and combustion chamber, a metal bridge wall supported in the fire-box and shielding the portion of the partition below the opening, and water legs formed at the sides of the shell and constituting the side-walls of the fire-box and extended across the bottom of the ash-pit.

982,970. SMOKE CONSUMER. AUGUST G. KRIEG, OF MINNEAPOLIS, MINN.

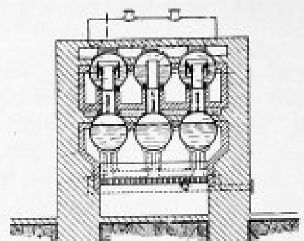
The combination, with a boiler front having a fuel opening and a door therefor and a draft door in said fuel door, of steam nozzles projecting through said front, a steam supply pipe connected with said nozzles, a valve provided in said pipe and normally closed, a rock shaft mounted on said boiler front above and near said fuel door, a crank secured on said shaft and pivotally connected with said valve, a yoke



secured on said rock shaft, a strap mounted on said fuel door and having a bearing on said yoke, whereby, when the door is opened, said yoke and shaft will be rocked and said valve opened, flexible means connecting said yoke with said draft door, and means connected with said shaft for slowly rocking it and returning said yoke and draft door to their normal position after the fuel door is closed.

981,722. STEAM GENERATORS. JEAN VAN COSTERWYCK, OF LIEGE, BELGIUM.

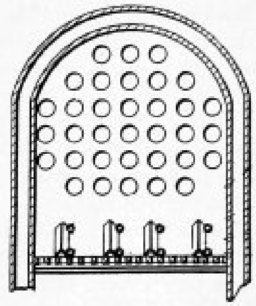
A steam generator comprising a plurality of elements, each including two drums arranged one above the other and connected by suitable vertical ducts, the upper drum of one element being provided adjacent one end with a suitable inlet, and water conduits connecting the upper and lower drums of said element with the corresponding drums of an adjacent element near the ends of said drums farthest from the inlet,



whereby water is caused to circulate through all of the upper drums before passing to any of the lower drums.

981,263. AIR-FEEDING ATTACHMENT FOR GRATES. FRED HILBURGER, OF DENVER, COL.

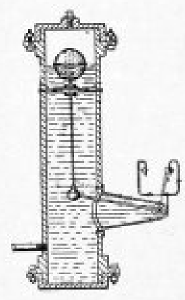
The combination with a fire-box and the grate thereof, of an upper and a lower series of pipes extending horizontally across the fire-box above



the grate, and inclined hollow bars connecting said upper and lower pipes in pairs, said bars being hollow and having longitudinal grooves.

980,214. WATER-LEVEL REGULATOR. JOSEPH E. DE BISSCHOP, OF NEW BRITAIN, CONN.

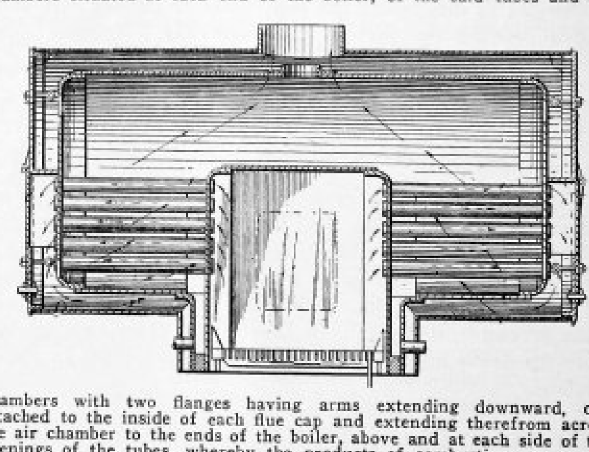
In a water level regulator, a contact arm pivotally mounted and provided with a float ball, the said float ball free to respond to low-water conditions, restraining means operative to limit the movement of said



ball during normal conditions of water level, and the said restraining means being released and inoperative during high-water conditions, the said restraining means comprising a second float ball that is operative during such high-water conditions.

981,078. STEAM BOILER. JOHN E. FERNSTRUM, OF MENOMINEE, MICH.

The combination, in a jacketed steam boiler having two sets of tubes, each set running in an opposite direction from the fire-pot to two air chambers situated at each end of the boiler, of the said tubes and air



chambers with two flanges having arms extending downward, one attached to the inside of each flue cap and extending therefrom across the air chamber to the ends of the boiler, above and at each side of the openings of the tubes, whereby the products of combustion are caused to take the course described in their passage from the furnace to the chimney outlet.

THE BOILER MAKER

MAY, 1911

FIREBOX GIRDER STAY DESIGN.

BY F. A. GARRETT.

Although it is a simple matter to proportion girder stays for the top of a firebox or combustion chamber from any of the many formulæ which are given, there is probably a good many who do not understand how these formulæ are obtained, or how to determine from first principles suitable proportions for these stays. The following notes are given to help those who are desirous of understanding how the various formulæ are obtained. To make the method quite clear we will design suitable staying for the roof of the firebox shown in Fig. 1, and we will assume:

Working steam pressure 100 pounds per square inch.

Tensile strength of material 28 tons per square inch (*i. e.*, 2,240 pounds).

Factor of safety = 6.

There are at the present time three distinct types of girders in general use:

1. Those which consist of two plates riveted rigidly together, with distance pieces in between, as shown in Fig. 2. The distance between the two plates should equal the diameter of supporting bolts, plus ⅛ inch or ¼ inch for clearance.

2. Those consisting of one thickness of plate, being suitably enlarged to take the supporting bolts, as shown in Fig. 3.

3. Those which are made of steel castings of the I section, and which are considerably lighter, strength for strength, than those which are made of uniform thickness throughout their depth. This type of girder is used to a considerable extent in English locomotives at the present time. The reason for their adoption is minimum weight with maximum strength. This type is illustrated in Fig. 4.

It should be noticed that if we taper the firebox towards the top, as in Fig. 1, we reduce the flat surface which has to be stayed, besides making it easier for the steam bubbles to leave the surface of the plate as they are generated.

Let us assume that after having proportioned the supporting bolts we find the distance apart of girder centers to be 5½ inches and the pitch of supporting bolts in each girder to be 5 inches. This will give us six girders with nine bolts in each.

Now, the design of a girder stay resolves itself to that of a beam with a span equal to the inside length of the firebox or combustion chamber taken between end plates. These end plates are assumed to take all the load on the girders due to the steam pressure on the firebox top. The loads coincide with the center line of each supporting bolt.

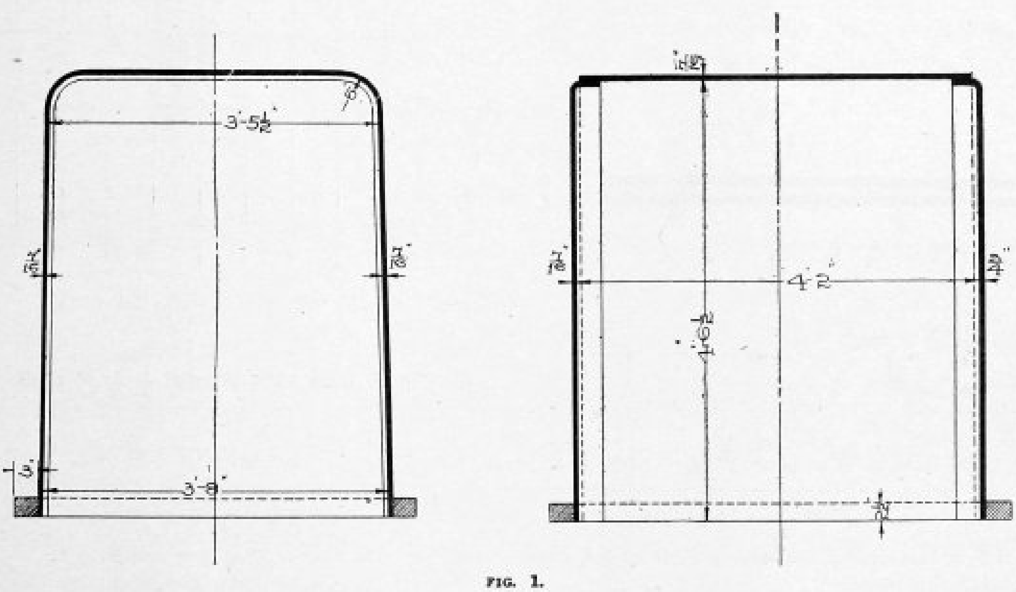


FIG. 1.

Taking a strip of the firebox top of width equal to the distance apart of girders in inches (equals 5½ inches), and apportioning an area to be supported by each bolt, we find this to be equal to

$$D \times P = A = 5.5 \times 5 = 27.5 \text{ square inches.}$$

Where D = distance of girders apart in inches.

P = pitch of supporting bolts in inches.

A = area supported by one bolt in square inches.

This multiplied by the working pressure (p) per square inch gives us a load on each bolt of

$$27.5 \times 100 = 2{,}750 \text{ pounds, or } 1.228 \text{ tons.}$$

The next thing which has to be found is the "bending moment" on the beam due to these loads. What we require to know is the *maximum* bending moment. The bending moment in such "beams" as we are considering are of such a character that when the number of supporting bolts is even—as 2, 4, 6, 8, 10—the *maximum* bending moment is between the two center bolts, and *is of the same amount between these two bolts.* When the number of supporting bolts is odd—as 1, 3, 5, 7, 9—the maximum bending moment is at the center of the girder, directly under the middle bolt. There is, generally speaking, two ways of finding these "moments" in a beam. First, by calculation; second, by graphical methods. We will only consider the first.

The moment of a force about a point is equal to the force applied multiplied by the perpendicular distance from that point, or force × distance from point = bending moment. In our girder we know the loads and the distances from the "point." But before we can calculate the bending moment we have to find the quantity of two forces which act at each end of the girder to resist the downward force due to the load. To find these proceed as follows:

Span of girder, 50 inches.

Loads of 1.228 tons at points indicated by arrows in Fig. 5.

F_1 (tons) =

Sum of (each load multiplied by its distance from point A).

Length of span in inches

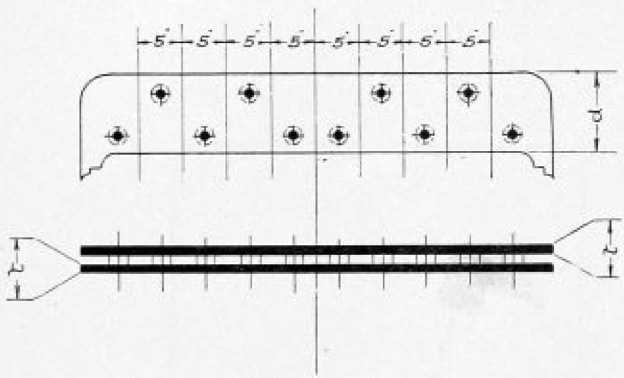


FIG. 2.

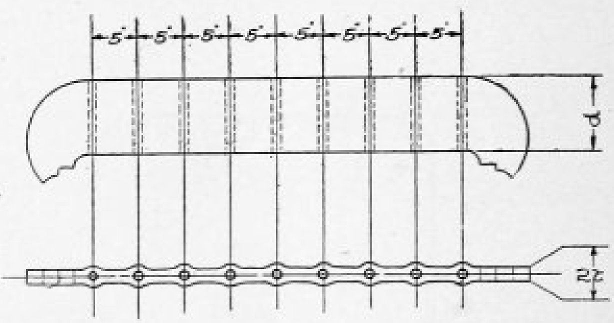


FIG. 3.

This =

$$\frac{5 \times 1.228 + 10 \times 1.228 + 15 \times 1.228 + 20 \times 1.228 + 25 \times 1.228 + 30 \times 1.228 + 35 \times 1.228 + 40 \times 1.228}{50} + \frac{45 \times 1.228}{50}$$

$$= \frac{6.14 + 12.28 + 18.41 + 24.55 + 30.71 + 36.83 + 43 + 49.15 + 55.3}{50} = \frac{276.57}{50} = 5.53 \text{ tons} = F_1.$$

The value of F is obtained by subtracting F_1 from the whole load on the girder, this equals

$1.228 \times 9 - 5.53$ tons $= 5.53$ tons $= F$.

So we see that there is an upward force at each end of the girder of 5.53 tons to resist the downward force due to the pressure.

The above method is given only to illustrate the meaning of "moments of forces." The practical way of finding these supporting forces in the case of a beam symmetrically loaded is to take the total downward force due to the pressure and divide by two.

$$= \frac{1.228 \times 9}{2} = 5.53,$$ the same as by the other method.

It should be noticed that there is a portion of area at the end of the firebox which is not taken into account as being supported by the girder. It is generally taken that the load on this area is transmitted directly to the firebox end plates. The length of this part is assumed to equal half the pitch of supporting bolts at each end of the girder. Then the total load taken by the girder is equal to

$$p\,(L - P) = W.$$

Where L = length of girder in inches.
P = pitch of supporting bolts in inches.
D = distance of girders apart in inches.
p = working pressure, pounds per square inch.
W = total load on girder in pounds.

Then the load on one bolt equals $\dfrac{W}{n}$.

Where n = number of supporting bolts.

For our case this equals

$$100\ (50 - 5) \times 5.5 = 24{,}750 \text{ pounds and } \frac{24{,}750}{9} = 2{,}750.$$

The same as before.

To find the bending moment of any girder stay take the "point" as being in the center of the girder. In our case we have:

At 1 (Fig. 6) we have a moment of 5.53×25 in one direction = 138.1 ton inches.

At 2 (Fig. 6) we have a moment of 1.228×20 in the opposite direction = 24.55 ton inches.

At 3 (Fig. 6) we have a moment of 1.228×15 in the opposite direction = 18.41 ton inches.

At 4 (Fig. 6) we have a moment of 1.228×10 in the opposite direction = 12.28 ton inches.

At 5 (Fig. 6) we have a moment of 1.228×5 in the opposite direction = 6.14 ton inches.

Then to find the maximum bending moment: Add together the product of 2, 3, 4, 5 above and subtract from 1. This gives us

$$138.1 - 61.38 = 76.72 \text{ ton inches.}$$

I give formulæ by which the maximum bending moment for a girder with bolts from one to ten in number may be calculated without finding the supporting forces:

No. of Supporting Bolts.	Formula.
1	$p\,(L - P)\,D \times L \times .000116$
2	$p\,(L - P)\,D \times L \times .0000744$
3	$p\,(L - P)\,D \times L \times .0000744$
4	$p\,(L - P)\,D \times L \times .000067$
5	$p\,(L - P)\,D \times L \times .000067$
6	$p\,(L - P)\,D \times L \times .0000638$

7	$p\,(L - P)\,D \times L \times .0000638$
8	$p\,(L - P)\,D \times L \times .0000621$
9	$p\,(L - P)\,D \times L \times .0000621$
10	$p\,(L - P)\,D \times L \times .0000609$

The references being the same as before and the answer being in ton inches. In our case, with nine bolts,

$$100\ (50 - 5) \times 5.5 \times 50 \times .0000621 = 76.72 \text{ ton inches.}$$

When we subject a beam, such as we are considering, to a load it bends about a line *OO*, Fig. 7, called the neutral axis, causing a tensile stress above this line and a compressive stress below the line. These stresses gradually increase from zero at *OO* to a maximum tensile at edge *A* and a maximum compressive at the edge *B*. This increase is at a uniform rate at

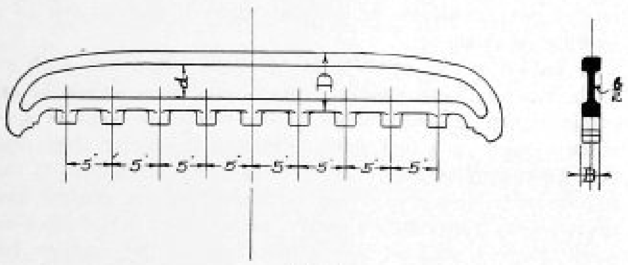


FIG. 4.

all points. If we take the case of an ordinary cantilever, Fig. 7, and apply a load of, say, 20 tons at 12 inches from the wall, we have a bending moment of

$$20 \times 12 = 240 \text{ ton inches.}$$

Now, if we move the weight to a distance of 2 feet from the wall we get a bending moment of $24 \times 20 = 480$ ton inches, or twice as much as previously.

If we call the distance between the support and the weight y_1 and the weight we represent by c a constant, because it does not vary with any particular case we may take, we get

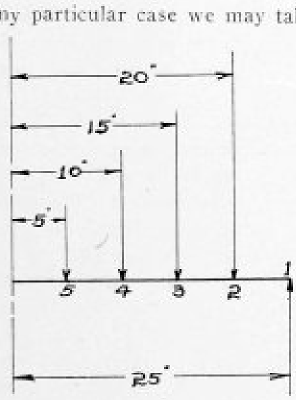


FIG. 5.

$$cy = M = \text{the bending moment at } n.\ m.$$

We see from this that M varies in direct proportion to the distance y_1. We get a similar case of we take a section *through* the beam (Fig. 7). The effect of the load is to cause stresses, which vary directly as the distance from the line *OO*, being greatest at *A* and *B*.

If we take an infinitely small area a (equal to $t \times t_1$) at a distance y from the neutral axis, then from the above force on area $a = c\ a\ y$.

Where c = a constant.

a = area.

y = the mean distance from the neutral axis.

Now the *moment of this force* about *OO* is

$$c\ a\ y \times y = c\ a\ y^2 = M \ldots\ldots\ldots\ldots\ldots (1)$$

Taking the sum of each small area a, multiplied by y^2 for the whole section, gives a value which we call the "moment of inertia" of the section. This is denoted by I, which, by the aid of the integral calculus, we find to be equal to

$$I = \frac{r\,d^3}{12} \text{ for rectangular sections} \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$I = \frac{B\,D^3 - b\,d^3}{12} \text{ for sections as that of Fig. 4} \ldots\ldots (3)$$

From the above 1 becomes

$$C\,I = M \text{ and } C = \frac{M}{I} \ldots\ldots\ldots\ldots\ldots (4)$$

From which we obtain the value of the constant.

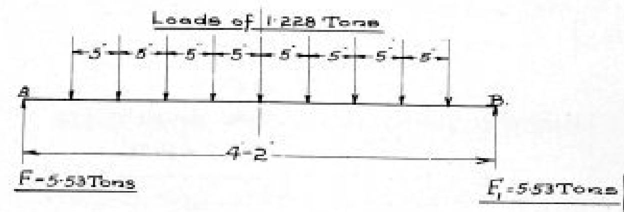


FIG. 6.

We have now seen how to obtain the values of M, the bending moment c, the constant, and I, the moment of inertia.

Since the stresses are proportional to y, evidently the greatest stress, f_c or f_r, is at the edges A or B, and is equal to

$$f = \frac{M}{I} \times y \ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

The value of y for each case is $\frac{d}{2}$, so that we get:

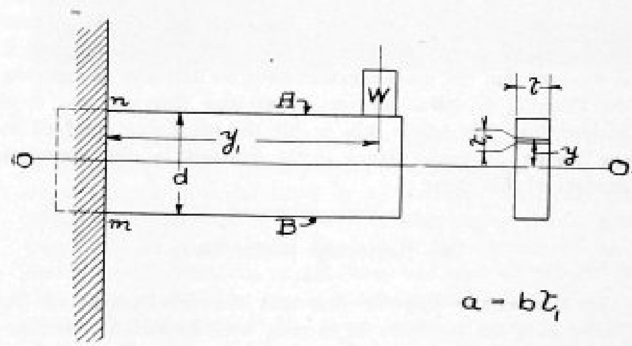


FIG. 7.

$$\text{Two equals } \frac{I}{Y} = \frac{\frac{t\,d^3}{12}}{\frac{d}{2}} = \frac{t\,d^2}{6} = Z, \text{ the strength modulus of the section} \ldots (7)$$

And three becomes

$$Z = \frac{\frac{B\,D^3 - b\,d^3}{12}}{\frac{D}{2}} = \frac{B\,D^3 - b\,d^3}{6\,D} \ldots\ldots\ldots (8)$$

Let us take the value of f_r and f_c at 28 tons per square inch for mild steel and at 30 tons per square inch for cast steel. Then with the factor of safety of 6 we get $\frac{28}{6} = 4.67$ tons per square inch permissible stress for mild steel and $\frac{30}{6} =$ 5.00 tons per square inch permissible stress for cast steel. The thickness of the plates for girders, as Fig. 2, is generally assumed to be ¾ inch, or a total thickness of 1½ inches. By transposing the equations 2, 5 and 7,

$$d = \sqrt{\frac{6 \times M}{r \times 2 \times f}} = \sqrt{\frac{6 \times 76.72}{.75 \times 2 \times 4.67}} = \text{say, } 8.125'' = 8.125''.$$

For Fig. 4 we have

$$f = \frac{6\,D\,M}{B\,D^3 - b\,d^3}$$

Taking $D = 7''$, $d = 3''$ and thickness of web $= \frac{3}{4}''$,

$$B \times 7^3 - b \times 3^3 = \frac{6 \times 7 \times 76.72}{5}$$

but $b = B - \frac{3}{4}''$. Then $B \times 7^3 - (B - \frac{3}{4}'')\,3^3 = \frac{6 \times 7 \times 76.72}{5}$

$$= 343\,B - 27\,B + 20.25 = 645 = 316\,B = 624.75$$

$$\therefore B = \frac{625.75}{316} = 1.98'', \text{ say } 2'' = B.$$

By calculating out the *weights* of the two types we find that the weight of the girder shown in Fig. 2 to be about 173 pounds, and that shown in Fig. 4 to be 148 pounds, which is a saving in weight of 25 pounds per bar; this multiplied by six, the number of bars, shows a total saving of 150 pounds per boiler. We have not time to discuss the problem of girders supported by sling stays fixed to the arch of the boiler, but it is thought that the reader should have no difficulty in applying the formula given to any case that may turn up, and it is trusted that this article will enable the principles involved in the design of girder stays to be grasped by the youngest readers of this paper.

The Neglected Boiler Shop.

It is a rather singular fact that the development of the boiler shop has not been in keeping with its activity, so characteristic in connection with other departments, and in many quarters a crying need for reform is strictly in order. Boiler shops can be found on roads even of considerable size that are equipped in a very inferior manner. Some of these are shops merely in name, and it is really astonishing that the repair work can be kept up at all with the limited facilities at hand. For instance, they may have but one power machine, and that of only moderate size, for punching and shearing; one or two drill presses in doubtful order, and one or two small bending rolls, together with the forges, etc.

This is a very inferior equipment for a boiler shop in which to handle any railroad work, even if nothing but repairs are done. It is impossible to do all the repairs in such a shop that may be necessary; or, at least, not possible to do them in an economical manner. On the other hand, an equipment sufficient to handle a fair amount of work at an economical figure should be supplied with tools somewhat as follows: A hydraulic riveting machine, if much new work is to be done, a large power punching machine, a large power shearing machine, large power plate bending rolls, a tube sheet boring machine, a power flue welder, drill presses, small shears, forges, etc. In other words, the boiler shop should be placed on an equal footing with the others, and it needs a mere glance through about half of the locomotive terminals in this country to make it plain that it is not.

No sufficient reason can be assigned for this neglect, and it certainly is one which costs money in labor arising from slow operations. We have in mind on a large Eastern railroad a shop not a great way from New York where flues are swaged down for ferrules by driving a die on the end by sledges. It requires three days' work for two men to so treat, say, 335 flues composing a set, where they might be done at the rate of one per minute by the application of suitable dies to a welding machine.

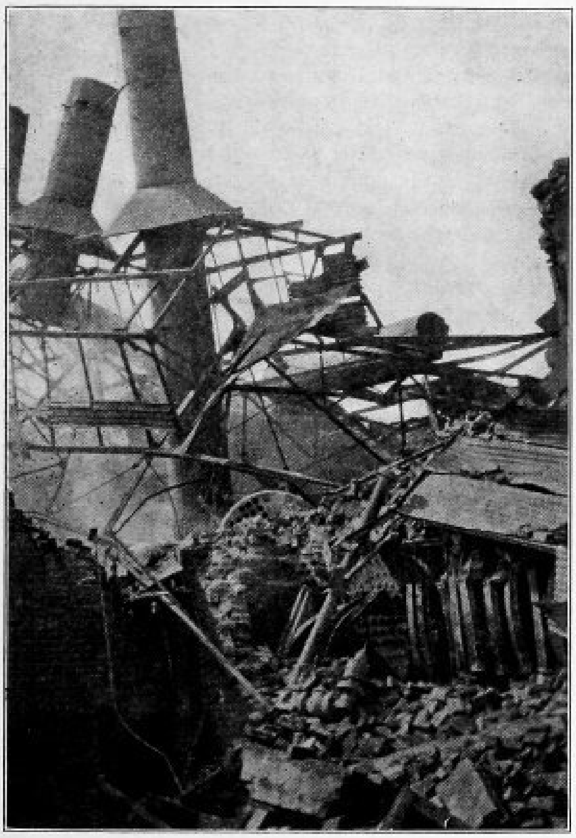
In regard to the small tools for boiler shop use, such as drills, reamers, taps, punches, chisels, etc., there should be an ample supply in every shop. They should be kept in systematic order in a tool room adjoining the boiler shop, and with strict regulations in regard to their use and return to the tool room. They should not be located in the general tool room, which is generally a part of, or an annex to, the machine shop, where a walk of half a mile becomes in order to get them, with, of course, the acompanying feature of so much lost time. Although the fact may have largely escaped notice, it is not very difficult to criticise boiler shop facilities in general, and it is now about time that this important department be accorded the attention to which it is entitled, and which is so liberally bestowed on other shops possibly far less vital to the success of the general scheme.—*American Engineer and Railroad Journal.*

Boiler Explosion at Georgetown, S. C.

On March 4, boiler No. 3 in plant No. 1 of the Atlantic Coast Lumber Corporation at Georgetown, S. C., exploded at 6:10 A. M., killing three persons and injuring four other persons.

The boiler plant consisted of ten H. T. boilers, set in one battery, eight of the boilers being in the boiler house proper and the other two boilers immediately adjoining the boiler house. As a result of the explosion the center sheet of No. 3 boiler was torn bodily from the boiler, and several boilers nearby were displaced and damaged to a greater or less extent. The roof of the boiler house, which was made up of structural iron trusses covered with corrugated iron, was almost a total ruin. Boilers Nos. 3, 4, 5 and 6 were practically ruined. The side walls of the boiler house, which was a building approximately 93 by 70 feet, were ruined to a greater or less extent, some of the wall being thrown down bodily, and much of the wall that remained standing must be taken down and rebuilt. A number of pumps, heaters, conveyors, engines, belting, etc., together with a very complete supply of operating materials in the engine room, were destroyed. The investigation as to the cause of the explosion appeared to show, according to sworn evidence of a number of witnesses, that the stipulated pressure of 100 pounds had not been exceeded. This fact was also corroborated by the record made by the recording steam gage, which showed a pressure of 98 pounds at the time of the accident. There was no evidence of burned sheets or of low water. Several pieces of the metal in the boiler were tested by being bent double while cold and showed no sign of fracture. The boiler failed at or near one of the longitudinal seams. Practically all of the fracture or break was not (as is usually the case) through rivet holes, but through the solid metal. There was, however, one section about 3 inches long torn through the rivet holes.

It is possible that there may have been a hidden crack at this point, and this appears to be the only reasonable cause of the accident; this boiler having been built in three courses with two sheets to each course, caused the longitudinal seams to be below the top of the tubes; consequently, it was practically impossible for an inspector to discover a hidden crack in the seam from the inside of the boiler, and it was equally impossible to discover the crack from the outside on account of the wall being close to the longitudinal seam. All of the boilers at the plant had been internally inspected during the Christmas holidays of 1910, and inspections were carefully and conscientiously made according to sworn statements of the chief engineer and foreman boiler maker at the plant, both of whom were with the inspector during the time the inspections were made. The boilers were insured with the Ocean Accident & Guarantee Corporation, which promptly paid $25,000 in settlement of the loss to property caused by the explosion.



THE EXPLOSION IN GEORGETOWN.

Extraordinary Collapse of a Furnace Tube.

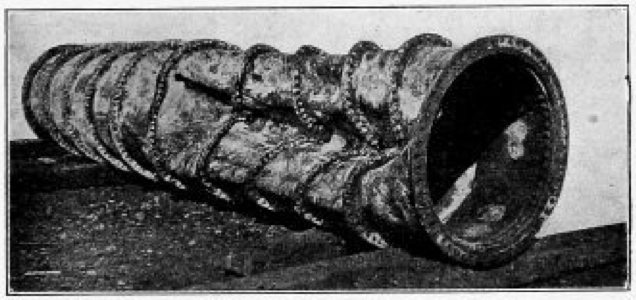
We reproduce a picture of an internal flue of a Lancashire boiler which recently collapsed to an extraordinary extent. The boiler was a high-pressure one, 8 feet 6 inches in diameter, with internal flues about 3 feet 5 inches, and, as will be seen, the flues were of the flanged ring type. The usual water gage glasses were fitted, and there was also a special low-water safety valve. It appears, however, all the water level indicators were out of order or misunderstood, and at the time of the collapse the level of the water in the boiler was probably about 1 foot 6 inches to 2 feet below the crowns of the flues. This is the most complete collapse of a flue composed of flanged rings that has come before our notice, and as there was no explosion, and the plates were not even fractured after their intense distortion, it speaks well for the ductile quality of the material. The crowns of the third and fourth rings from the front end, situated over the hottest part of the fire, were depressed until they were only about 8 inches from the bottom of the rings or ash-pits.

The boiler was not fitted with fusible plugs. This, in our opinion, is to be regretted, as reliable plugs would undoubtedly have been an advantage. Glass water gages and low-water valves should, however, not be neglected, even if boilers are fitted with fusible plugs. Water gages should be blown through and tested every few hours by the boiler attendant, and low-water safety valves overhauled and carefully adjusted by a competent fitter at every convenient opportunity. When water gages and low-water valves are out of order the attendant may be easily misled, but there is no mistaking the warning given by the melting of a fusible plug. In addition, it may be pointed out that an efficient plug will fuse in the event of overheating caused by deposit on the plates as well as by shortness of water.—*Vulcan.*

INCREASING THE CAPACITY OF BOILERS.

BY H. R. CALLAWAY.*

Among the many factors to be considered in the design of a central station is the provision for as large a capacity as possible per square foot of ground area. This is particularly important when the station is to be located in a large city where ground values and taxes are high.



A COLLAPSED FURNACE TUBE.

In the engine room great economy has been effected by the development of the steam turbine. Although the point most often advocated in its favor is its economy of steam consumption as compared to the reciprocating engine, the turbine's superiority is much more marked in the matter of space saving. Unfortunately, as yet there has been no parallel development of the boiler house, and if economy of space is to be attained in this part of the power plant it must be accomplished with the present boiler equipment. To this end a great many plants have been designed with the boilers arranged in two and even three tiers, but it is impossible to go any further in this direction.

In view of these facts, it is evident that the logical way in which to increase a station's capacity is by forcing the boilers to handle much greater overloads than have yet been attempted. In some cases as high as 200 percent of rating has been developed with water-tube boilers operated by mechanical stokers and with forced draft, but with the present design such a rating cannot be attained in every-day operation.

In looking over the field of boiler equipment with this purpose in view, natural-draft outfits of all descriptions and also hand-fired boilers are at once eliminated. The possibility of forcing a boiler to 250 or 300 percent of rating with natural draft or with hand firing is remote. The amount of coal burned per square foot of grate for, say, 300 percent of rating would probably amount to between 100 and 125 pounds per hour, and, obviously, no fireman could handle any

* *Power*, January, 1911.

such amount as this. Even if coal could be shoveled fast enough, it would be necessary to open the doors frequently, with a corresponding loss of efficiency through the introduction of cold air. Furthermore, in order to obtain a rate of combustion as rapid as this, it would be necessary to carry a very thick fire, and no chimney could furnish sufficient draft to burn coal at this rate unless the flue temperatures were very high, in which case the efficiency of the unit would be low and the object of forcing the boilers would be defeated. Therefore, in order to maintain such a high rate of combustion, forced draft and some method of mechanical stoking are essential.

As already mentioned, as high as 200 per cent. of rating has been obtained with ordinary settings. In certain tests in which this figure was reached a 650-horsepower Babcock & Wilcox boiler was fired by a gravity underfeed stoker with forced draft. Although the boiler was designed to deliver 650 horsepower, the baffling and combustion chamber being proportioned for this load, a rating of 1200 horsepower was reached with only a small drop in over-all efficiency. A set of curves plotted from these results shows conclusively that a much higher rate could have been attained if the combustion chamber had afforded sufficient space in which to completely burn the hydrocarbons. There seems to be little doubt that the stoker could have been operated at a much higher rate with very little, if any, drop in the efficiency, but the boiler was undoubtedly taxed to its limit, and the conclusion seems to be that alterations in boiler design would enable the same unit to be forced to an even greater extent. In the unit under consideration, the length of the first pass along the bottom tubes was 7½ feet out of a total length of 16 feet of tube. It might be practicable to increase this length to 9 feet, thus obtaining a 20 percent greater area of cross-section for the first pass.

In order to provide a larger combustion chamber, the boiler might be raised two feet higher, which, in this case, would have given a 40 percent volumetric increase in the furnace. At 1000 horsepower the velocity of the gases through the tubes, although varying to some extent at different points, approximated 24 feet per second throughout. At double this horsepower, which would correspond to slightly more than 300 percent of rating with the same proportions of air and coal burned, and assuming that the efficiency remained nearly constant, the velocity of the gases would be about double, or 48 feet per second. If, however, the area of the first pass were increased as previously mentioned, this figure would be cut 20 percent, giving a velocity at the entrance of the first pass of 40 feet per second. The second and third passes would of necessity be decreased in size, thus tending to produce a greater velocity in this section of the boiler; but, on the other hand, it has been well demonstrated that an increase of velocity of the gases is productive of an increased rate of heat transfer through the boiler tubes, in which case the gases would be cooled at a higher rate and their volume correspondingly diminished. Accordingly, the velocity at the back end of the boiler would probably drop to nearly the same rate as that obtained in the first pass.

Assuming that the increased rate of heat transfer was not proportional to the increased velocity in the first pass, the effect would be to make the middle and upper tubes of the first pass do a greater proportion of the work of evaporation than is the case at present. It is well established that between 75 and 85 percent of the evaporation in watertube boilers of this type takes place in the first pass, and it is probably true that one-half of this amount is contributed by the two lower rows of tubes. In view of this, an increase in temperature in the upper part of the first pass would merely result in the upper tubes of the first pass and all the tubes in the second and third passes doing more nearly their proper share of the evaporation. If the velocity of the gases were greatly increased, as would probably be the case throughout the boiler, and the heat transfer increased, at least to some degree, it is scarcely likely that the flue temperature would be raised enough to seriously affect the efficiency of the unit. The increased velocity and greater volume of gas would increase the resistance offered by the tubes, but this could be taken care of by a stronger draft.

In order to evaporate water at such a rate, and consequently burn coal so rapidly, the fuel bed would probably have to be between 4 and 6 feet thick, which would make it necessary to have a greatly increased draft in any case. A fuel bed 3 feet thick has been successfully carried by the type of stoker used in the tests referred to with a draft of from 2 to 3 inches, and there is no reason to doubt that one considerably thicker could be maintained. It would require experiment to determine with any degree of accuracy how great a draft would be required, but probably 8 or 10 inches of water would answer.

In Professor Nicolson's researches on heat transfer with increased velocity of the gases, he advocates draft-gage pressures of 20 inches of water, but these would be utterly impracticable, as it would be impossible to keep the coal on the grates with such a heavy pressure. In the tests mentioned it was found that while the temperature of the combustion chamber varied very little under different load conditions, the temperature at the middle of the first pass varied, roughly, 200 degrees between normal rating and 100 percent overload. As this rise in temperature at the middle of the first pass was proportional to the rise in load throughout the test, it is reasonable to assume that the same law would hold up to 300 percent of rating. In this case, the temperature at the middle of the first pass would be 400 degrees higher than when the boiler was operated at 650 horsepower. This added temperature would make it necessary for the upper part of the first pass to do considerably more work, and it is scarcely probable that the temperature in the second pass would be much higher than under normal conditions.

It seems, on the whole, quite feasible to so arrange a boiler that it will absorb economically the heat evolved from coal burned at such a high rate. Then the problem would be to burn the coal with a good enough economy to make this excessive overload worth while. The impossibility of doing this with hand firing is obvious, and the stoker which will accomplish the desired result must not only furnish the coal at this tremendous rate but must also coke it thoroughly before it becomes ignited, in order that the hydrocarbons and other volatiles may be distilled off and pass through the zone of maximum heat in order to be completely consumed. Otherwise, smoke will result and with it a loss of efficiency.

The necessarily intermittent operation of hand cleaning with its checking of the fire could not be permitted, so the stoker, to meet these conditions, must be of the self-cleaning type and the ashes must be removed without the admission of cold air. As the whole object of the scheme herein outlined is rapid and continuous operation, the importance of automatic cleaning of the stoker grates is evident.

The phase of this problem, which is not only the most difficult but also the most important, aside from the stoker design itself, is that of securing the proper proportions of air and coal. As the amount of coal fired per hour is increased, the amount of air should be automatically controlled in such a way as to increase proportionately; that is, if the allowable amount of excess air has been determined upon for the coal used, it should be possible to so arrange the mechanism of the stoker that this ratio of excess air is maintained constant, regardless of the load conditions. This is a problem the solution of which has not heretofore been reached for these extreme conditions, because such overloads as those considered have not been tried.

DIAGONAL JOINTS AND TUBE-HOLE ROWS.*

In boilers of certain types, holes for the reception of tubes are cut through drums or shells, so that the perforations constitute lines of weakness in the plate. When these perforations are so disposed that the line of probable (or possible) fracture runs parallel to the length of the shell or drum, or circularly around it, there appears to be no misunderstanding as to the method to be followed in investigating the effect of such perforations upon the pressure to be allowed upon the boiler. On the other hand, when the line of possible fracture follows a diagonal or oblique course, so as to make an acute angle both with the longitudinal joint and with the girth joints, we find much the same confusion as to the effect of such holes upon the safe working pressure in the boiler that exists in the case of the diagonal joint. In the present article, therefore, we shall dwell not only upon the diagonal riveted joint, but also upon the lines of weakness caused by the presence of tube-holes in a drum or shell. In explaining the principles of the subject, however, we shall speak merely of the riveted joint, taking up the application to tube-holes subsequently.

MEANING OF THE TERM "UNIT OF A JOINT."

In calculations relating to riveted joints, it is often convenient to confine our attention to a single "unit" of the joint; a "unit" being a section of the joint of such length that the whole joint can be regarded as made up by a repetition of such units, or sections, by placing them end to end. In Fig 2, for example, the shaded sections show "units" of the respective types of joint there illustrated, and it will be plain that each joint may be regarded as made up by merely repeating these shaded sections, as indicated by the numerals 1, 2, 3, 4, etc. If the joint is of indefinite length, it is also evident that a section two, three, four, or any integral number of times as long as one of the shaded sections, might also be regarded as a "unit," inasmuch as the entire joint could still be considered to be made up by a repetition of these longer sections, or units. But it is usual to use the word "unit" to signify the smallest portion of the joint that fulfills the given condition of being sufficient, by continued repetition of itself, to make up the whole joint.

The advantage of dealing with a unit of a joint, instead of with the entire joint, consists in the fact that the efficiency of the whole joint is the same as the efficiency of any one of its units; and we therefore do not need to know anything about the total length of the joint, in calculations relating to efficiency.

AMBIGUITY OF THE TERM "EFFICIENCY OF A JOINT."

One of the chief difficulties encountered in connection with explaining the principles involved in the diagonal joint consists in the fact that the term "efficiency" is used in two different senses. The commonest way to define the word is to say that the "efficiency" of a joint is a fraction which expresses the strength of a unit of the actual joint, in terms of the strength of an equal section of the solid plate, before it is perforated by rivet holes. Expressed in other words, this definition says that the "efficiency" of the joint is the fraction, or percentage, by which we must multiply the strength of the solid, unperforated plate, in order to obtain the strength of a section of the joint of equal length. This is perhaps the commonest point of view respecting riveted joints, and it is quite satisfactory when applied to fore-and-aft joints in a boiler shell or drum, or to joints in any position whatever in a metal plate in which the tension is the same in all directions. We shall call the efficiency, as so defined, the "ordinary efficiency" of the joint.

There is another sense in which the word "efficiency" is used in connection with riveted joints, however. This may best be explained in the following way: Let us first calculate the internal pressure that would have to be applied to the boiler in order to produce rupture of the shell, if the shell were solid, and had no riveted joints whatever. Now the actual shell, since it *has* riveted joints, is presumably weaker than this, and fracture would presumably occur at a joint, before the shell itself gave way.† The fraction by which we must multiply the pressure that would rupture the solid shell, in order to obtain the pressure that would produce fracture at the joint, may also be called the "efficiency" of the joint; and this is the definition that is actually used, in dealing with diagonal joints. We shall call this kind of efficiency the "effective efficiency" of the joint (scholars will please pardon the unlovely name), because it is upon this efficiency that the effective strength of the boiler or drum directly depends. The "ordinary" and "effective" efficiencies are identically the same thing in the case of a longitudinal (or fore-and-aft) joint in a boiler shell, but they are quite different in the case of a diagonal joint, or a girth joint. As a perfectly clear understanding of the difference between these two kinds of efficiency is essential to a correct treatment of the problem of the diagonal joint, we shall discuss the matter at some length before proceeding further.

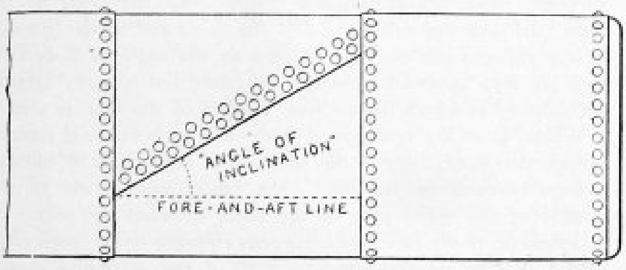


FIG. 1.—ILLUSTRATING THE DIAGONAL RIVETED JOINT.

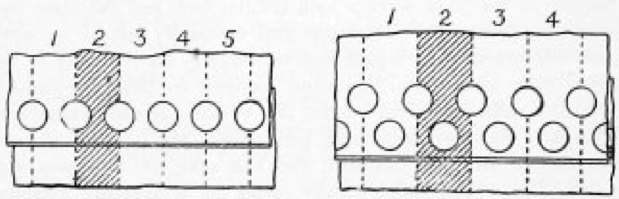


FIG. 2.—ILLUSTRATING THE TERM "UNIT OF A JOINT."

THE "ORDINARY" EFFICIENCY OF A LONGITUDINAL JOINT.

In determining the "ordinary" efficiency of a longitudinal (or fore-and-aft) joint, we begin by considering the various ways in which the joint can fail (as, for example, by shearing the rivets, or by breaking the ligaments between the rivet holes). Fixing our attention upon some one of these possible modes of failure, we then calculate the tension that would have to be exerted upon one unit of the joint, in order to cause it to fail in the proposed manner. We then calculate the tensile stress that would have to be exerted upon a strip of the solid, unperforated plate, of a width equal to the length of a unit of the joint, in order to cause the fracture of the solid plate. The stress that would have to be applied in order to cause the failure of the joint in the proposed manner, divided by the stress that would have to be applied to the plate itself in order to rupture it, gives the "ordinary efficiency" of the joint, so far as failure in the proposed manner is concerned.

We next proceed to consider, in the same way, every other mode of failure that appears probable, or possible, and for

* *The Locomotive.*

† This is not necessarily the case with a diagonal joint, if its obliquity is large; but for the sake of simplicity we do not refer to this exception in the text.

each we compute the "ordinary" efficiency as regards failure by that particular method; so that for every method by which failure might conceivably occur, the joint has a corresponding "ordinary efficiency." Some of these various efficiencies may happen to be equal to one another, but in general they will all be different, and we then take, as our final estimate of the "ordinary efficiency" of the joint, the lowest value obtained in these various calculations; for the joint will fail, presumably, by that mode for which the calculated efficiency is least.

THE "EFFECTIVE" EFFICIENCY OF ANY JOINT.

Our definition of the "effective efficiency" of a joint does not throw any light, directly, upon the way in which the numerical value of that efficiency is to be obtained, in practice. It merely fixes the meaning of the term "effective efficiency," so that when we go about the actual work of calculating that numerical value we may do so with a clear understanding of the nature of the thing we are after.

To make the matter clear, let us look at the case from the following point of view: First, let us suppose that the boiler containing the joint whose "effective efficiency" we are seeking is so strong in all other respects that, if we expose it to a hydrostatic pressure until it bursts, the failure will consist either in the rupture of the joint, or in the development of a fracture elsewhere, running fore and aft through the solid metal of the shell; the heads and other parts being assumed (for the sake of the illustration we are about to give) to be stronger than any part of the shell. The hydrostatic pressure being applied until the boiler gives way, let us further suppose that the rupture occurs at the joint. (This would necessarily happen if the joint were a longitudinal one, and the plate had everywhere the same thickness and strength; but, as we shall see subsequently, it would not necessarily be the case if the joint were a diagonal one, and inclined to the fore-and-aft line at a sufficiently high angle. As we have already remarked, diagonal joints of these high inclinations are left out of consideration, for the moment, for the sake of clearness and simplicity.) The failure may occur by a fracture running from rivet-hole to rivet-hole, or by the rivets shearing, or perhaps by the edges of the plate giving way so that the rivets tear out directly; or two or more of these possible modes of failure may occur simultaneously, in different parts of the joint. Whatever the manner in which the rupture at the joint occurs, let us call the corresponding pressure the "bursting pressure with a joint."

Now consider a shell made up of exactly the same material as before, and identical with the previous one in every respect, except that it has no joint whatever, but is a mere cylindrical sheet, everywhere uniform in strength and thickness, and provided with heads so stiff and strong that failure must occur in the shell itself. If hydrostatic pressure be applied to this shell until it ruptures, then (since the stress in such a structure is greatest in the girth-wise direction) failure will take place by the formation of a fracture running through the solid metal of the shell, in a direction parallel to the length of the boiler. Let us call the bursting pressure, in this case, the "bursting pressure without a joint."

If, now, we divide the "bursting pressure with a joint" by the "bursting pressure without a joint," the quotient will be what we have called the "effective efficiency" of the joint. Conversely, if we knew the "effective efficiency" of the joint, and we wanted to find the pressure at which a boiler shell, provided with such a joint, would give way, we should first determine the pressure at which the shell would burst if it were continuous, or jointless, and we should then multiply this pressure by the known "effective efficiency" of the joint, and the product would be the pressure under which the joint might be expected to fail.

CAUSE OF THE DIFFERENCE BETWEEN THE TWO KINDS OF EFFICIENCY.

If the tensile strength in a boiler shell were the same in all directions, the two kinds of efficiency, as defined above, would be identically the same. It is known, however, that when a boiler is subjected to an internal pressure which acts both upon the shell and upon the heads, the shell is (in general) subjected to a state of stress such that the tension, at any given point, is different in different directions. If the heads of the shell are not braced in any way, but are capable of resisting the pressure simply by reason of their thickness, or by reason of their being bumped, then the tension per square inch on the metal of the shell is exactly twice as great in the round-about direction as it is in the lengthwise direction. In actual boilers, however, the stress, lengthwise of the shell, is often much less than half of the girthwise stress. In the horizontal tubular boiler, for example, the two heads are connected, in the lower part of the shell, by tubes, which reduce the stress upon the shell in two ways: (1) by diminishing the area on the head that is exposed to pressure, and (2) by supporting the entire steam load that comes upon the ligaments between the tube-holes, as well as that upon a certain fraction of the remaining portion of each head. In some boilers, the upper parts of the heads are stayed by through braces, running from head to head, so that a considerable part of the steam load upon the heads is directly transmitted from one end of the boiler to the other, through these braces, without influencing the shell in the least. In such cases the action of the tubes and of the through braces reduces the endwise tension on the shell so materially that we may approach (though we could not actually attain) a condition in which the endwise tension of the shell is zero.

When, as in the commonest form of the horizontal tubular boiler, the heads, above the tubes, are supported by oblique braces running to the shell, the lengthwise stress in the middle of the upper part of the shell, between the points of attachment of the two sets of braces running to the respective heads, will be nearly equal to half of the girthwise stress. In the upper part of the shell of this same form of boiler, between either head and the points of attachment of the braces running from that head, the lengthwise stress will be somewhat less than in the middle of the boiler—how much less depends upon the number, disposition, and effectiveness of the braces. To attempt to take account of all these points in any general or systematic way would lead to a long discussion that would doubtless, in the end, be of little or no practical value. We mention these various details, however, to emphasize the fact that in the case of an actual boiler the lengthwise stress in the shell may have any value, from almost nothing up to one-half of the girthwise stress. Now in our first definition of efficiency (i. e., in the case of "ordinary efficiency"), there is nothing said about the position of the joint in the boiler shell; and hence we should obtain the same result, in following out that definition, whether the joint had to resist the full girthwise stress in the shell, or only the lengthwise stress, which has a very different value, as we have just seen. A joint having an "ordinary efficiency" of 50 percent would give way, if it were placed longitudinally on a boiler, when the test pressure became equal to one-half of the pressure that would be required to burst the solid shell; but a joint of identically the same design, if placed girthwise of the boiler, would not give way until the test pressure became great enough to fracture the shell itself in a lengthwise direction, even if the boiler had no tubes nor braces, so that the longitudinal stress in the shell had the greatest value possible. Such a girth joint would therefore have an "ordinary efficiency" of 50 percent, while its "effective efficiency would be 100 percent or more.

In longitudinal and girth joints, the two definitions of "efficiency" do not give rise to any confusion, because the facts are well understood in these cases; but when we come to deal with the less familiar diagonal joint, we have to proceed with considerable care.

DERIVATION OF THE RULES FOR DIAGONAL JOINTS.

On account of the apparent difference of opinion among engineers respecting the proper method of calculating the efficiency of a diagonal joint, or that of a diagonally disposed row of tube holes, we have thought it best to explain the theoretical principles that underlie the rules that are given in the present article.

As we have already pointed out, the stress in a boiler shell is greater, girthwise, than it is lengthwise; and hence the weakening of a boiler shell due to the presence of a riveted joint depends not only upon the design of the joint, but also upon the angle that the joint makes with a line running lengthwise of the boiler. Let us now picture to ourselves a boiler shell, built all in one piece, so that it is simply a thin steel cylinder, without any joints whatever, except where it is fastened to the heads; and let us assume that this shell is exposed to a steady hydrostatic pressure, of such intensity that the shell is strained to a point just short of its breaking strength. Next, let us draw upon this shell a line, say, one foot in length, and making a definite angle with the fore-and-aft direction, and let us consider the condition of stress that the metal of the shell is in, immediately under this line. That is, let us consider what the stress is which acts upon the shell so as to tend to fracture it along the line we have marked out. If this line is parallel to the length of the boiler, the metal under it will be strained to a point just short of its breaking strength; but if it runs at right angles to this direction (that is, if it runs girthwise), the tension acting in the shell in a direction perpendicular to the line will not exceed half of the breaking strength, and it may be much less than this, as we have already pointed out in discussing the effect of tubes and bracing in the preceding section of this article. It is easy to infer that if the line is neither parallel to the length of the shell nor perpendicular to it, but lies at an oblique angle between those two positions, the stress acting perpendicularly to the line, and tending to produce fracture along it, will have a value intermediate between the full tensile strength of the plate and the tension experienced by the same line when lying in the girthwise position. In fact, if the shell upon which the line is drawn is provided with heads that are not braced in any way, nor connected by tubes (the lengthwise stress in the metal being then one-half of the girthwise stress), it may be shown that when the line we have marked out makes an angle of 30 degrees with the length of the boiler, the tension acting perpendicularly to the line, and tending to produce fracture along it, will be 0.875 of the strength of the plate; and that when the line makes an angle of 45 degrees with the length of the boiler, the corresponding tension will be 0.75 of the strength of the plate; and that when it makes an angle of 60 degrees with the length of the boiler, the tension tending to produce rupture along the line will be 0.625 of the strength of the plate. The stress in the plate perpendicularly to any given line, in other words, varies in a perfectly definite manner as the inclination of the line to the length of the boiler varies, and is greatest when that inclination is least.

To find the "effective efficiency" of a diagonal joint making a given angle with the length of the boiler, we therefore calculate the "ordinary efficiency" first, in the usual way. This would be the efficiency to be used in calculating the strength of the boiler, if the joint were placed parallel to the length of the boiler; but inasmuch as the actual joint is inclined to the length of the boiler, and is therefore not subjected to so great a stress as would come upon it if it lay in a fore-and-aft position, it does not reduce the strength of the boiler by the amount corresponding to the "ordinary efficiency" as so calculated; and to find the efficiency that is to be assigned to such a joint in calculating the resistance of the boiler to internal pressure (i. e., the "effective efficiency"), we therefore have to increase the efficiency as calculated for a fore-and-aft joint, by an amount which depends upon the position of the diagonal joint, and upon the way in which the heads of the boiler are braced. The numbers by which the efficiencies of longitudinal joints must be multiplied, in order to obtain the corresponding efficiencies of diagonal joints of a like design, are given in the accompanying table, and the use of the table is explained by the following rules and the illustrative example.

LIMITATIONS OF THE RULES AND OF THE TABLE.

The rules that are given below apply only to lap joints, which fail either by the breaking of the ligaments between the rivet-holes, or else by the shearing of the rivets. In a butt strap joint, or in any kind of a joint in which failure may occur partly in one way and partly in another (as by the shearing of certain rivets and the simultaneous fracture of the plate elsewhere), the same rules apply, for finding the effective efficiency of the diagonal joint with respect to modes of failure consisting solely in the shear of the rivets, or solely in the breakage of the plate; but the rules no longer hold true, in such butt joints, for other modes of failure, consisting in a simultaneous rivet-shear and plate-failure. This is because the tabular factor for finding the effective efficiency as respects the shearing of the rivets is different from the corresponding factor for finding the effective efficiency as respects fracture of the plate. A rule that would apply accurately to butt strap joints (or to other joints of a similarly complex design), for any mode of failure whatever, would be quite complicated; and as such joints are seldom used in the oblique position, we have not thought it necessary to discuss them. In any case of this sort that may arise, we shall err on the safe side if we calculate the efficiency, first, as though the joint were a longitudinal one, and then multiply the result, whatever the probable mode of failure, by the "factor for rivet efficiency" in the table; because, in any given joint, the factor for rivet efficiency (for a given inclination of the joint) is never greater than the factor as regards plane-fracture; and hence, if a diagonal butt strapp joint is safe when this factor is used for all modes of failure, we may be assured that it would be safe if we used the mathematically correct factor for each mode of failure separately.

THE ARRANGEMENT AND USE OF THE TABLE.

For convenience of reference, each column of the table has been provided not only with its own proper head-line, but also with a black-faced letter, A, B, C, etc., by which the column may be designated.

The angle that a given diagonal joint makes with a line running lengthwise of the boiler is called the "inclination" of the joint, as indicated in Fig. 1; the table was arranged so that in using it we had to know the inclination, in degrees, in order to make the necessary calculations. It is much more convenient in practice, however, to designate the obliquity of the joint by giving what is called the "sine" of the inclination, instead of the inclination itself, in degrees. Fig. 3 shows what is meant by the "sine of the inclination" of the joint. To determine it we mark off a convenient number of units of the joint, and measure the total length (AB) of this selected number of units. In the illustration we have supposed that the inspector has chosen to measure the length of the eight units of the joint, and that he has found the total length of these eight units to be exactly 20 inches. Next, we measure the amount (*BC*) by which the diagonal joint departs, in a girthwise direction, from a straight fore-and-aft line, in eight units of its own length. In the illustration we have supposed that this girthwise departure, or travel, of the diagonal joint is 9½ inches, for eight units of length of the joint. If we now divide *BC* by *AB*, we obtain what is called the "sine of the inclination" of the joint. Thus in the case we have illustrated in Fig. 3, the "sine of the inclination" is $9.5 \div 20 = 0.475$.

In using the table in accordance with the rules presently to be given, we take the "sine of the inclination" of the joint as the measure of the obliquity of the joint; and Column *A* gives the values of the sine of the inclination, for every hundredth, and for all possible angles of obliquity, from the position where the joint is a true fore-and-aft joint to where it becomes a true girth joint. As cases may arise in which it is more convenient to use the actual angle of inclination (*BAC* in Fig. 3) instead of the sine of that angle, we have given in Column F, the angles corresponding to the respective sines in Column *A*.

RULES FOR FINDING THE "EFFECTIVE EFFICIENCY" OF A LAP-RIVETED DIAGONAL JOINT.

RULE 1. To find the "effective" ligament efficiency; that is, the "effective" efficiency with respect to the breakage of the plate through the rivet-holes:

First find the ordinary efficiency of the joint, in the usual way, so far as concerns the tendency to break the ligaments of the plate between the rivet-holes. Then, in column *B* or column *D* of the table, find the factor corresponding to the sine of the inclination of the joint, and multiply the ordinary

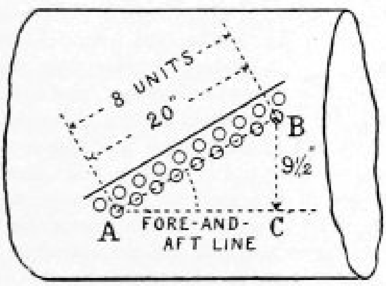


FIG. 3.—ILLUSTRATING THE "SINE OF THE INCLINATION."

efficiency, as just found, by this factor. The result is the effective efficiency which is to be assigned to the joint, so far as fracture of the ligaments between the rivet holes is concerned. The tabular factor is to be taken from column *B*, if the joint occurs on a shell whose heads are not braced, and not connected by tubes; and it is to be taken from column *D* if the shell is entirely free from lengthwise stress, by reason of the heads being united by braces or tubes, in such a manner that the load on the heads is directly transmitted from one head to the other, without any part of it coming upon the shell. For cases in which the support of the heads is such that the stress, lengthwise on the shell, is intermediate between zero and the greatest value that is possible, a value for the efficiency should be selected, intermediate between the two values obtained as here described; the selection of this intermediate value being made with due reference to the actual mode of support of the heads, and to the consequent degree of approximation of the conditions to the two respective extreme cases covered by the table. In a horizontal tubular boiler, fitted with tubes in the usual manner, the efficiency of the joint will approach that calculated by column *D*, when the joint is in the lower part of the shell, and it will approach that calculated by column *B*, when the joint is in the upper part of the shell and near the middle of the boiler.

RULE 2. To find the "effective" efficiency as regards the shearing of the rivets:

First find the ordinary efficiency of the joint, in the usual way, so far as concerns the tendency of the rivets to fail by shearing. Then, in column *C* or column *E* of the table, find the factor corresponding to the sine of the inclination of the joint, and multiply the ordinary efficiency, as just found, by this factor. The result is the effective efficiency that is to be assigned to the joint, so far as the shearing of the rivets is concerned. The tabular factor is to be taken from column *C*, if the heads are unsupported by either braces or tubes; and it is to be taken from column *E* if the load on the heads is so perfectly supported by tubes, or through braces, or otherwise, that no part of it comes on the shell. In practical cases in which neither of these conditions is accurately fulfilled, a value of the effective efficiency lying between these two extreme values is to be selected, the principles governing the selection being the same as in the preceding rule.

Having determined the effective efficiency as regards breakage of the plate through the rivet-holes, and also the effective efficiency as regards the shearing of the rivets, the lesser of these two efficiencies is to be accepted as the final estimate of the effective efficiency of the joint, for use in computing the strength of the shell upon which the joint occurs.

EXAMPLE IN THE USE OF RULES.

To illustrate the application of the foregoing rules to a concrete case, let us consider a double-riveted lap joint of the following proportions: Pitch of rivets, 2⅞ inches; diameter of rivet-hole, 13/16 inch; thickness of plate, ⅜ inch. The plate

TABLE OF FACTORS FOR DIAGONAL JOINTS.

A.	HEADS ENTIRELY UNBRACED ENDWISE STRESS ON SHELL EQUAL TO FULL LOAD ON HEAD.		HEADS SUPPORTED IN SUCH A MANNER THAT THERE IS NO ENDWISE STRESS ON SHELL.		F.
SINE OF THE CLINATION OF THE JOINT.	B. Factor For Ligament Efficiency.	C. Factor For Rivet Efficiency.	D. Factor For Ligament Efficiency.	E. Factor For Rivet Efficiency.	Inclination of Joint to Fore-and-Aft Line.
.55	1.178	1.137	1.434	1.197	33° 22′
.60	1.220	1.170	1,562	1.250	36° 52′
.65	1.268	1.210	1.732	1.316	40° 32′
.70	1.325	1.257	1.961	1.400	44° 26′
.75	1.391	1.315	2.286	1.512	48° 35′
.80	1.471	1.387	2.778	1.667	53° 08′
.85	1.566	1.477	3.604	1.898	58° 13′
.90	1.681	1.596	5.263	2.294	64° 09′
.95	1.822	1.759	10.256	3.203	71° 48′
1.00	2.000	2.000	Infinite	Infinite	90° 00′
.05	1.001	1.001	1.003	1.001	2° 52′
.10	1.005	1.004	1.010	1.005	5° 44′
.15	1.011	1.009	1.023	1.011	8° 38′
.20	1.020	1.015	1.042	1.021	11° 32′
.25	1.032	1.024	1.067	1.033	14° 29′
.30	1.047	1.036	1.099	1.048	17° 27′
.35	1.065	1.049	1.140	1.068	20° 29′
.40	1.087	1.066	1.190	1.091	23° 35′
.45	1.113	1.086	1.254	1.120	26° 45′
.50	1.143	1.109	1.333	1.155	30° 00′

will be assumed to have a tensile strength of 55,000 pounds per square inch of sectional area, and the rivets will be assumed to be of steel, with a shearing strength of 42,000 pounds per square inch. The inclination of the joint to the fore-and-aft direction will be assumed to be such that when we measure off eight units of the joint, as shown at *AB* in Fig. 3 (the total length of *AB*, in the present case, being $8 \times 2\frac{7}{8}$ inches $= 23$ inches), we find that the distance *BC*, by which this length of the joint departs, in a girthwise direction, from the fore-and-aft line through *A*, is 11½ inches; so that the sine of the inclination of the joint, in this case, is $11\frac{1}{2} \div 23 = 0.500$.

We must find the ordinary efficiencies of the joint in the usual way, with respect both to fracture through the rivet-holes, and to the shearing of the rivets. Thus:

Tensile strength of a strip of solid plate of width equal to the length of one unit of the joint $= 55{,}000 \times \frac{3}{8}$ inches $\times 2\frac{7}{8}$ inches $= 59{,}297$ pounds.

Shearing strength of one rivet (see table in the *Locomotive* for October, 1903, page 150) $= 21{,}776$ pounds. As there are two rivets in each unit of the joint, the total strength of the rivets that must be sheared in each unit, to cause failure of the joint by shearing, is $2 \times 21,776 = 43,552$ pounds.

Hence we have:

Rivet efficiency $= 43,552 \div 59,297 = 0.734$.

We also have

Ligament efficiency $= (2\frac{7}{8}$ inches $- 13/16$ inch$) \div 2\frac{7}{8}$ inches $= 2.0625$ inches $\div 2.875$ inches $= 0.717$.

Our results therefore are:

"Ordinary efficiency" as regards breakage of the plate through the rivet-holes = 71.7 percent.

"Ordinary efficiency" as regards the shearing of the rivets = 73.4 percent.

We have now to take account of the fact that the joint lies in a diagonal or oblique position, instead of in a true fore-and-aft direction; and we shall do this, *firstly*, for the case in which the heads of the boiler or drum, upon which the joint occurs, are entirely unsupported by braces or tubes, so that the full steam load upon the heads is transmitted to the shell; and, *secondly*, we shall do it for the case in which the heads are so perfectly supported, by tubes or through braces or otherwise, that no sensible part of the load upon them is transmitted to that part of the shell where the diagonal joint is located.

When the full load upon the heads is transmitted to the shell, the factors for taking account of the obliquity of the joint are to be sought in columns *B* and *C* of the table. We found that the sine of the inclination of the joint under consideration is 0.500. We therefore look for this number in column *A*; and opposite to it, in columns *B* and *C*, respectively, we find the numbers 1.143 and 1.109. Hence, for this particular joint and for the assumed conditions, we have:

"Effective efficiency" as regards breakage of the plate through the rivet-holes $= 71.7 \times 1.143 = 82.0$ percent.

"Effective efficiency" as regards the shearing of the rivets $= 73.4 \times 1.109 = 81.4$ percent.

It will be noticed that the "ordinary" efficiency of this joint is least with respect to the breakage of the plate through the rivet-holes; while the "effective" efficiency of the actual joint in its oblique position is least with respect to the shearing of the rivets. This change, or reversal, in the point of weakness is due, manifestly, to the fact that the factors in column *C* are smaller than the corresponding factors in column *B*; and a similar change, or reversal, will always occur, if the joint is oblique, and the ordinary rivet-efficiency exceeds the ordinary plate-ligament efficiency by a sufficiently small amount.

We pass, next, to the consideration of the case in which the joint has the same proportions as before, and the same degree of obliquity, but where the heads of the shell or drum on which the joint occurs are so perfectly supported by tubes, or through braces, or other equivalent means, that the shell receives none of the steam load upon the heads. In this case the procedure is the same as before, except that the factors must now be taken from columns *D* and *E*. We find these factors, accordingly, to be 1.333 and 1.155, respectively, for breakage through the rivet-holes, and for shearing of the rivets. Hence, for the conditions here assumed, we have:

"Effective efficiency" as regards the breakage of the plate through the rivet-holes $= 71.7 \times 1.333 = 95.6$ percent.

"Effective efficiency as regards the shearing of the rivets = 84.8 percent.

Here, also, we find that the rivets have become weaker than the net section of the plate, when the joint is in its oblique position; but the disparity is now much greater than it was before. It is in fact so great as to suggest that in diagonal riveted joints that are to be used on shells in which the endwise tension is very small, it would be well to make the rivets somewhat stronger, relatively to the net section of the plate, than is customary in ordinary longitudinal joints. For example, if the joint is to be used on such a shell, and the materials are the same as are assumed above, then we should have a stronger construction (with the joint in the diagonal position) if we should make the pitch of the rivets $2\frac{5}{8}$ inches instead of $2\frac{7}{8}$ inches, the proportions being otherwise the same as before. Such a joint has a ligament efficiency of 69.0 percent, and a rivet efficiency of 80.4 percent, when used as a longitudinal joint; but upon multiplying these values by the tabular factors, 1.333 and 1.555, respectively, we find that the joint, in its diagonal position, would have an "effective" efficiency of 92.0 percent, with respect to breakage between the rivet-holes, and 92.9 percent with respect to the shearing of the rivets.

This, it should be observed, is for the case in which the heads are fully supported, in such a manner that no endwise stress comes on the shell. When the construction is such that the entire load on the heads is transmitted to the shell, it would be better, in the joint here considered, to use the pitch $2\frac{7}{8}$ inches, as in the first part of this example.

When, as is the case in a horizontal tubular boiler, the heads are connected by tubes (or otherwise) so that a considerable portion of the load upon the heads is transmitted directly from one head to the other, without influencing the shell, while, at the same time, there is also a considerable portion of the load on the heads that is not so transmitted, but which must be sustained by the shell, it is practically impossible to give a rule for finding the effective efficiency of a diagonal joint exactly. The effective efficiency in such cases will be intermediate, however, between the least value obtained from columns *B* and *C* of the table, on the one hand, and the least value obtained from columns *D* and *E* on the other hand; and the best that we can do is to estimate its value, within this range, from our own knowledge of the actual mode of support of the heads.

When the joint is so designed that the rivet-efficiency and the ligament-efficiency are approximately equal, as calculated for a longitudinal joint in the ordinary way, there will not be any very wide difference between the effective efficiencies as calculated from columns *B* and *E*, unless the obliquity of the joint is extreme; so that in many of the practical problems that arise the assigning of a probable value to the effective efficiency of a diagonal joint in a structure similar to a horizontal tubular boiler is not at all a difficult matter. For example, in the illustrative joint considered above (with a pitch of $2\frac{7}{8}$ inches) we obtained the results given in the accompanying short table.

EFFECTIVE EFFICIENCIES OF THE ILLUSTRATIVE JOINT.

Nature of Lengthwise Stress on Shell.	Ligament Efficiency.	Rivet Efficiency.
Heads entirely unbraced; lengthwise stress on the shell a maximum.	82.0 %	81.4 %
No lengthwise stress on the shell.	95.6 %	84.8 %

The effective efficiency that we should have to adopt for the diagonal joint, if it were on a structure similar in design to a horizontal tubular boiler, would therefore be intermediate between 81.4 percent and 84.8 percent, the former being the smaller of the two values obtained for the case of a maximum endwise stress on the shell, while the latter is the smaller of the two values obtained for the case of the entire absence of endwise stress on the shell. If the joint were on the bottom of the shell, where the load on the heads is almost entirely sustained by the tubes, its effective efficiency would approximate closely to 84.0 percent (i. e., a little less than 84.8 percent); while if it were on the upper part of the shell, towards the middle of the boiler (so as to be between the braces running from the heads to the shell), its effective efficiency would approximate to 82.0 percent (i. e., a little more than 81.4 percent). We could therefore take the effective efficiency of the joint as equal to (say) 83.0 percent, for any part of the boiler, unless the computation were being made for the purpose of deciding some very fine point; and in that case the problem in hand would have to be considered on its own merits.

Having determined the "effective" efficiency of a diagonal joint on a cylindrical shell or drum, we proceed to calculate the bursting pressure of the shell in the usual way, except that this "effective" efficiency is to be used for the joint, instead of using the "ordinary" efficiency, as calculated for a longitudinal joint. The rule would therefore be:

RULE FOR FINDING THE BURSTING PRESSURE OF A SHELL HAVING A DIAGONAL LAP-RIVETED JOINT.

Multiply the tensile strength of the material of the shell, in pounds per square inch, by the "effective" efficiency of the diagonal joint, and multiply the result by the thickness of the plate, in inches. The product so found is then to be divided by the radius of the shell, in inches, and the result is the bursting pressure of the shell, in pounds per square inch.

Of course, if the boiler has joints of other kinds, these must be separately investigated, and the final estimate of the bursting pressure must be based upon the strength of the weakest part of the shell, wherever that may be.

The parts of the table relating to positions of the diagonal joint nearly parallel to the girth joint will seldom be required in practice for calculations relating to the strength of riveted joints. A double-riveted lap joint, whose ordinary efficiency is 72 percent, has an effective efficiency of 100 percent or more, when its angle of inclination to the fore-and-aft line is upwards of 53 degrees on a shell with unbraced heads, or upwards of 44 degrees on a shell which is entirely free from endwise stress. When such a joint has an obliquity greater than these respective values, we therefore do not need to use the table at all, since we do not care what the effective efficiency of the joint may be so long as we know that it exceeds 100 percent.

DIAGONAL ROWS OF TUBE-HOLES IN A BOILER SHELL, OR DRUM.

In boilers of certain types there are cylindrical shells, or drums, which are perforated with rows of holes for the insertion of tubes, the arrangement of the holes being similar to that suggested in Fig. 4. A shell or drum of this sort might conceivably fracture along a line parallel to the length of the drum, as indicated by the dotted line *AB*, or the fracture might take a diagonal course, as is suggested by the full line *AC*. The calculation of the efficiency of the shell, so far as fracture along *AB* is concerned, is a simple matter; so that we omit this mode of fracture from present consideration, and confine our attention to the other case, in which fracture may occur along a diagonal line, as shown at *AC*.

In determining the effective efficiency of a drum with respect to diagonal fracture along a line of tube-holes, we may proceed precisely as we did in determining the effective efficiency of a diagonal riveted joint, with respect to possible fracture of the plate through the rivet holes; and in fact we may apply Rule 1 (given above) directly. It is necessary to exercise a little caution in obtaining the "sine of the inclination," however, because in many of these drums the length of the drum lies vertically, and in such cases the line which we have called the "fore-and-aft line" runs vertically also, instead of running horizontally, as it does in a horizontal tubular boiler. In explaining the application of Rule 1 to the calculation of the "effective efficiency" of a diagonal row of tube-holes, we shall illustrate our remarks by the aid of Fig. 5, which represents, on an enlarged scale, a few of the tube-holes of Fig. 4. The letters *A, B, C,* and *D* are here to be understood as applying to the *centers* of the holes beside which they stand.

First, as to the calculation of the "sine of inclination" of the assumed line of diagonal fracture, *AC*. To obtain this, we measure the distance *BC* (in Fig. 5), which is the girthwise pitch of the holes, or the distance from the center of one hole to the center of the one that comes next to it in the roundabout direction. We also measure the distance *AC*, which, as will be seen, is double the pitch of the holes, as measured along the diagonal line that we assume the line of fracture may follow. (In other words, *AC* is the distance from the center of one tube-hole to the center of the second hole from it, as we pass along the oblique line that the fracture will presumably follow.) We then divide the distance *BC* by the distance *AC*, and the quotient is the "sine of the inclination" of the line of fracture.

Having found, in this way, the "sine of inclination" of the fracture, we proceed to determine the "ordinary efficiency" of the shell, along this line of fracture. This is done precisely as in an ordinary longitudinal riveted joint. That is, we measure the pitch, *AD*, of the row of holes along the oblique line of fracture, and from this pitch we subtract the diameter of one tube-hole. The remainder is then to be

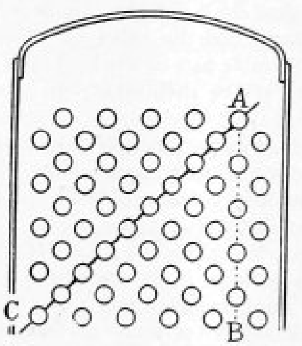


FIG. 4.—ILLUSTRATING A CYLINDRICAL SHELL PERFORATED WITH TUBE-HOLES.

divided by the pitch, *AD*, and the quotient is the "ordinary efficiency" of the row of tube-holes, along the line of fracture, *AC*.

As we now have the "ordinary efficiency" of the shell along the line of fracture, and also the "sine of the inclination" that the line of fracture makes with the fore-and-aft line (or lengthwise direction) of the shell, we can apply Rule 1 at once. An example will make that procedure clear.

Let us suppose that the various dimensions that are involved in the calculation are those shown in Fig 5; the diameter of each hole being 4 inches, the girthwise pitch (*BC*) being 5.50 inches, and the diagonal pitch, *AD*, being 6.25 inches (so that *AC* is equal to 12.40 inches). The "sine of the inclination" of the line of fracture is then equal to 5.50 inches ÷ 12.40 = 0.45; and the "ordinary efficiency," along the line of fracture, is (6.25 inches — 4.00 inches) ÷ 6.25 inches = 0.360, or 36.0 percent. Following Rule 1, we find the value 0.45 of the "sine of the inclination" in column *A* of the table, and opposite to it we find 1.113 in column *B*, and 1.254 in column *D*. Then we have 36.0 × 1.113 = 40., and 36.0 × 1.254 = 45.144 (retaining the figures, in each case, to the nearest

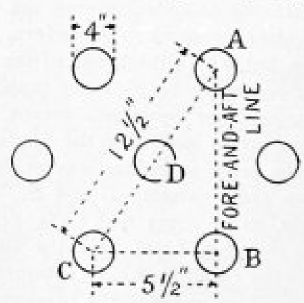


FIG. 5.—A PORTION OF FIG. 4, ON AN ENLARGED SCALE.

tenth). Hence the "effective efficiency" of the row of holes, so far as fracture along the diagonal line AC (in Fig. 4) is concerned, is 40 percent if the heads of the drum are entirely unbraced (so that the entire load upon them is transmitted to the shell), and it is 45.144 percent if the heads are supported in such a way that none of the load upon them is transmitted to the shell.

Having thus found the "effective efficiency" of the shell, so far as fracture along the diagonal line is concerned, we may proceed to compute the bursting pressure of the drum in the usual way, as has already been explained in connection with diagonal riveted joints.

THE MASSACHUSETTS RULE FOR DIAGONAL ROWS OF TUBE-HOLES.

The Massachusetts Board of Boiler Rules has given a formula for calculating the effective efficiency of a diagonal row of uniformly spaced tube-holes, which must be followed in the Commonwealth of Massachusetts, in all boilers which are under the jurisdiction of the State authorities. Expressed in words, the formula is as follows: Subtract the diameter of one tube-hole from the diagonal pitch (AB in Fig. 6) of the tube-holes, and divide the result by the distance BC in Fig. 6), measured along a fore-and-aft line of the drum or shell, between two successive rows of tube holes; all measurements

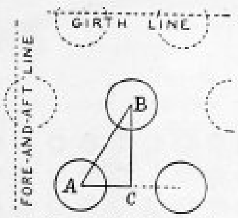


FIG. 6.—ILLUSTRATING THE MASSACHUSETTS RULE.

being taken in inches. The result is the efficiency of the tube-sheet, so far as concerns fracture along a diagonal line such as AC in Fig. 4. It will be observed that this rule takes no account of the way in which the head of the shell is supported, and it therefore cannot be exact under all conditions. It has a very simple form, however, and when applied to the tube-sheets that are of most common occurrence in practice it gives results that do not differ markedly from those obtained by the more exact method of calculation that we have given above, for the case in which the heads of the shell are is entirely unsupported by braces or tubes.

The Massachusetts rule, in fact, gives results that are identical with those that would be obtained by the method we have described above; if we should use the factors in column E of the table, instead of those in columns B or D. The conditions under which the rule is applicable, outside of Massachusetts, may therefore be judged by comparing those columns in the table. Usually, the drums on which rows of tube-holes occur have bumped heads, so that in our exact rule we should use the factors in column B. It will be seen that for tube-hole rows having a degree of obliquity such as occurs in ordinary practice, the factors in column E are nearly equal to the corresponding ones in column B; and the Massachusetts rule, in such cases, has a degree of precision corresponding to this approximate equality.

RULE OF THE U. S. STEAMBOAT INSPECTION SERVICE FOR DIAGONAL TUBE-HOLE ROWS.

The rule of the Board of Supervising Inspectors for calculating the pressure allowable upon a shell that is perforated with staggered rows of tube-holes (as in Fig. 4) differs in outward form from the Massachusetts rule, but is in reality identical with it, except that the Supervising Inspectors require a factor of safety of *six* to be used in calculating the working pressure to be allowed upon such shells, whereas the Massachusetts rule does not explicitly specify any particular factor of safety, for use in connection with a construction of this sort.

CASE OF TWO OR THREE PARALLEL STAGGERED ROWS OF TUBE-HOLES.

Cylindrical drums, or shells, are often met with, in practice, in which two or three staggered rows of tube-holes occur, as indicated in Fig. 7. There is no difficulty, in such cases, about finding the strength of the drum so far as a straight fracture is concerned, running fore-and-aft through a single row of holes. Fracture may conceivably occur, however, in the zig-zag fashion indicated in the illustration; and hence it is important to know the efficiency of the drum respecting this mode of failure. In the mathematical discussion of zig-zag fracture of this sort, some rather vexatious difficulties arise, and we are not aware that anyone has given a solution of the problem that is beyond reproach in all respects. It is usual, however, to calculate the efficiency of the shell in such cases as though the plate were perforated all over with regularly spaced holes, as indicated by the dotted circles, and as though fracture took place along the line AB. The idea underlying this method of calculation is that, although the successive sections of the actual fracture are turned first one way and then the other, yet they all make the same angle with the fore-and-aft line. Hence it is assumed that the

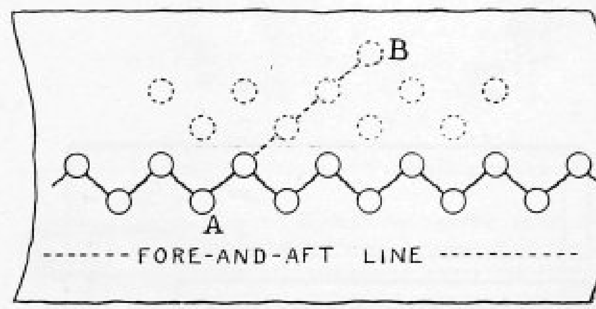


FIG. 7.—TWO PARALLEL STAGGERED ROWS OF TUBE-HOLES.

strength of the drum is the same as it would be if all these sections were turned in the same direction, so as to lie along the straight line AB. As we have already suggested, this assumption is not altogether beyond criticism, and yet it appears to be the best one that we can make, in the present state of our knowledge.

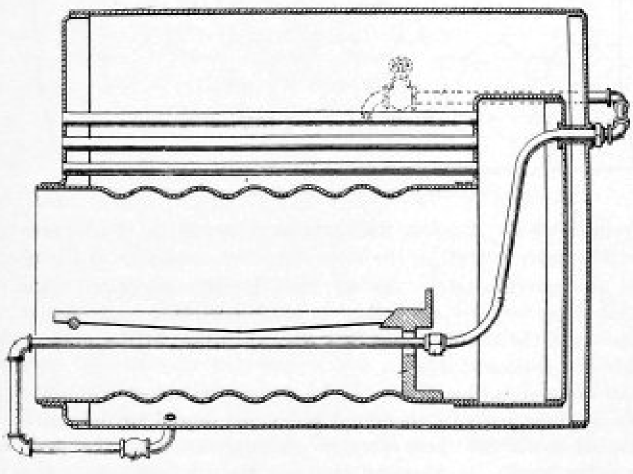
In calculating the efficiency of a drum perforated with only two or three rows of staggered holes, we should furthermore proceed as though there were no endwise stress on the shell. In other words, in applying our rule for the efficiency of a diagonal row of tube-holes to this case, the factor that we must take from the table should be taken from column D. This is because any endwise tension that there may be on the shell, in a construction similar to that shown in Fig. 7, does not affect the ligaments between the tubes to nearly so great an extent as it does when the line of possible fracture runs a straight (or helical) course, around a considerable part of the circumference of the shell, as in Figs. 1 or 4.

A Unique Thermo-Syphon for Internally Fired Boilers.

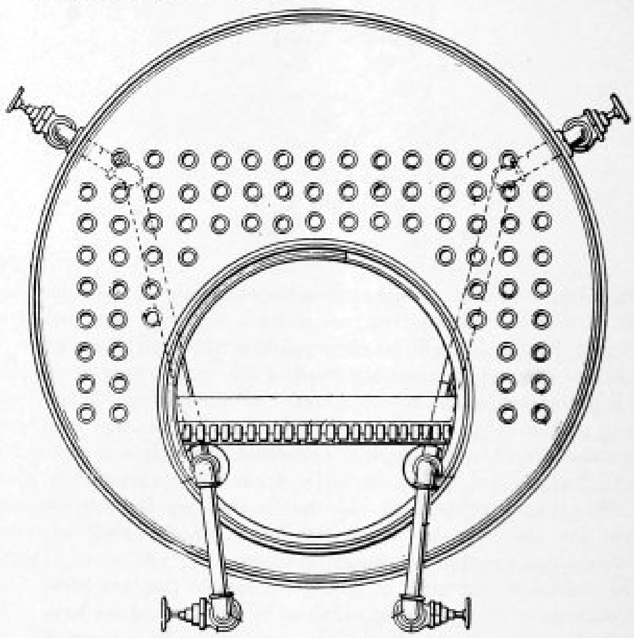
BY FRANK C. PERKINS.

The accompanying drawing shows the construction and indicates the method of operation of a unique thermo-syphon of the Newhall type designed for use in Continental and Scotch marine forms of boilers. The inventor calls attention to the fact that the transfer of heat from the incandescent fuel on the grate bars to the water contained in the boiler is by radiation, conduction and convection. Radiation of heat is accomplished through the air, and the losses due to radiation depend largely upon whether the heated air is confined, or restricted in its passage, or free to disseminate into the surrounding atmosphere.

He points out that the transfer of heat through the material of the boiler is by conduction, and experiments have shown that, relatively, the quality or thickness of material makes little, if any, difference, thick iron or thin brass working practically the same, the safe limit being the thickness which will stand the strain of pressure and transmit the heat without overheating so as to reduce the strength of the material. It will be seen that the transfer of heat through the water in the boiler is by convection; the particles of water next to the hot sheet absorb heat and raise into the main body of the water, giving place to cooler water. Since liquids are poor conductors of heat, the rapidity with which heat will be absorbed by convection therefore depends upon the effectiveness of the water circulation. It is, of course, true that water circulation is essential to a boiler, as it assists in preventing the deposit of sediment, and by more equally equalizing the temperature of the different parts of the boiler prevents those intense strains of unequal expansion and contraction and prevents overheating of the parts exposed to the fire. In all shell boilers the water is contained in a solid mass, broken only by flues and tubes which afford passageways for the heated gases, and the water circulation is more or less interfered with by opposing currents. The circulation of this thermo-syphon holds that the poor circulation of the water results in unequal expansion and contraction of the shell sheets and furnaces, and that this is especially true in those boilers having two or only one furnace, as no heat is applied directly below the grate-bar line, and an accumulation of ashes in the combustion chamber aggravates the condition, leaving a still greater percentage of the water to become heated by the slow process of convection, besides distorting the shell and furnaces out of their approximate true circular form, by the difference in temperature of the water above and below the fire-line. It is maintained that the various types of "Hydrokineters" and internal circulating devices dependent on some mechanical motor appliance to effect a circulation of the water, while beneficial to a greater or less extent, are not operative except when the pump or injector is working, or another boiler is under steam to furnish motive power to warm the one generating steam from cold water. As they are enclosed within the boiler, they are not accessible for observation or repair except at such times as the boiler may be empty, and the boiler must be emptied before any defects can be repaired. Again, being rigidly secured to certain positions within the boiler, what circulation they do effect does not reach to all parts of the



SECTIONAL VIEW THERMO-SYPHON SYSTEM.



FRONT VIEW THERMO-SYPHON SYSTEM.

is more rapid and effective if the water is constrained to follow a particular path, and any mechanical device that will tend to produce this condition is worthy of your most earnest consideration. The Scotch marine boiler and all internally-fired boilers, such as the "Clyde Marine" and "Continental" types, offer the most confined space of the heat radiated, with a consequent more effective absorption of the heat units by the material of the boiler transferring the heat to the water contained within, on account of having no brickwork setting to absorb and disseminate heat units into the surrounding atmosphere. It is held that this fact also is conducive to lower insurance rates, as well as cleanliness around the boiler plant, and results in greater economy of fuel consumption without having to resort to the use of "Dutch-ovens" and smoke-consuming devices, if properly designed and installed.

There was a great deal of interest taken in the discussion of the best method of keeping water in circulation in these types of boilers at the twenty-first annual convention of the American Boiler Manufacturers' Association. The inventor

boiler, and consequently are not effective to maintain a constant circulation and even temperature throughout the boiler. It is held that they each and all deliver their quota of heat units (either by steam-jet or pump impulse) into exactly the same spot that the preceding delivery was discharged, and depend upon the distribution of the heat to the cooler portions of the boiler by the slow process of convection, thus making use of that natural law to attain their object that they were designed to partially overcome, as they do not bring any cold water to a point where it can absorb heat and then distribute it, but simply blow heat in at one point and trust to nature to mix it.

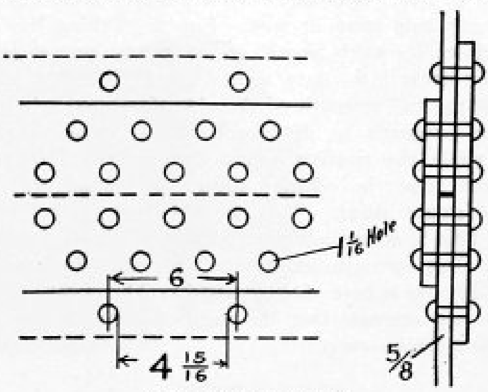
It is maintained that this defective circulation is common to all "fire tube" (shell) types of boilers, and was the prime reason for the introduction of the "water tube" types. The thermo-syphon was designed to insure a constant and positive circulation of the contained water within the boiler, dependent only upon the radiation of heat from the fuel of the furnace. It will be seen from the drawings that in the construction of this apparatus there are no special or expensive castings to be bought and replaced at frequent intervals, and any boiler maker and pipe fitter can easily install the complete equipment, either to new work or old. There is nothing experimental about it, as all of its component parts, consisting of standard valves, pipes, pipe fittings and boiler tubing, are common hardware stock articles, obtainable readily and at a competitive price. It is held that the packing gland, and packing used on the exterior wall of the combustion chamber where the circulating apparatus passes through, does not require any cast metal "stuffing box" and gland, as commonly understood by this term, but is simply a sheet metal, flat-formed packing gland, holding an asbestos gasket, or grommet, in place so as to allow of free expansion or contraction movement of the apparatus itself, and form an obstruction to the free passage of smoke or soot, which would be disagreeable, to say the least. This gland is held rigidly in place by studs and nuts, and requires no attention or frequent renewal except on such occasions as when making repairs or renewals. These latter items should not be frequent; but the best of material will wear out in time, and accidents occur even under the most skillful supervision. But, assuming that defects were frequent at this point, for the sake of argument, either sheet asbestos to make a new gasket, or twisted or braided asbestos to make a new grommet, ought not to cost more than five cents, and there is no liability of damage to the wrought iron gland.

It is pointed out that the valves at the inlet and outlet connections of the circulating apparatus can be used to regulate, within certain limits, the flow of water within the circulating device, and this feature is included in the patent. They are also instantly available in case of accident due to defective material, or damage by carelessness or design, to close off the pipe affected, from which damaged condition, with the valves closed, no serious consequences could result, as the pipe would empty itself through the defect, and that portion exposed to the flame in the combustion chamber would be "burned off" so as to require renewal when the opportunity offered, while the undamaged pipe would keep right on with its share of the work. To replace any so damaged part of the apparatus, it would not be necessary to empty the boiler, as none of the device is within the water space of the boiler; simply haul fires, and, as soon as it is possible to enter the combustion chamber, the burned off "S"-shaped portion could be renewed, the valves opened up and fires started again. Where boilers are using water that forms a sediment, the inventor states that it is advisable to use an internal nipple at the lower connection extending, say, about two inches into the boiler. This will avoid drawing the sediment into the pipes. The short section of boiler tubing passing through the water space of the "Scotch Marine" type is expanded into the head and combustion chamber sheets, then beaded over exactly similar to installing an ordinary boiler tube to carry off the gases of combustion. This tube may be located so as to pass through the sheets between stays, or may be located as a substitute for a stay; in the latter case, however, care must be taken to make up the cross-sectional area of the removed stay. A boiler-tube 2½ inches outside diameter and No. 12 B. W. G. thickness contains as much metal as a stay ⅞ inch diameter, and the same sized tube No. 5 B. W. G. thick exceeds the metal in a stay 1⅜ inches in diameter; between the two gages a thickness will be found that can be used to replace the stay removed. Above any beyond the "S-shaped pipes," the trend of all the piping should be a slight raise from the horizontal, never downward, and should deliver below the working water level.

It is held that experience has shown this automatic circulating device to be as safe, sure, and reliable as the attachment of a hot-water-boiler to a kitchen range, and the only thing new or novel is the application of the principle, in combination with a boiler.

Strength of Riveted Joints.

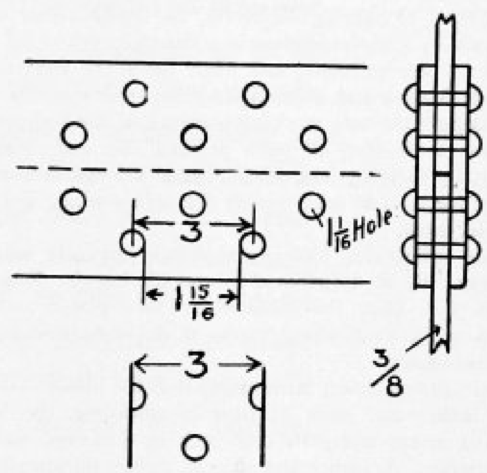
A corespondent has written us for the rule for finding the strength and efficiency of a butt joint which he has not drawn in accordance with modern practice, but we will endeavor to answer the question intended. The rivets are 1 inch in diameter, and the plate is given as ⅜ inch thick. We may say that 1-inch rivets are generally used with ⅝-inch plate. The



JOINT OF ⅝-INCH PLATE.

pitch of rivets given is 3 inches, and there is a welt inside and out. See Fig. 1.

The first thing to do is to find the relative value of the punched sheet as compared with the solid sheet. This has nothing to do with the tensile strength of either sheet or rivet.



JOINT OF ⅜-INCH PLATE.

The value of the solid sheet is taken at 100, and the punched sheet has, of course, only some percentage of solid sheet strength. The holes are 1 1/16 inches, for the 1-inch rivets, and from outside to outside of rivet-holes there is a space of 1 15/16 inches. The strength of the sheet for one pitch length of 3 inches is in the proportion as 3 : 1 15/16 : : 100 : X. This works out to 64.4 percent.

Now, according to our correspondent, the plate has a tensile strength of 55,000 pounds. The full strength of the plate for one pitch length is $3 \times \frac{3}{8} \times 55{,}000 = 61{,}875$ pounds. If the rivets are iron, assuming 40,000 pounds shearing strength, we have in one pitch length one whole and two half rivets in double shear. That is equal to double shear on two rivets.

A rivet in double shear being equal to 1 3/4 times a rivet in single shear, the two rivets in double shear are thus equal to 1 3/4 + 1 3/4 or 3 1/2 rivets in single shear.

We found the full strength of the plate for one pitch length to be 61,875 pounds. The strength of the rivets is therefore 3 1/2 × area a hole 1 1/16 diameter × 40,000 or 3 1/2 × .8866 × 40,000 = 124,124; this is a little over twice the full strength of the plate to shear. The plate with rivet holes is only 64.4 percent or .664 of the full strength of the plate. That is, 61,875 × .664 = 41,085. This shows that for one pitch length the rivets in double shear are about three times as strong as the punched plate.

The way this joint is generally made is with 5/8-inch plate and a row of rivets at double pitch are driven in an extension of the inner butt strap or welt. Fig. 2. Taking the outer row of rivets for pitch length, viz., 6 inches, we get as percentage of strength 6 : 4 15/16 : : 100 : X = 82.3 percent, or .823 of the full strength of the plate for one pitch length. The plate strength is of course 6 × 5/8 × 55,000 = 206,250 pounds, while the riveting would show 4 rivets in double shear and one in single shear, or equal to eight rivets in single shear. This would give us the following: 8 × .8866 × 40,000 = 283,712 pounds, as the rivet strength. The full plate strength becomes 82.3 percent when punched, and that amount is here 169,743 pounds. This means that the rivets are 1.67 stronger than the punched plate.—*Railway and Locomotive Engineering.*

FIGURING THE SAFE WORKING PRESSURE OF THE SHELL OF A LOCOMOTIVE BOILER.

BY H. S. JEFFERY.

"I should like to know how to determine the safe working pressure of the shell of a locomotive boiler constructed with several courses of varying diameters," is the character of an inquiry made by a correspondent in a recent letter.

This is no new question; and while there has appeared in THE BOILER MAKER and other trade papers the solution as to how to compute the safe working pressure of the boiler shell, it does not seem that all have grasped the underlying or fundamental principles, and this is due in a large measure to the several methods of ascertaining the safe working pressure of the boiler shell.

With the locomotive boiler, per sketch, the safe working pressure can only be ascertained by considering the diameters *A*, *B* and *C*. Also, the thickness of the plates and the efficiencies of the longitudinal seams of the respective courses must be considered.

Now, my correspondent informs me that the inside diameter *A* is 72 inches and plate 3/4 inch in thickness, the inside diameter 61 inches and plate 9/16 inch in thickness, and the inside diameter *C* 60 inches and plate 1/2 inch in thickness. The efficiency of the riveted joints for the respective courses, which information was obtained upon request, not having been stated in the prior letter, was given for course *A* as 82 percent, course *B* as 84 percent, and course *C* as 86 percent.

It may be asked here what is this difference in efficiency in the respective courses? This is because the over-all distances, *D*, *E* and *F*, are such that the same maximum pitch could not be obtained in the respective courses, and a change of pitch, large or small, will make a difference in the efficiency of the net section of plate, maximum pitch of rivets, which point is made the weaker of the several parts of a riveted joint.

Assuming the factor of safety to be 5, and the plate to have a tensile strength of 60,000 pounds, then the working pressure of the boiler, as far as the shell is concerned, may be determined by the following formula:

Where T = Thickness of the plate in inches.
D = Diameter of the boiler in inches.
T_s = Tensile strength of the plate in pounds.
F = Factor of safety.
E = Efficiency of the longitudinal seam.
P = Pressure in pounds per square inch.

$$\frac{T \times T_s \times E}{D \times F} = P.$$

The safe working pressure for course *A* then will be

$$\frac{(2 \times 3/4) \times 60{,}000 \times 82}{72 \times 5} = 205 \text{ pounds.}$$

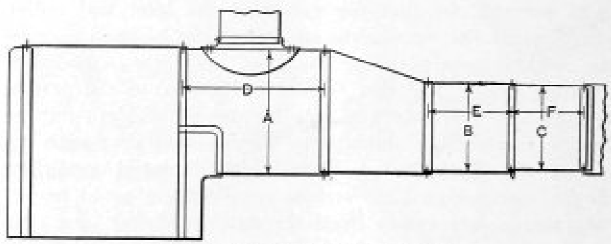
The safe working pressure for course *B* then will be

$$\frac{(2 \times 9/16) \times 60{,}000 \times 84}{61 \times 5} = 186 \text{ pounds.}$$

The safe working pressure for course *C* then would be

$$\frac{(2 \times 1/2) \times 60{,}000 \times 86}{60 \times 5} = 172 \text{ pounds.}$$

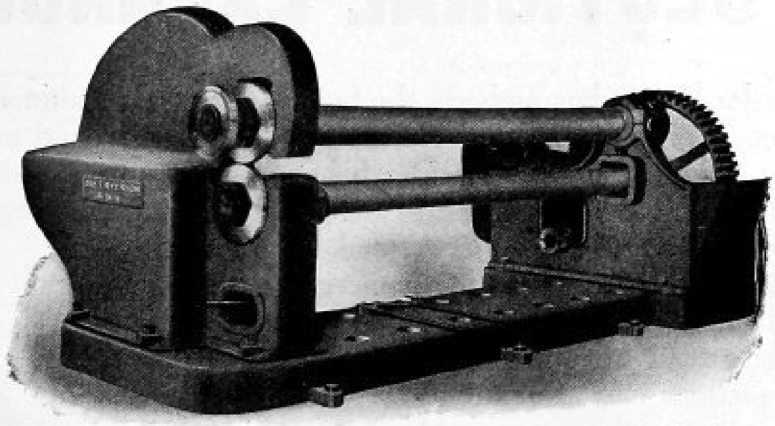
The calculations thus show that the course *C*, the course with the least diameter and the longitudinal seam with the greatest efficiency, to be the weaker of the three course *A*, *B* and *C*. Therefore, the pressure for the boiler, considering the shell only, would be 172 pounds.



FIGURING SAFETY WORKING PRESSURE.

Had the boiler designer in the first instance made the course *C* 9/16 plate and the course *B* 5/8-inch plate, the boiler shell in question could have been allowed a greater pressure than 172 pounds. To a real boiler designer these calculations would suggest several things. First would be that if no change was to be made in course *C*, then the thickness of course *A* could be reduced, perhaps, 1/16 inch in thickness. This would make a saving in the cost of the boiler. Second, if need be the efficiencies of the longitudinal seams of courses *A* and *B* could be less. This is, of course, on the assumption that course *A* will undergo no changes in regard to thickness of plate, diameter, efficiency of longitudinal seam and tensile strength of plate.

The Bement horizontal hydraulic punching machine is described in circulars issued by the Niles-Bement-Pond Company, 100 Broadway. A No. 5 machine is operated by 1,500 pounds water pressure. It can punch 1-inch holes in 1-inch steel plate. The action is semi-automatic, and when the lever is pulled the punch head comes forward and automatically returns to its initial position. The die holder is removable, so that other holders of special shapes can be attached. The packings are hemp, and placed all outside, making renewals easy without dismantling the machine. A Bement hydraulic machine cannot be forced or overloaded beyond its designed capacity, as the action stops of its own accord when the capacity limit is reached.



COMMUNICATIONS.

A Machine Punch.

EDITOR THE BOILER MAKER:

The drawing shows a punch I have been using for several years for cutting heavy plate iron, such as boiler saddles, deep gusset plates, openings in shell for domes, or any straight

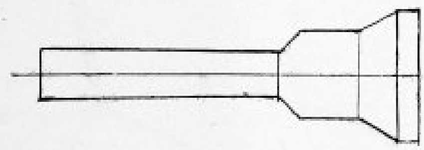


FIG. 1.—MACHINE PUNCH.

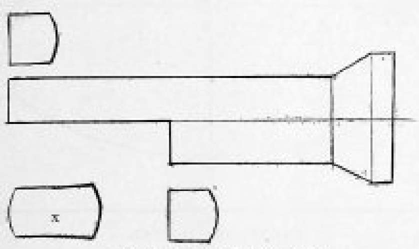


FIG. 2.—MACHINE PUNCH.

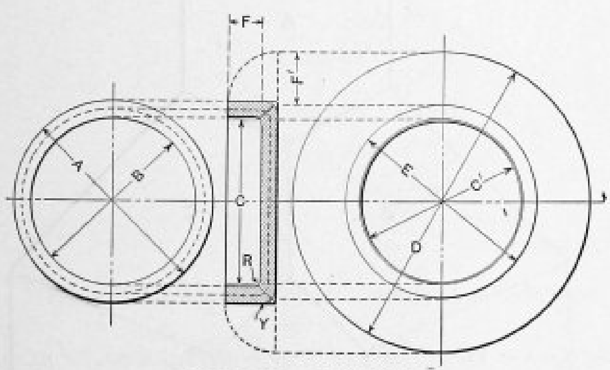
line work. This punch will be found very useful where finish of work is an object, as the old-fashined way of punching with the round punch does not make a nice job. The drawings are half size, and can be set up in any punching machine. The mark *X* shows the opening in the die. JOHN A. HIGGINS.

Lay-Out of a Tank Head.

EDITOR THE BOILER MAKER:

I take pleasure in forwarding to you for publication a drawing of a tank head and the layout of same in the hopes that others will suggest something more accurate.

The accompanying drawing shows how to layout a tank



LAYING OUT A TANK HEAD.

head which is to fit nicely into a tank in which case *A* is equal to the inside diameter of the shell. Now, then, to flange this head to correspond with *A* for a tight fit it is necessary that the flange line must be as *B*, minus 1/32 inch, or, as can be seen at *C*, in which case the original flange line would be as shown at *C'*. The radius of the knuckle of flange at *R* is too sharp to need any mention as to difference in the length of plate. The diameter *E* is equal to *A*, minus 1/32 inch, which will allow for the head to pass into the shell of the tank. After the flange has been turned it can be dressed off, after annealing, in a boring mill. E. EATON.

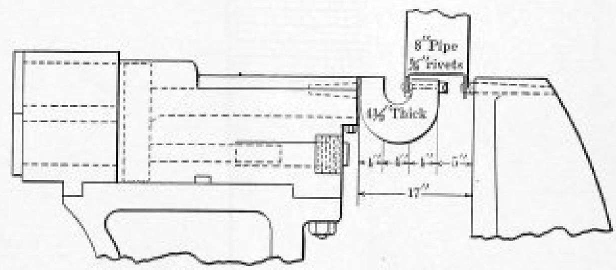
West Hoboken, N. J.

Driving Heads in an 8-Inch Pipe.

EDITOR THE BOILER MAKER:

On page 62 of your February issue I notice Mr. "Bulldriver" wishes to know how to drive heads in 8-inch pipe to be riveted with ⅝-inch rivets. I herewith inclose a blue print of my way of driving the work.

Most boiler men would say, "Why not do this with a supplementary stake?" It could be so done, but when there are only about twenty heads to drive they can be driven by my



HOW TO DRIVE HEADS.

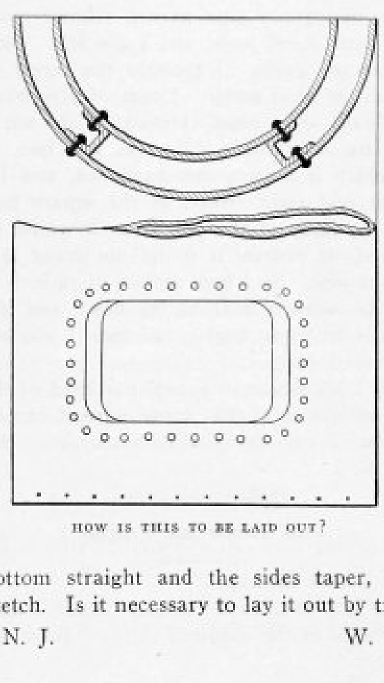
method in as short a time as it would take to rig up the supplementary stake. The die, or "gooseneck," is just a steel casting 4½ inches wide, with other dimensions as shown in blue print. The weight of the gooseneck casting is about 75 to 80 pounds, and can be attached to the machine as quickly as any die. Mr. "Bulldriver" also asked for rivet-heating furnaces, with which I have had considerable experience. I will try and send you something on this subject later.

Springfield, Ohio. JOHN BUTLER.

Concerning a Vertical Boiler Door.

EDITOR THE BOILER MAKER:

I should like to know through your valuable paper the best method of laying out a door for a vertical boiler with the



HOW IS THIS TO BE LAID OUT?

top and bottom straight and the sides taper, as shown in herewith sketch. Is it necessary to lay it out by triangulation?

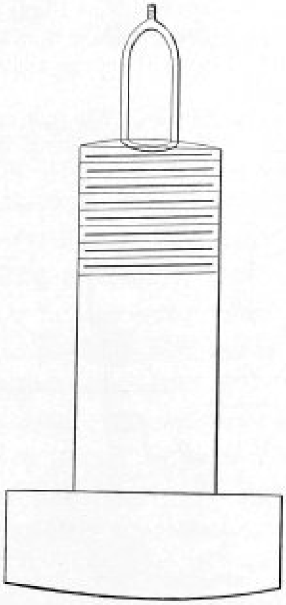
Newark, N. J. W. PICKERING.

How to String a Bolt.

Editor The Boiler Maker:

We take pleasure in sending to you a description of how we "string" a bolt, which so often has to be done in boiler work.

With hack-saw, nick down the end of the bolt deep enough to lay in a small wire, rivet a piece of wire, say, 2 inches long, in this slot, doing the riveting in the center of the bolt, turn up



STRINGING A BOLT.

the ends of the wire so as to be sure they are below the bottom of the thread and twist them together, forming a loop; into this you can pass your string and also string on your nut and washer. While this method takes a little more time it is safe and sure, and anyone after trying it will never go back to the old way. Webber & Thomas.

Washington, D. C.

The Emergency Pipe Wrench Scheme.

I tried the emergency pipe wrench scheme you showed on page 119 of your April issue, and I got left. But I took my eyes only for my guide. I thought the screw was just an ordinary philister head screw. I noticed afterwards you said they were "hard short-head" screws. I do not think there are any of that kind made. I never saw one, so I took a set-screw, which is always case-hardened, and I found that that was not just right either, as the square head is about the size of the body of the screw, so it would not stand at an angle; and, of course, if it did not stand at an angle it would grip the pipe. So I bent a piece of ⅛-inch wire around the bar of the wrench next to the head, and that held the set-screw so it set at an angle; and then I was all right, and the kink worked bully.

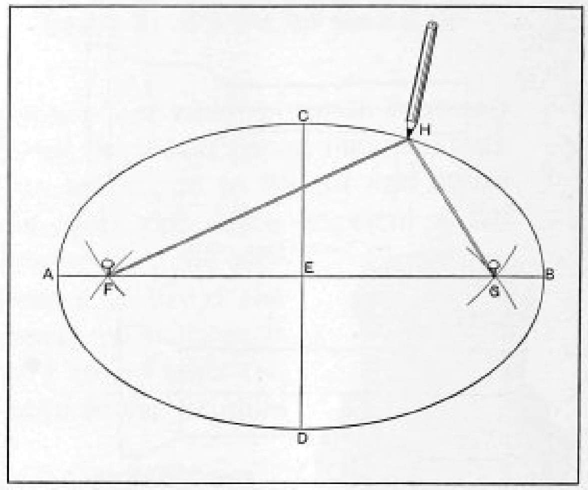
Next time, I am going to anneal the head of the set-screw and drill a hole in it so that I can wire it in place; then it won't fall out. I am very glad to know about this trick.

Hoboken, N. J. Nemo.

To Draw an Ellipse.

Editor The Boiler Maker:

Here is one way to draw an ellipse: Draw a line *A B* equal to the major axis of the required ellipse. Bisect the line *A B* at *E*. At *E* draw a line *C D* perpendicular to *A B*. Make *E D* equal to *E C* and equal to one-half the minor axis. Set the compass to a distance equal to *A E* or *E B*, and with *C* or *D* as centers describe an arc, cutting the major axis at *F* and *G*. *F* and *G* are the foci of the ellipse. Fasten the ends of a string, whose length is equal to the length of the major axis *A B*, at the foci *F* and *G*. This may be done by fixing pins at the foci and by providing the ends of the string with loops.



MAKING AN ELLIPSE.

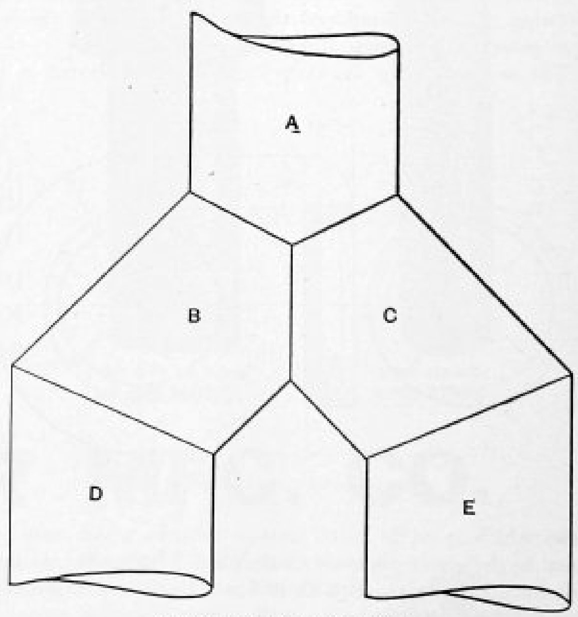
Trace a curve with the point of a pencil *H* pressed against the string so as to keep it stretched. The curve thus traced will be the required ellipse. The same can be accomplished on iron by making light center punch marks and using the trammels as pins. E. Eaton.

West Hoboken, N. J.

A Laying-Out Question.

Editor The Boiler Maker:

I have noted very carefully Mr. Jashky's remarks in your



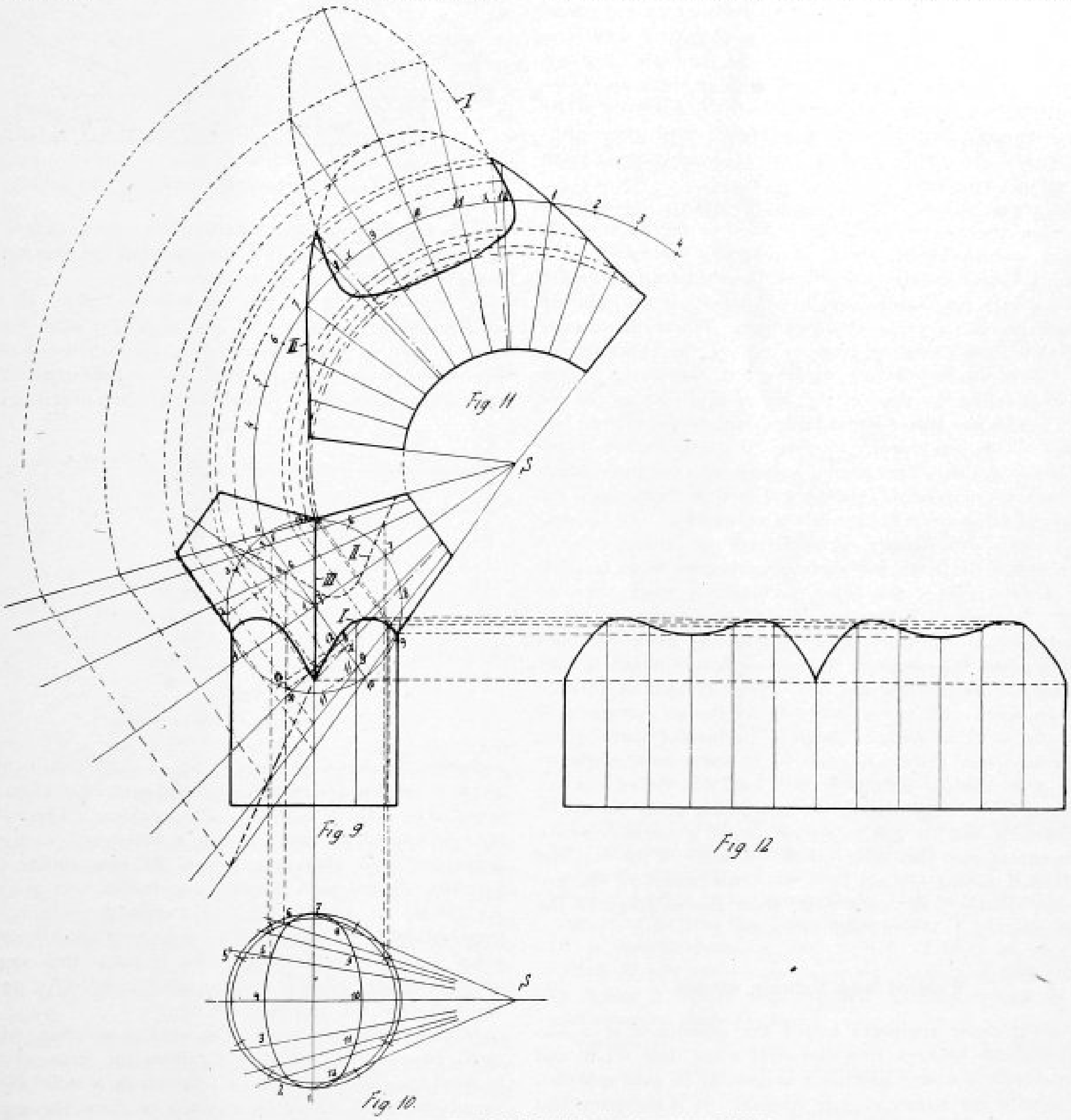
LAYING OUT PIPE CONNECTIONS.

April issue relative to figures 3 and 4 of my article which appeared in December's issue of The Boiler Maker.

The elevation, Fig. 3, as I have shown it should have been drawn as per the attached sketch. Each of the pipe connections, as *A, B, C*, etc., should be of an equal diameter. The same method of development can then be readily applied, as explained in the article.

Mr. Jashky states that the lines of intersection between the cones and cylinder, Fig. 4, are incorrectly shown. I would be glad to have him show them correctly drawn.

Scranton, Pa. C. B. LINSTROM.



ANOTHER METHOD OF LAYING OUT PIPE CONNECTIONS.

Intersecting Lines of Right Courses and Cylinders.

In the April issue of THE BOILER MAKER Mr. Jashky takes exception to Mr. Linstrom's solution of the problem of two similar right cones meeting a cylinder, given in our December issue, 1910.

Herewith Mr. Jashky shows his solution of the problem, and it differs materially as to the form of the intersecting line at the base of the cone with the cylinder. Looking at Figs. 9, 10, 11 and 12, the line referred to is of curved outline and is made heavy, beginning at the common center line and ending in the right-hand cone at 9, Fig. 9. In Mr. Linstrom's solution this curved line does not exist, but is given as a straight line, and here is where the two gentlemen differ. It is self-evident that the solution here given is more work, but the question under dispute is whether the simpler form of layout by Mr. Linstrom is a correct one?

Editorially we comment on the advantage of laying out these problems in paper and rolling them up, as in so doing not only are the well versed in laying out aided, but the student is given an "eye example," which is of the very greatest value and the work is brought to mind most practically. We would advise that if our suggestion is tried that the paper models be made twice as large as are our drawing. We give above the letter from Mr. Linstrom. We shall be very glad to have expressions concerning the question from other readers.

Firing a Boiler.

Most boiler attendants recognize in a general way that the economical working of a boiler furnace depends largely on the way in which the air supply is distributed and regulated and endeavor to do the best they can to comply with proper combustion conditions, but few of them can give an intelligent reason for the procedure they adopt. But a small proportion of engineers secure the best attainable furnace results and in a great many cases the matter is so imperfectly understood that there is serious waste of fuel.

The total amount of air required for the proper combustion of fuel in a boiler furnace depends on the nature of the fuel used. With ordinary coal the theoretical minimum quantity required for combustion is about 11 pounds of air per pound of coal, but because the film of gases escaping from a burning surface interferes with the access of the fresh-air supply, it is impossible to burn a pound of coal with anything approaching so small an amount; consequently 19 to 22 pounds of air represents more approximately the quantity used under ordinary conditions, or between 8 and 11 pounds more than theoretically required.

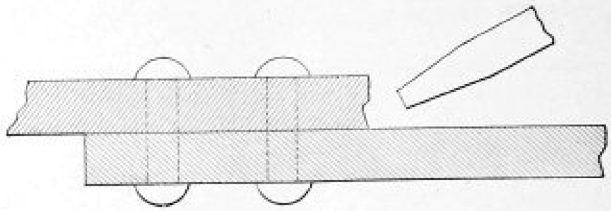
The great bulk of the air supply is drawn through the grates and the rate of flow is determined by the thickness of the fire and the draft, which is generally controlled by a damper. Under ordinary conditions, the thickness of the fire does not vary very much, and the air supply, if the dampers are not moved, is reasonably constant. When the furnace receives a fresh charge of bituminous coal, the volatile gases are at first driven off very rapidly, and, therefore, require a corresponding increase in the air supply, just as the air flow through the grates is diminished, due to the thicker bed formed by the fresh fuel. In order to supply the necessary air the furnace doors are generally fitted with openings which the fireman can open or close at will, and in many cases the bridgewall is also arranged to admit a supplementary air supply by means of a damper operated from the furnace front.

Frequently the bridgewall-damper connection is so disabled that the air orifices are either permanently stuck open or closed. Air admitted through the fire door serves to better advantage than when admitted through the bridgewall, because it passes the length of the furnace before mingling with the gases liberated from the fuel. Some designs of furnace door are fitted with a box from whence the air emerges into the furnace as a spray through a perforated baffle plate. Frequently these plates are removed, or burnt away, with the result that the air supply is not well distributed. After the fires have been charged, the ventilating grids should be opened wide and allowed to remain so for a minute or two, the length of time depending on the character of the coal and determined by the fireman from his observations of the fire and the chimney, or, better still, from the readings of the CO_2 recorder.—J. F. Crusland, in *Power*.

Welding and Calking at Sea

A good many engineers at sea are sometimes at a loss to distinguish between iron and steel when they see it, and are therefore not sure whether it is possible to weld a broken article with the means at their disposal. It is therefore just as well in passing to mention for the guidance of young engineers that cast iron is simply iron ore smelted and contains a very large amount of carbon; it cannot, therefore, be welded. It is possible, however, to burn two pieces together, but this cannot be done on an ordinary tramp steamer. Wrought iron is cast iron which has been puddled; by means of this process the bulk of the carbon in the cast iron is extracted, rendering the wrought iron capable of being forged or welded. Steel is pure iron with the addition of a smaller amount of carbon than is present in either of the two classes mentioned and it can be cast, forged or welded with facility. Cast iron is distinguished by its brittle fracture and gray color; wrought iron, by its fibrous fracture, and steel, by its close grain. It is also lighter in color than cast iron.

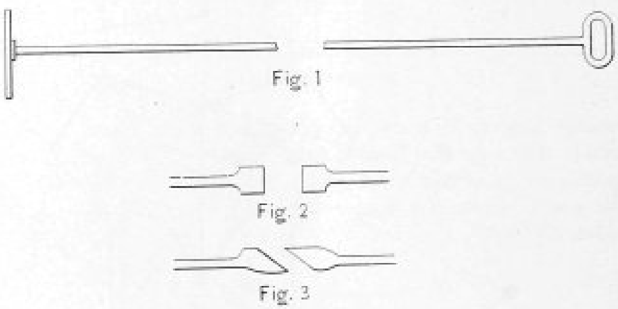
Welding is very seldom done in the engine-room at sea, and it usually turns out to be a failure, owing to some detail having been neglected. It is not, of course, to be expected that a heavy job, such as a connecting rod or similar part, can be welded at sea, but if care is taken it is quite possible to weld small parts of wrought iron or steel, such as firing tools used in the stoke hold. If this is done, considerable



CALKING A SEAM.

trouble may be avoided by repairing the rake and slices instead of using the spare ones and waiting until the ship arrives at home in order to send repairs ashore.

In order to weld or join together two pieces of iron or steel on board a vessel, they are heated to white heat, and sand is used as a flux before they are hammered together. For example, in order to weld, say, a rake shaft, the two ends which have to be joined together are heated (Fig. 1),



WELDING FIRE ROOM TOOLS.

and then they must be jumped up or thickened in diameter as shown in Fig. 2 in order to make sure of getting the rod down to its original size again after welding. The ends must then be scarfed, as shown in Fig. 3, and then heated to white heat; any scale that may be on the heat should then be knocked off, and sand should be sprinkled over the surface. As quickly as possible the two scarves must be hammered together and everything must be done very quickly, otherwise a bad weld will be formed. This is worse than useless, as after using the rake for a little while it will give way again and half of it will be left in the fire.

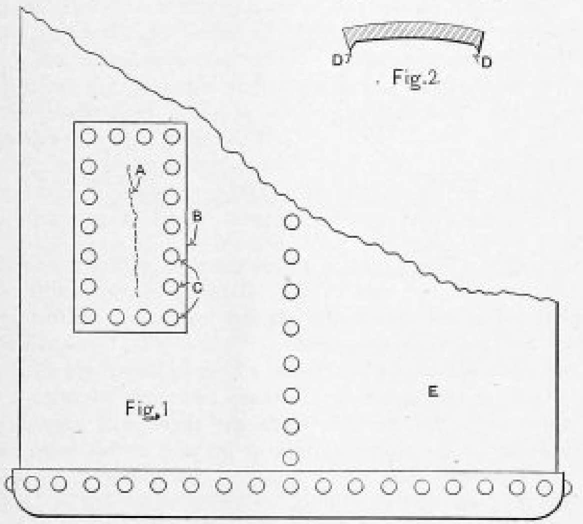
Attention may be drawn to another point: many engineers at sea have a very poor idea of calking the seams of a boiler, or what tools may be required. By calking is meant the closing up of the seam, either by riveting or upon the appearance of a leak. Such a leak is probably caused by excessive expansion, owing to the fact the water was not properly circulated in the boiler when steam was being raised. In the calking the edges of the plate are first chipped or planed in order to present a good, clean working surface, and then the calking tool is used. The ordinary tool aboard ship is just a blunt chisel about ¼-inch thick at the mouth and it is used to burr up the inner edge of the plate. A good engineer will, however, make for himself tools of different sizes and shapes in order to suit all kinds of work, such as calking round awkward corners and bends. If he attempts to use the ordinary tool for all classes of calking he is only damaging the plate to no purpose.—*A Weld Calker, in International Marine Engineering.*

Repairing a Crack in a Boiler.

EDITOR THE BOILER MAKER:

Recently, I was called upon to see what could be done with a boiler, rated at 80-pound pressure, that had developed a crack about 10 inches long which leaked badly.

Incidentally, in connection with this, I ran across a previously attempted repair which had been done a few days before that would be amusing if it was not for the great amount of labor and time wasted by the first party, who had taken the job on contract basis and guaranteed satisfactory results. The machinist had repaired the boiler as shown in the drawing, Fig. 1. The dotted lines at *A* represent the crack. A plate, *B*, was made as shown, and a series of holes drilled all around for ⅜-inch bolts, which is shown at *C*, the boiler having had holes drilled and tapped to correspond with



REPAIRING A CRACK IN A BOILER.

the plate. But, before fastening the plate on to the boiler, the ends on the plate had been upset as shown at *DD*, Fig. 2. A calking chisel had then been applied all around the plate for the purpose of making a tighter joint. To further insure a tight joint, a mixture of muriatic acid and water had been applied, with the intention that this would cause a corrosion and thereby help to tighten the joint. This done, the repair was considered finished, but when tested out for leakage it leaked without having any pressure on, let alone 80 pounds pressure. The result was a series of fixings, but was finally given up as a bad proposition after about $50.00 in labor had been wasted.

Knowing the up-to-date method of oxy-acetylene welding, it was an easy matter to repair the boiler. I ordered the plate taken off. The ⅜-inch bolts were screwed back in the holes of the boiler (which were made to hold the plate) and then sawed off even with the surface. The boiler was then packed up on a wagon and taken to a place where oxy-acetylene welding is done. The crack plus the bolts were welded within a couple of hours. When put back in service the boiler was as good as new. The cost for labor, hauling and welding did not exceed $35.00, and all was done within 12 hours.

Bayonne, N. J. J. A. LUTHER.

One-tenth of an inch of scale in a boiler is equivalent to a thickness of 10-inch plate in resisting the transmission of heat.

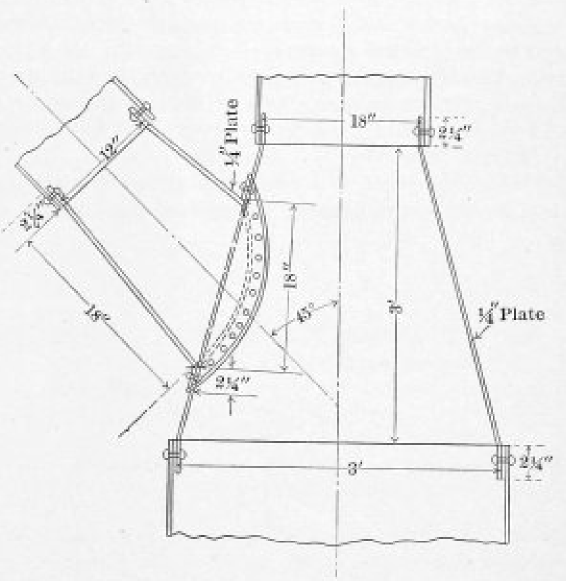
One hundredth of an inch of soot or grease is equal to the same thickness of plate, *i. e.,* 10 inches.

Fahrenheit mixed ice and salt together and produced what he thought was the lowest possible temperature; this he called "zero." He then boiler water, and called that temperature 212. He divided the space between the 0 position of mercury when the thermometer was in the ice and salt and when in the boiling water into 180 divisions, and called these degrees. Just why he took these figures is a question.

Who Can Solve This Problem?

EDITOR THE BOILER MAKER:

In your April issue, Mr. Jashky has on pages 14 and 15 a very good explanation of how to lay out intersecting cones. I find I can use his method without any trouble, and the work comes out all right. His explanation of how to do it has been



LAYING OUT AN INTERSECTING CONE.

a great help to me. Now, I want THE BOILER MAKER to tell me more, and the problem is as follows:

The accompanying illustration shows what I have to lay out, and I want to know, especially, how to lay out the small cone so as to have the flange come right. I will use ⅝-inch rivets, spaced about 2¼ inches pitch. I shall be very glad indeed if you can secure for me a solution of this problem by laying it before your readers. I think it will be very interesting to many of them.

Norfolk. VIRGINIA.

A Correction.

EDITOR THE BOILER MAKER:

I wish to correct the camber formula given on page 97 of the April issue of THE BOILER MAKER to read as follows:

$$C = \frac{W\,(W - w)}{7.5\,h}.$$

Where C = required camber, inches,
W = straight width, large end, plus laps, inches,
w = straight width, small end, plus laps, inches.
h = straight height of developed plate, inches.

Lebanon, Pa. JOHN V. PETTY.

Causes of Boiler Explosion.*

What interests most men in charge of engines and boilers is what causes the boiler explosions that have happened so frequently of late. Doubtless the cause in many cases is unknown and often no clew is left, but in many instances the cause can be traced if those viewing the exploded boiler put two and two together.

In some cases the management of the company having experienced a boiler explosion will not permit the parts of the boiler to be examined, evidently fearing that the possible evidence will show that neglect on their part has had considerable to do with the disaster. The coroner holds his inquest and does the best he can, but without proper knowledge of the course to pursue in digging into the technical facts the verdict is often far from what it should be. A manufacturer can put an old boiler in commission or keep a boiler in use long after it has passed a safe condition, and when that boiler explodes no one even thinks of arresting a president or general manager of the company on a criminal charge of manslaughter. On the contrary he tells the leading men of the community how mysterious the whole affair is and how deeply he regrets the loss of life that Providence has deemed fit to take.

If the jury would find such men guilty of manslaughter when an old second-hand boiler explodes there would not be

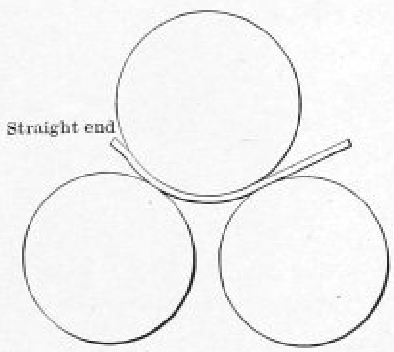


FIG. 1.—ROLLING PLATE.

so much buying of and putting into use boilers that have been discarded by men who had sense enough to take them out of service in their own plant, but who let the greed for the almighty dollar blind their sense of justice to persons who are endangered by those same boilers when they are sold to the man who will run a chance of killing a few workmen by a boiler explosion rather than pay a few more dollars and get a new boiler. A National law holding such persons responsible for loss of life due to the exploding of a boiler of poor type, or one that has been allowed to become defective, and has not been inspected, not by an engineer in the employ of the company, but by a competent inspector, receiving his salary from an outside source, would do much toward lessening boiler explosions. The usual cause of boiler explosions is over-pressure, or the inability of a boiler to withstand the working pressure. There are several reasons why a boiler is unable to withstand the ordinary working pressure, such as defective design, reduction of strength from corrosion, incrustation and wear, defective workmanship or material, or mismanagement.

In the opinion of a good many engineers any lap joint boiler is a defective boiler, whether it is new or old. The type of joint is treacherous because it is impossible to detect a crack along the edge of the rivet holes on the inner side of the plate where it is hidden from view. If it were possible to make the return tubular type of boiler perfectly round, the lap joint would not offer the cause for criticism that it does. This point has been brought out in many articles, and yet too much cannot be said on the subject. It is evident to any one who has taken the trouble to think the matter over

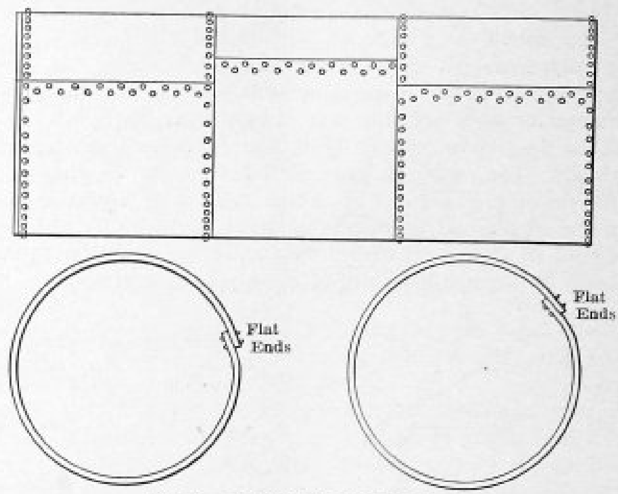


FIG. 2.—THREE-PLATE TYPE OF BOILER.

that when a boiler plate is rolled the ends do not get the same curvature as the rest of the plates. The two ends of the plate come out practically straight instead of conforming to the curvature of the circle the plate will form when the two ends are riveted together. This is illustrated in Fig. 1.

As it is impossible to get these two ends to form a true circle when the joint is made up, there will always be a tendency of the plate to strain or breathe at this point, which will ultimately result in a crack, if the boiler is allowed to operate long enough. This breathing effect has a tendency to crack the plate, the same as the bending back and forth of a piece of tin. It will not break the first or second time it is bent in a reverse way, but if the bending is carried on long enough the tin will part at the point where the bending has occurred. In the return tubular boiler the steam pressure in the boiler has a tendency to force the shell into a true

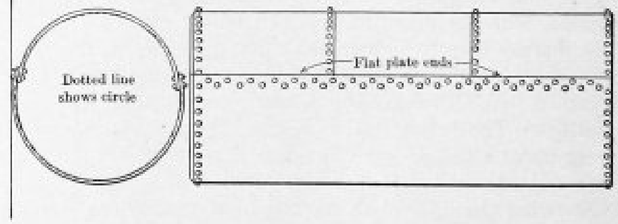


FIG. 3.—BOTTOM HALF OF ONE SHEET.

circle, and as the shell was not originally made in a true circle, each time the boiler is cooled or the steam pressure is reduced very low the bending strain takes place as the boiler tends to assume its original position.

With the three-plate type of boiler this contortion would come on the center sheet to a greater extent than on the two end sheets, because the two tube sheets hold the two end plates in practically a true circle at one end, while the inner ends of the end sheets have the bending strain at the seam as the shell is forced toward a true circle. The center sheet, however, not only has an out of true circle of its own to contend with, but that of the two inner ends of the end sheets, the riveted longitudinal seams coming out of line, making three out-of-round sections in the center of the boiler

* *The National Engineer.*

shell. These points are brought out in Fig. 2, which shows the shell somewhat exaggerated.

To overcome this effect of the boiler shell and possibly cheapen the cost of manufacture, the bottom half of the shell has been made of one sheet, and the top half of the shell made up of three sheets, as shown in Fig. 3.

That this is not good practice is evident if the matter is given a little thought. While the bottom half of the boiler is free from riveted circumferential joints, there is the disadvantage of having three half-circular plates riveted to it on the longitudinal seam, and added to that the additional disadvantage of having a greater straight end of the bottom plate than in the case of the boiler constructed of three sheets. This is because the bottom half of the boiler is made of one piece, and in order to roll it the rolls must necessarily be longer, or three times as long as would be the case in rolling the plate to make up a three-ring boiler. As a consequence, the rolls are bound to spring in the center and the plate is not rolled in a true circle. When the long and three short plates are riveted together the defect in the true circle at the longitudinal seam is more marked than when the boiler is made up of three rings.

In Fig. 4 is shown another joint where but two top sheets are used in connection with one bottom sheet. This, while better than the design of three top sheets, has the same disadvantages, that of a badly rolled bottom plate, due to long rolls springing in the center when the plate is passed through them.

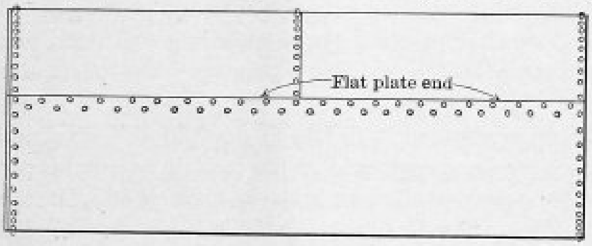


FIG 4.—TWO TOP SHEET CONSTRUCTION.

In Fig. 5 is shown another design of shell in which but two sheets are used, the top and bottom sheets being of the same length, and as both are subjected to the same process of rolling, the error in making a true circle, not only at the ends, but in the center, is magnified. When these two plates are riveted together at the longitudinal seam either the plate must withstand considerable mauling to get it somewhere to a true circle, or the boiler is considerably out of true or under a strain when both joints are riveted together. The result is that after a few years of use these riveted joints have been worked one way and the other, the hinged point coming just outside the rivets of the longitudinal seam. In time either the plate will crack or the rivets will shear.

Two explosions of this type of boiler have recently been brought to notice, one at Shelton and the other at Canton. One was a boiler made up of one bottom sheet and three top sheets, the other of one bottom sheet and two top sheets. The Shelton boiler without doubt gave way at the longitudinal seam and was doubtless due to the breathing action of the boiler, and which caused a crack on the inner side of the joint, but could not be detected. The cause of the crack coming in the first place, however, was not due to faulty material, but to faulty design, a lap joint and faulty work, as the plate could not be rolled true.

Although the account of the Canton boiler explosion does not state the cause, the evidence as given in the various accounts published indicate that the top plates were blown from the bottom plate, the rivets shearing the entire length of the longitudinal seam and on both sides of the boiler at the same time. Putting two and two together the evidence points to an initial rupture midway of the longitudinal seam and then extending toward both ends at practically the same instant, and on both sides of the boiler. This would account for the bottom plate being found almost in its original position while the top plates were hurled to a considerable distance.

The pressure of steam in a boiler exerts a force in every direction, but the force tending to tear a boiler in two pieces endwise is equal to the pressure times the area of the boiler head in square inches times the steam pressure, which equals about one-half that tending to burst the boiler longitudinally, and therefore a boiler made with a single bottom sheet and one, two or more top sheets does not eliminate any of the dangers of the steam pressure to rupture it along the longitudinal seam, but on the contrary another seam has been added to the boiler shell, so that instead of having but one on one side of the circle it has one on each side. As the longitudinal seam always sustains the greatest load it is not necessary to calculate the circumferential seam. A fact worth remembering is that the relative stress on the circumferential seam of any size boiler is always two to one, or the stress per unit of length of longitudinal seam is just twice that of the circumferential seam. If the circumferential seam has a strength of, say, 50 percent of the plate, which it has not, the longitudinal seam in order to be twice as strong would have to have a strength of 100 percent, which is out of the question. The following illustration will show how the strength of the two joints differs:

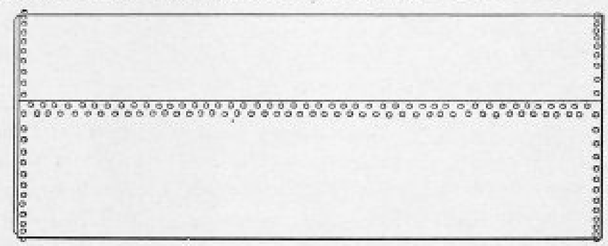


FIG. 5.—TWO SHEET CONSTRUCTION.

Taking a boiler 60 inches in diameter and carrying a steam pressure of 100 pounds per square inch, the pressure tending to pull the boiler apart at the circumferential seam would be found by multiplying the area of the head by the pressure. The area would be $60 \times 60 \times 0.7854 = 282,744$ pounds.

The circumference of the shell is $60 \times 3.1416 = 188.5$ inches.

Therefore: $282,744 \div 188.5 = 1,494$ pounds, the disruptive force of the circumferential seam per inch.

As one inch of the longitudinal seam will carry a load equal to the diameter of the boiler times the steam pressure divided by two, we have $\frac{60 \times 100}{2} = 3,000$ pounds, or twice as much as one inch of the circumferential seam.

It is easier to make circumferential seam last longer in good condition, because it has less strain on it than the longitudinal seam, and because it is free from the breathing effect of the boiler. It is, of course, subjected to the abuse of some firemen who do not use care in getting up steam on a cold boiler or in cooling down a hot boiler, but one seldom hears of the circumferential seam giving way first in a boiler explosion, although they are torn apart after the rupture has started at the longitudinal seam.

With all the troubles that have been traced to the longitudinal seam it stands a proven fact that one lap joint in a boiler for each ring is bad enough, and that two seams in the same ring is about as bad as can be imagined.

The Boiler Maker

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

NOTICE TO ADVERTISERS.

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

The American Boiler Manufacturers' Association will hold its twenty-third annual convention in Boston, July 11, 12 and 13. We trust every member of the association will make it a point to attend this important convention. Every manufacturer not a member ought to become one. There are many features of the work, especially of contract boiler shops, that need co-operation, and the best way to secure this co-operation is by every man connected with the business giving the association the benefit of his support. There are not only questions of high-pressures and conforming to the increased requirements brought about by a steadily growing demand for economy in steam plants, but important side issues, such as the boiler manufacturers furnishing the fittings and attachments for the boilers and taking these and other profits for themselves instead of allowing them to go to outside concerns. Every manufacturer owes it to himself, and to his brother manufacturer, to help improve the conditions of his business, and to take an active part in the forthcoming convention.

A little rest is good for all of us, and among the master boiler makers of the country who are members of the International Master Boiler Makers' Association, and all ought to be, there are many who have three hundred good, hard-working days every year, not to mention quite a number of hard-working nights, and who deserve and should take a little rest. But the active mind and healthy body does not merely wish to rest by just loafing—doing nothing. The brain wants something which is congenial and relaxing, interesting and instructive, and if this is got the physical body will be greatly helped. No better opportunity can be found for the members of the association than the May meeting in Omaha, beginning on the 23d, to take a rest and thoroughly enjoy themselves. Here will assemble men noted in their profession, who speak on the topics selected for discussion, and all can listen to them with advantage.

The subject of blue print sizes is of interest to all, and a standard for them would be most advantageous. Small, odd-sized prints are always getting lost and hunting for them costs a good deal of money and a great loss of time. Flue questions, and they are many, both as to the material best for general use and their application at terminals and on the road, and the man who is responsible for having the motive power "mote" should come forward and say something on these heads. Shop tools are certainly all-important to produce good work, and at small cost. Here is a chance for men who have had experience to add to the general knowledge by not being afraid of telling of a good tool for fear of being thought booming some particular make. To adopt a standard of flanges would be a very wise move, but what has been done in this direction should not be overlooked. What is really wanted is not another standard, but a standard. Everybody can tell something about staybolts and their use, no one can be around boilers much and not get on intimate terms with them, and there will be no excuse for not having a full discussion, as has been planned. Fire-brick arches and arch pipes should bring out useful experiences. After superheated steam, and perhaps even before it, the question of circulation in boilers is most being thought of at the present time, and how to accomplish it, and the effect of good circulation in boilers is well understood, yet more should be known about it. The youngest tool, if it can be called a tool in the boiler shop, is the oxy-acetylene burner, and it rather points to being a possible way out of a lot of troubles, and any one who knows anything about this tool should let his brother boiler maker profit by his experience.

Most boiler makers are apt to be modest in the valuation of themselves. They are more doers than talkers, and quite often they think what they know is of little value, but they forget that every one can learn, and that the usual methods, quite common to some, are quite unknown to others, and to impart information is good for all hands. Also, just meeting men who know things is an advantage, and meeting men who know less than you do is an advantage to them, so it behooves all members of the association to get to this convention and enjoy a few days' rest and intercourse with their fellow-craftsmen and come back refreshed for their work.

Subjects and Committees as Proposed at the Last Convention.

At the fourth annual convention of the International Master Boiler Makers' Association held at Niagara Falls, May last, the following subjects and committees were proposed for the 1911 convention:

"Standardizing of Blue Prints for Building of Boilers."—W. H. Laughridge, Chairman, Columbus, O.; E. W. Rogers, Paterson, N. J.; A. E. Brown, Louisville, Ky.; Claud E. Lester, Meadville, Pa.

"Best Method of Applying Flues. Best Method of Caring for Flues While Engines are on the Road and at Terminals and Best Tools for Same."—D. A. Lucas, Gavelock, Neb., Chairman; John German, Kankakee, Ill.; A. Hedberg, Winona, Minn.; John T. Bond, New Haven, Conn.; A. C. Dittrich, Minneapolis, Minn.; A. M. Dustin, Sedalia, Mo.

"Steel vs. Iron Flues, What Advantages and What Success in Welding Them and Effect of Length of Tube and Maintenance."—F. A. Linderman, Albany, N. Y., Chairman; B. F. Sarver, Fort Wayne, Ind.; John McKeon, Galion, O.; C. E. Elkins, Little Rock, Ark.; M. M. McCallister, Cleveland, O.; H. J. Raps, Chicago, Ill.

"Standardizing of Shop Tools."—John B. Tate, Altoona, Pa., Chairman; Henry L. Wratten, Racine, Wis.; Stephen E. Westover, Pueblo, Col.; George W. Bennett, Albany, N. Y.; F. A. Batchman, Elkhart, Ind.

"Standardizing of Pipe Flanges for Boilers and Templets for Drilling Same."—James Crombie, Hamilton, Ont., Chairman; Wm. Horsley, Jersey City, N. J.; Wm. B. Boom, Bay City, West Side, Mich.; James H. Fahey, Racine, Wis.; Chas. Letteri, W. Pittston, Pa.; G. C. Wehling, Rome, N. Y.

"Best Method of Staying the Front Portion of Crown Sheet on Radial Top Boilers to Prevent Cracking of Flue Sheet in Top Flange."—J. W. Kelly, Oak Park, Ill., Chairman; J. P. Malley, Springfield, Mo.; W. H. Hopp, Dubuque, Iowa; C. Ryan, Omaha, Neb.; Thomas Lewis, Savre, Pa.

"Cause of Flue Holes in Back Flue Sheet Elongating and a Preventive for Same and Effect of the Use of Combustion Chamber."—T. J. McKerihan, Altoona, Pa., Chairman; H. M. Barr, Lincoln, Neb.; D. G. Foley, Green Island, N. Y.; Thomas W. Lowe, Winnipeg, Manitoba; H. Wandberg, Minneapolis, Minn.; William M. Wilson, Silver Shops, Ill.; Joseph McAllister, E. Buffalo, N. Y.

"What Radical Departures Are Being Made in Boilers and Fireboxes."—J. T. Johnson, Los Angeles, Cal., Chairman; F. A. Bachman, Elkhart, Ind.; J. A. Doarnberger, Roanoke, Va.; M. O'Connor, Missouri Valley, Iowa; Fordyce L. Lothrop, Susquehanna, Pa.; Charles P. Patrick, Paterson, N. J.; James C. Weir, Holyoke, Mass.

"What are the Advantages and Disadvantages of the Use of Brick Arches and Arch Pipes in Locomotive Fireboxes?"—John German, Kankakee, Ill., Chairman; Henry J. Wandberg, Minneapolis, Minn.; John F. Beck, Grand Rapids, Mich.; Joseph F. Fitzsimmons, Hornell, N. Y.; E. J. Hennessy, Depew, N. Y.; John Troy, Saginaw, Mich.; E. W. Young, Dubuque, Iowa.

"What Can Be Done to Produce Better Circulation in Marine Return Tubular and Vertical Boilers?"—Henry L. Wratten, Racine, Wis., Chairman; J. C. Weir, Holyoke, Mass.; James Beatty, Toledo, O.; John E. Wiess, Toronto, Ont.; James Crombie, Hamilton, Ont.; Elmer A. Hooper, Hartford, Conn.; H. P. May, Springfield, Ill.

"What Are the Advantages or Disadvantages of Using Oxy-Acetylene Process in Making Repairs to Boilers?"—M. F. Courtney, St. Paul, Minn., Chairman; William M. Wilson, Silver Shops, Ill.; M. J. Guiry, St. Paul, Minn.; James Bruce, Kansas City, Kans.

Law.—C. L. Hempel, Omaha, Neb., Chairman; A. E. Brown, Louisville, Ky.; William M. Wilson, Silver Shops, Ill.; John J. Mansfield, Paterson, N. J.; William H. Laughridge.

Apprenticeship.—George Wagstaff, New York City, Chairman; A. E. Brown, Louisville, Ky.; John B. Tate, Altoona, Pa.; James Crombie, Hamilton, Ont.; J. A. Doarnberger, Roanoke, Va.

To Recommend Topics for Committee Reports at the Annual Convention in 1912.—J. T. Goodwin, New York City, Chairman; W. H. Laughridge, Columbus, O.; George W. Bennett, Albany, N. Y.; William M. Wilson, Silver Shops, Ill.; Frank Gray, Bloomington, Ill.

LEGAL DECISIONS OF INTEREST TO BOILER MAKERS.

Liabilities for Injuries to Boiler Makers for Escaping Steam.

The plaintiff went to repair one of a battery of boilers. One was cold, the other under steam. They were all connected. He entered the cold boiler, and a fireman opened up the valve leading to the same, and the plaintiff was scalded. Judgment for the plaintiff was originally affirmed on appeal, but this was reversed on rehearing, and a new trial ordered for the following reasons: The original judgment was affirmed on the theory that it was the defendant's duty not to turn on steam without being sure that connection to the cold boiler was closed, but owing to the position of the valves, which would prevent steam entering the cold boiler and which was closed when the defendant entered it, it could not be opened or closed without the defendant knowing, as he was working within 2½ feet of it. The defendant opened this valve when he first went to work, in order to draw out water, and he was notified that he must keep the valve closed, and he closed it. But the court held it was the duty of the defendant to know that this valve was closed before turning on steam, but as it had turned over the boiler in a safe working condition the court was persuaded that the defendant ought not to be held responsible for the opening of the valve without some way tending to show that it was opened by some person in its service. Comstock and Hadley, *JJ.*, dissented upon the ground that the judgment could only be reversed by weighing the evidence.—*United States Board & Paper Company v. Landers, Indiana Appellate Court.*

Liability for Death of Engine Repairer.

The city of Atlanta was sued by minor children of an employee killed while repairing one of the city's engines. The plaintiffs claimed that through a leak in the steam jacket the engine started while employee was at work, killing him; that this leak was due to a leaky valve; that the bleeder valves or the cylinder were not open, and no warning of their condition was ever given the deceased. The city claimed that the plaintiff had no cause of action. This was reversed by the Court of Appeals of Georgia, which held the city did not surrender the custody of the premises to the deceased employee. A breach of duty to warn him of any latent danger in the condition surrounding the premises was wrong, and would give rise to a cause of action against the city. The city contended that the deceased was engaged to repair a defect on the very engine that killed him, therefore could not complain of defective machinery. The court held that it could not infer that the defect which resulted in the workman's death was the very defect he was sent to repair. That it is the duty of the owner of machinery undergoing repairs to warn those employed in making such repairs of any latent danger, and if this is not done a cause for action may arise.—*Huly v. City of Atlanta, Georgia Court of Appeals.*

Inter-State Commerce.

The agent of an Illinois engineering corporation made a contract with a Missouri corporation for two high-speed engines and electric generators to be erected in St. Louis, Mo. The order was carried out and the sellers sued for a balance. Both the corporations were doing business in various States, and both were incorporated. The defense was that the Illinois corporation was not authorized to do business in Missouri. Rev. St. 1909, S. S. 3,037, 3,039, 3,040, which requires a foreign corporation to obtain a certificate in order to sue in the State. The plaintiff held that the transaction was inter-State commerce, and the statistics relied upon did not prevent foreign corporations from maintaining an action. Judgment for plaintiff was affirmed.—*Chase Engine & Manufacturing Company v. Vromania Apartment Company, St. Louis Court of Appeals, Missouri.*

Assumption of Risk of Explosion in Boiler Furnace.

A fireman was injured by back fire of a sawdust and shaving-fed boiler. He was taking the place of the regular fireman and night watchman. He sued for damages received. His experience was six years in charge of boilers in the United States navy, during which he fired boilers with coal, but never had had any experience in firing with sawdust and shavings. The plaintiff charged negligence on the part of the defendant in not warning him of the danger of back-fire explosions for the fuel used. The defense was, such dangers were obvious, springing from natural laws. There was no claim of defects in the boiler by the plaintiff. That the plaintiff could not plead ignorance as his experience was extensive.—*Props. v. Washington Pulley & Manufacturing Company, Washington Supreme Court.*

Parol Evidence Inadmissible to Add Warranty to Written Contract for Sale of Boiler.

A boiler sold to the defendant for resale did not prove satisfactory, and defense was breach of warranty. The plaintiff's theory was that the defendant relied upon his own judgment in selecting the boiler; the defendant's theory was that he relied upon the judgment and opinion of the plaintiff. A letter was introduced from the defendant to the plaintiff, which represented a desire to have a special locomotive boiler built according to his instructions. A letter for the plaintiff to the defendant describing the boiler, giving price and terms, shipping direction, and the defendant's order was entered in accordance with the representative's instructions, to this was appended a note signed by the representative, "above in accordance with my instructions"; this was confirmed by defendant. It was held that there was a complete written contract, and that verbal evidence was inadmissible to prove any warranty of the fitness of the boiler for the purpose.—*Erie City Iron Works v. Miller Supply Company, West Virginia Supreme Court of Appeals.*

Things Some Know, Others Have Forgotten, and Some Never Knew.

Bituminous coal contains 14,400 B. T. U.; anthracite, 13,500 B. T. U. A British thermal unit, usually abbreviated as B. T. U., is the heat required to raise 1 pound of water 1 degree F.

To change water at 212 degrees F. into steam requires 986.6 B. T. U. After becoming steam only .48 B. T. U. are required for each additional degree raised.

Superheated steam contains more energy than saturated steam.

Saturated steam may be either wet or dry, and owes its temperature to pressure.

Superheating cannot be carried to any extent, as after what is known as the "critical point" is reached the steam will disintegrate into its gases, oxygen, hydrogen.

To superheat does not cost much, as with 20 percent additional fuel 250 degrees of superheat is obtained.

Superheated steam has the advantage that it cannot condense until it has lost all its superheat.

Water will shrink in volume in cooling until 30 degrees F. is reached, after which it expands until it freezes or reaches 32 degrees F. The reason for this is not understood.

Water expands 1,700 times in volume in becoming steam, 1 cubic inch becoming 1,700 cubic inches of steam.

Absolute zero is —495 F., and has never been reached.

The centigrade thermometer makes its 0 freezing, and divides the space between it and boiling point into 100 divisions, hence its name.

Examinations for Federal Locomotive Inspectors.

The United States Civil Service Commission announces that examinations will be held on June 7 and 8 in about 300 cities and towns in various parts of the country to secure eligibles to fill positions under the new federal locomotive inspection law. The salary of the position is $1,800 a year. Applicants must have reached their twenty-fifth birthday but not their fiftieth. Applicants must be physically qualified and may be required to take a physical examination. Other requisites are good moral character and habits, good speech and address; they must have had not less than three years' railroad experience or not less than five years as a locomotive fireman, and must within two years preceding the date of application have been in active service. No person interested either directly or indirectly in any patented article for use in connection with locomotives will be considered. Applicants must be citizens of the United States. Those who wish to take the examination should apply at once for Form 1892 to the United States Civil Service Commission, Washington, D. C. Examinations will be on the basis of 100 points. Spelling counts 5, arithmetic 5, report writing 5, knowledge of locomotive boilers and appurtenances 30, training and experience 30, personal characteristics 25.

PERSONAL.

JAMES DAVIS, who was assistant foreman at the works of the Berry & Zecker Company, has accepted the position of assistant foreman with the Lancaster Iron Works, Lancaster, Pa.

AUGUSTUS DOBECK, formerly riveter with the Thompson Iron Works, Philadelphia, Pa., is now foreman of riveters with the Lancaster Iron Works, Lancaster, Pa.

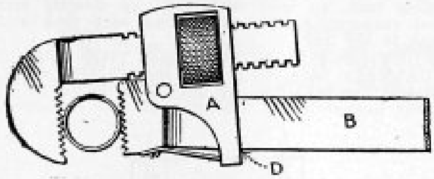
SAMUEL J. JEFFERIES, formerly with the Philadelphia Iron Works, of Philadelphia, has resigned to take the position of outside superintendent with the Quaker City Iron Works, also of Philadelphia. Mr. Jefferies desires to be remembered by his friends and patrons.

THE ZIMMERMAN BOILER & TANK WORKS, of which William H. Zimmerman is manager, have been established at Dayton, Ohio, corner of Irwin street and the Big Four Railroad. This company will make a specialty of plate and sheet metal work of all kinds, with particular reference to repair work.

ENGINEERING SPECIALTIES.

How to Use a Pipe Wrench.

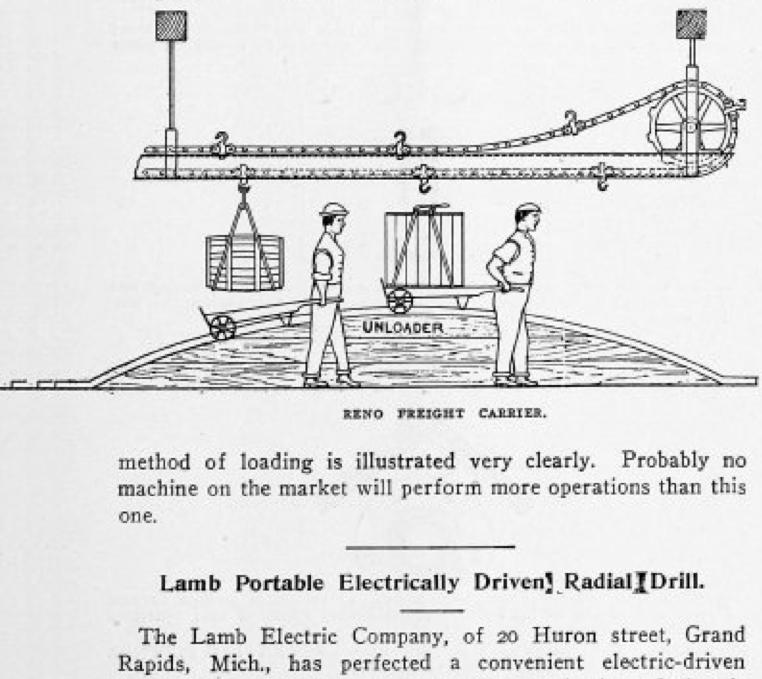
Every engineer knows that a pipe can be easily jammed by a pipe wrench, but if my instructions are carried out, one can be used on even thin pipes without jamming them, says a correspondent in *Power*.



Place the wrench on the pipe and get it to bite; then slack off on the nut until the frame *A* comes in contact with the handle *B*, at *D* (see illustration), thus preventing the jaws from closing; the wrench then has power to turn, but not to jam the pipe.

The Reno Freight Carrier.

We illustrate the Reno freight carrier, a device which can be fitted in warehouses, on steamship piers and at railroad terminals, for the rapid handling of freight. It is manufactured by the Reno Inclined Elevator Company, of 555 West Thirty-third street, New York, U. S. A. The machine consists of an endless chain of special construction provided with pivoted hooks, which are carried by small iron wheels, which roll upon the flanges of a pair of channel beams bolted together and spaced about 1 inch apart, thus forming a strong truss frame or carrying track capable of spans of considerable length. At each end the chain passes over a sprocket wheel, and these wheels can be driven by motors in either direction. The

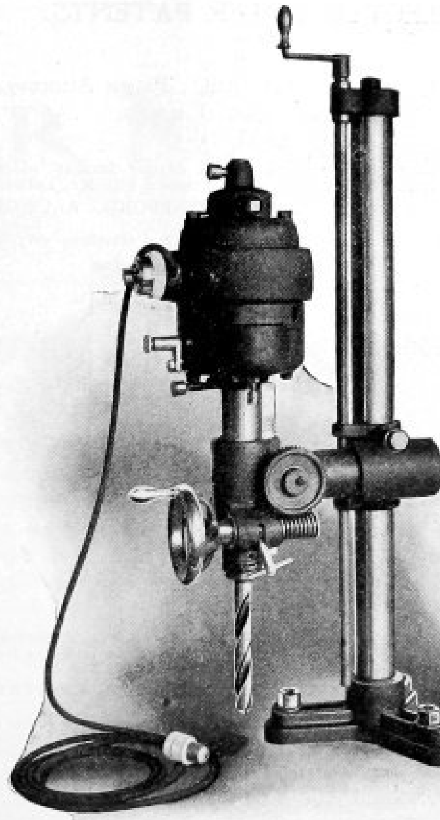


RENO FREIGHT CARRIER.

method of loading is illustrated very clearly. Probably no machine on the market will perform more operations than this one.

Lamb Portable Electrically Driven Radial Drill.

The Lamb Electric Company, of 20 Huron street, Grand Rapids, Mich., has perfected a convenient electric-driven radial drill, which we illustrate. The application of electric drive in this drill simplifies the construction, so that while there is ample power to drive a 1-inch drill and feed it to its work properly the weight is only 125 pounds to 150 pounds, depending on the current available. The feed is through a worm and wheel, pinion and rack, and a quick return is provided when wanted; the thrust is received on ball bearings, the column is made of steel tubing, and is 2½ inches diameter. As usually made the following is the range of work: Twenty-eight inches from spindle to base, 8¼ inches from center of spindle to column, travel of spindle is 5 inches, and the hole in same is No. 3 Morse taper. The extreme height of the drill is 40 inches. One convenient feature of this drill is that it can



LAMB ELECTRICALLY DRIVEN DRILL.

be fitted for two speeds, and to make the change only a button has to be pushed. The radial feature makes it most convenient. The range, as above given, can be altered to meet requirements.

The Hauck Portable Brazing Outfit.

The Hauck Manufacturing Company of 140 Livingston street, Brooklyn, N. Y., has brought out a portable brazing outfit, using kerosene oil as fuel, as shown in the illustration. The outfit consists of one seamless tank, equipped with hand air-pump and two inside burners. These burners are held in any desired position by adjustable stands. The manufac-

HAUCK PORTABLE BRAZING OUTFIT.

turers claim that these burners will give very large, powerful, clean flames, with entire absence of smoke. The flames can be readily regulated. A convenient feature is that the flames can be worked in any position. As the outfit uses kerosene oil and as the consumption of this oil is very low, the outfit is economical in operation. It has few parts or adjustments, and nothing to get out of order. All joints are brazed.

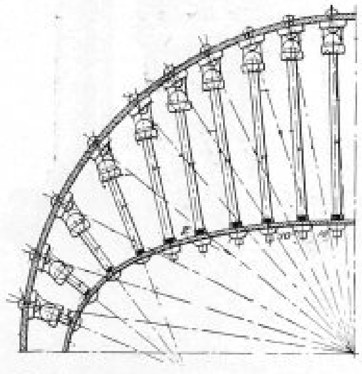
SELECTED BOILER PATENTS.

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

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

980,696. STAY-BOLT. B. E. D. STAFFORD, ALLEGHENY, PA.

As a new article of manufacture a bracket for attaching stay-bolts to



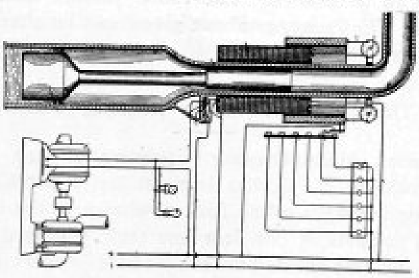
the roof sheets of boilers comprising a base flange having rivet holes, a web intermediate said rivet holes and seats projecting laterally from the web, the said seats being in line with the rivet holes.

985,778. FEED-WATER HEATER. C. CAILLE, LE PERREUX, FRANCE.

A heater for the feed-water of locomotive and other boilers, characterized by a contrivance for automatically regulating the pressure and consumption of steam taken from the engine exhaust, this contrivance comprising two automatic valves located respectively in the steam escape and inlet pipes of the heater; the springs of these valves being regulated in such a manner that the escape valve closes when the steam pressure in the heater reaches a predetermined minimum, while the inlet valve closes when the steam pressure rises above a predetermined maximum.

986,210. LEVEL-INDICATOR FOR BOILERS. FRANK PEARSON, OF MOUNT RAINIER, MD.

A level indicator for boilers comprising a tube, a solenoid slidably



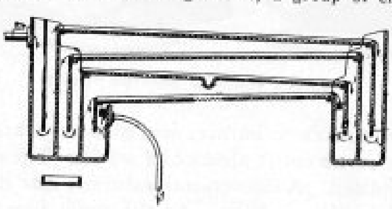
mounted on the tube, a float received in the tube having an armature, said armature attracting and moving the solenoid upon the movement of the float, an electrical circuit, and means operated upon the movement of the solenoid for making or breaking the circuit.

986,791. LIQUID-FUEL GOVERNOR. GEORGE E. WITT, OF SAN FRANCISCO, CAL.

An oil-burning system having in combination a boiler, an oil pump, a burner having a steam pipe connected with the boiler and also having an oil pipe connected with the pump, governors in the oil and steam pipes controlled by the variations of steam pressure in the boiler, said governors regulating the steam and oil feeds independently by the boiler pressure, and means for operating the oil pump, a governor regulating the oil adapted to respond to a decrease of boiler pressure and to admit an increased feed of steam to the oil pump, for causing an accelerated boost to the oil pump to cause it to raise the oil pressure in the oil pipe.

986,968. FEED-WATER CLEANER AND HEATER. EMIL EFRAN, OF BRUENN, AUSTRIA-HUNGARY.

In a liquid heating and cleaning device, a group of chambers, each



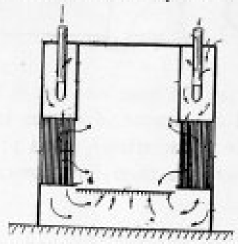
chamber having a partition therein extending from the top into proximity with the bottom thereof, a second group of chambers of similar construction to first said group, a supply pipe and a discharge pipe communicating with said chambers, and inclined aqueducts connecting the two groups of chambers.

986,886. WATER HEATER AND PURIFIER. JOHN EDWARD WOOD, OF NOTTINGHAM, ENGLAND.

In a water heater and purifier the combination of a water inlet pipe, a cowl for breaking up the feed water, a tray on to which the water falls, a settling tank, an inlet from the tray directly into the tank, and a helical evaporating tray surrounding such tank and an outlet from the tank to the tray.

985,188. DEVICE FOR INCREASING THE EFFICIENCY OF FUELS. CAMILLE MAGNÉ, OF MARCINELLE-CHARLEROI, AND EDOUARD DEMEURE, OF BRUSSELS, BELGIUM.

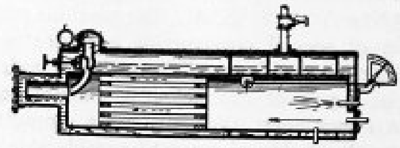
A device for increasing the efficiency of fuel comprising the com-



bination with a firebox having a firegrate and a bridge wall, said firebox forming a combustion chamber, of mixing chambers for air and steam located within the firebox and exposed to the direct heat of the fire, vertical tubes or conduits connected to the bottom of the mixing chambers and discharging beneath the firegrate, said tubes being within the firebox and also exposed to the direct heat of the fire.

985,281. BOILER. GEORGE PETERSON, OF DULUTH, MINN.

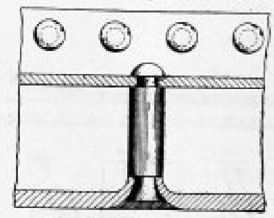
In a boiler, the combination with the inner and outer shells having a water jacket therebetween, of a coil having a water jacket, said coil



leading from the inner shell, means for providing combustion in the inner shell, the coil serving to conduct away the gases of combustion, and means for introducing steam into said coil.

985,077. WATER JACKET. SAMUEL W. TRAYLOR, OF ALLENTOWN, PA., ASSIGNOR TO M. P. SCHANTZ.

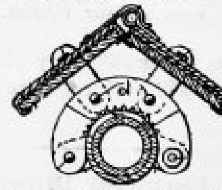
A jacket comprising an inside and an outside sheet, the inside sheet being provided with openings having their outer ends closed by plugs



welded to the sheet and thereby forming sockets, stay-bolts having one end embedded in said socket and the opposite end engaging the outside sheet.

984,676. ATTACHMENT FOR BOILER GAGES. CHARLES A. JOHNSON, OF CRESTON, IA.

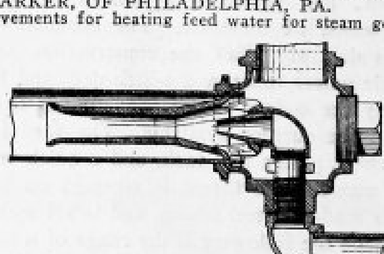
In an attachment for boiler gages, a frame, means to hold said frame on a water gage, said frame being provided with a shield adapted to fit



over the front of the gage glass, a pair of reflectors pivoted to said frame, and means to hold the opposed lateral edges of said reflectors releasably together.

985,834. FEED-WATER HEATER FOR PREVENTING PITTING. JOHN C. PARKER, OF PHILADELPHIA, PA.

The improvements for heating feed water for steam generators which



comprises, in combination with a tube, a nozzle through which heated water is discharged into said tube, a second nozzle by which feed water is discharged into said tube through said nozzle first named, and means for conducting feed water to said second nozzle.

THE BOILER MAKER

JUNE, 1911

PROCEEDINGS OF THE FIFTH ANNUAL CONVENTION MASTER BOILER MAKERS' ASSOCIATION.

The fifth annual convention of the International Master Boiler Makers' Association was held at the Rome Hotel, Omaha, Neb., May 23, 24, 25, 26, 1911.

FIRST DAY.

At 10:30 A. M., President A. N. Lucas, of Milwaukee, Wis., rapped for order, and made the following remarks:

Gentlemen, please come to order, and we will proceed in our regular way with the opening morning exercises. I am certainly pleased to see such a large gathering.

The Rev. Frederick T. Rouse, of the First Congregational Church of the City of Omaha, will open our morning session with prayer.

After the invocation the president introduced His Honor James C. Dohlman, Mayor of Omaha, who welcomed the association most warmly, giving them the key of the city and every assurance that he, as well as all citizens, would do everything in their power to make the meeting of the association a profitable and enjoyable one. His Honor called attention to the great advantages of Omaha, and hoped none but the pleasantest recollections would be carried away by the ladies and members of the Master Boiler Makers' Association of the city.

The president asked Brother J. W. Kelly, general foreman of the Chicago & Northern Railway system, to respond to His Honor's words of welcome. Brother Kelly told the Mayor that he could rest assured that the key of his beautiful city would be returned to him in good condition and with regret, and on behalf of the association he thanked His Honor for the cordial greeting and welcome.

SOME OF THE MEMBERS AND THEIR FRIENDS.

An address by G. E. Haverstick, chairman executive committee of the Commercial Club of Omaha, was most happy, and he made it plain that the club he represented was alive to the advantages of the city and welcomed most heartily those who had honored it by their presence.

Brother J. H. Smythe was asked by the president to respond to Mr. Haverstick, and he made himself solid at once by according to the ladies their power, and expressed the satisfaction the association felt in being in Omaha and being so kindly welcomed by the Commercial Club.

General Manager C. E. Fuller, superintendent of the Missouri Pacific, who is also assistant general manager of the Union Pacific, was next called upon by the president. Mr. Fuller made in his address most pertinent remarks, placing the boiler in its true position as the heart of railroading; he pointed out that improvements were being made in material, design and workmanship, but we were not yet at the "end of the asking." He also strongly urged all boiler makers to carry out in every way not only the letter of the law but its spirit, as regards inspection and steps taken to protect life from boiler explosions. Mr. Fuller extended an invitation to the association to visit the shops of the Union Pacific.

Mr. J. D. Goodwin was very brief in responding to Mr. Fuller, whose presence was, he said, an honor, and whose ability was so well recognized, and that an inspection of the Union Pacific shops would be looked forward to with pleasure.

The president introduced Mr. E. W. Pratt, assistant superintendent of motive power, Chicago & Northwestern Railway Company, Missouri Valley, Ia.

Mr. Pratt said in part: It has been my general observation that boiler makers are very zealous in what they believe to be right practice, and that their discussions on the same are apt to be heated and to the point—apparently they all come from Missouri, and want to be shown; they are rather set in their own ways until they find better ones. Foreman boiler makers who do things should be encouraged. This is an age of action. Many of our best boiler devices were produced by round-house foremen and round-house boiler makers; they are the ones who have to keep things right and in working order, and it should be our care that we avoid easy "back-shop" practices that do not produce desirable results; on the contrary, we must guard against "easy" round-house work. How often do you find a round-house boiler maker who likes the brick-arch, and who does not have to be watched to see that it is replaced when taken out?

Much advantage is to be derived from better round-house care of locomotive boilers, and I believe this can be brought about better by giving the foremen boiler makers jurisdiction over the flue borers, arch cleaners, arch-brick men, wash-out men and those upon whose work depends the care of these boilers. Where arch tubes are used in bad-water districts he should see that they are bored out properly when engines are washed out; he should also have charge of the tools that these men work with in the proper performance of their duties. One of the expensive renewals in the locomotive boiler is the back flue sheet. I presume by this time most of you are giving good water space between flues, keeping flues a good distance away from the top and side flanges. Many of you stay the flue sheet with rods or blind flues at several points, and are turning all flanges with a larger radius. By the way, I presume by this time most of you agree that the flue sheet moves upward with repeated expansion of flues, instead of the crown sheet moving down; but I believe that this is a very delicate subject to mention in this assembly. Notwithstanding all these improvements in design and workmanship do we not often renew flue sheets because the corner and top flue holes are badly out of round, or because the sharp heel of the calking tool has cut nearly through the sheet? This latter can only be avoided by careful and frequent checking of calking tools with templates; but cannot some tool be used in the top and corner holes to prevent driving them out of round so badly?

The more extensive application of superheat to locomotives will doubtless have a tendency to reduce the boiler pressure somewhat but will necessitate greater care and attention being given the larger flues and superheater tubes. Probably the modern firebox and tubes are the weakest parts of the modern locomotive, and the superintendents of motive power on this continent are looking to you men and your organization for improvements in design and care, and your work and efforts in the past would lead me to believe that they will not be disappointed. This opening year of the Federal Boiler Inspection Law is bound to be a severe test of your efficiency as heads of a most important department, but you are a class of men whose training has been such that difficult problems will only spur you on to greater accomplishments. I wish to thank you for the privilege of meeting and addressing you, and trust that your convention will be the most successful one which you have ever held.

The president asked Mr. William Laughridge to respond to Mr. Pratt.

Mr. Laughridge considered Mr. Pratt had struck the key-note of the convention in his address, and that the boiler maker was a man of action, and progressive Omaha was a surprisingly beautiful city, and the kindly welcome extended to the association would be remembered, and all the city would not be carried off by departing members of the association.

The president announced that Mr. T. R. Roope, of Lincoln, Nebraska, assistant superintendent of motive power of the Chicago, Burlington & Quincy, had hoped to be on hand, but as he was not he would call on Col. T. W. McCullough, of the *Omaha Bee*.

In a most interesting address the Colonel showed how the old longing was still in him for his firing days, and of his affection for those who stand behind the shovel to-day. He sketched the progress in locomotives and of the city, and called to mind that fifty years ago Omaha was just born.

Secretary Harry D. Vought, of New York City, was called upon by the president. Mr. Vought is ever ready, and while he did not think the previous speaker had it on him in any way, it did not appear that Brother Vought got quite as near as Colonel McCullough had in being a motive power man. The secretary laid no claim to having shoveled coal to produce power, but he did claim to have gone so far as to load bags of oats for the army mule, which, after all, is not so far behind as a prime mover.

President Lucas then gave the following address:

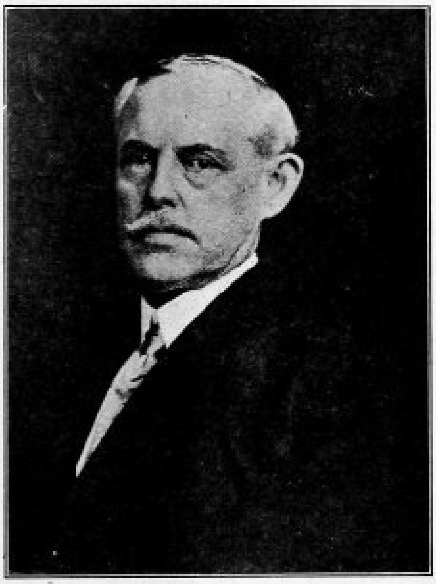
Ladies and Gentlemen, Members of the International Master Boiler Makers' Association and Guests: It gives me much pleasure to meet you all at our fifth annual convention. During the past five years we have had the pleasure of visiting a number of beautiful cities in the East and South. This year we meet for the first time in the Wooly West, in the attractive city of Omaha.

I feel sure that I voice the sentiment of every member of this convention when I state that we feel honored by the presence of the gentlemen who have preceded me and those who have tendered us so hearty a welcome to this enterprising city.

We are here primarily for the interchange of ideas and the uplifting of the boiler maker as well as boiler making. We have made substantial increases in all directions—financially, in numbers and in power—during the past year. The committee reports and individual papers to be presented at this meeting will indicate clearly the good work that has been done by those in charge. With the co-operation of every member to make our association a success, it is wise for us to hold our apprentices and keep them in service where they can work to their own and our advantage, advancing them to positions of trust and of responsibility. Much harm can be done to the young man who has finished his term of apprenticeship by turning him loose, as the saying is, to let him go out and get experience. Many times he falls in with the wrong class of men, and is ill-advised by the so-called "rounders" traveling from shop to shop. I would urge the railroad companies to select capable young men to serve as apprentices, directing them in their work during the four years they serve, and give them to understand that there is something to look forward to, providing they show the proper interest, and they will, nine times out of ten, turn out well. I know of no better recommendation for a young man at the expiration of his apprenticeship than to have the foreman say to his superior officers, "That young man is all right; I want to keep him and we should give him journeyman's pay."

To the ladies who have gathered here we appreciate your companionship during our meeting; it is always a pleasure to have you with us; it spurs us on to do our duty, and I trust you will enjoy your visit in Omaha.

Boiler making is an art. Good designers and first-class workmanship in boiler construction are essential. This organization has been a great school of instruction for a great many of us; it has given us new ideas, something to work for, something to look forward to.



HARRY D. VOUGHT, RE-ELECTED SECRETARY.

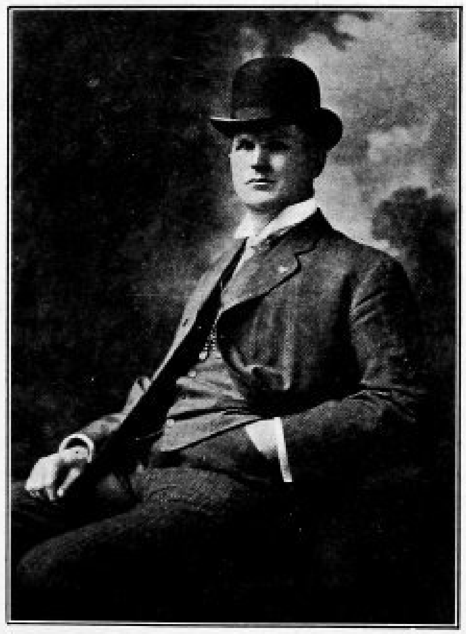
The boiler maker foreman holds one of the most responsible positions in the mechanical world to-day. As a matter of fact, much depends on his judgment, not only of material, work and construction, but also of men. His position is one where material or labor can be lost or saved. He has the opportunity to do much for his fellow workmen in interesting them in themselves first, in their work and the company they work for.

A few words for the apprentice. We should aim to give him every advantage to help him to become a first-class workman, and when his time has expired we should stand ready to take him on as a full-fledged journeyman, knowing as we do that he is a better man, all around, for the company where he has served his time than men we could pick up from time to time. I believe that every railroad should aim to develop their own mechanics. In closing I feel that I should be very ungrateful if I did not recognize with thanks the assistance given me by the officers of the association, the executive committee and the several committees and individuals who have prepared reports for this meeting—to all my heartiest thanks are given. Mr. George Slate would like to make an announcement.

Mr. George Slate: My announcement is to the ladies. If you will refer to your entertainment programme you will find that there is a reception to be held at the residence of Mrs. C. L. Hempel, of 2545 Davenport street. I would like to arrange for cars to take the ladies out there, and it is necessary on account of the congested condition of the streets on which the cars run that you be promptly on time. We would like you to gather in the hotel lobby here not one minute later than 2:30 o'clock, as the cars must leave the corner down here at 2:40. Promptness is the necessary feature.

The President: I will declare a recess of five minutes now to give those who wish to leave the room an opportunity to do so.

The president, calling the meeting to order after the recess, asked for the report of the treasurer, Mr. Gray, which was read, received and referred to the auditing committee, the members of which, the president stated, he would announce later.



GEO. BENNETT, THE NEW PRESIDENT.

On the motion of Mr. Laughridge, which was at once seconded and unanimously carried, it was ordered that a message of condolence be sent Mrs. J. R. Cushing, the news of Brother Cushing's death having been announced. The president appointed Mr. W. H. Laughridge, John McKeown and D. A. Lucas as a committee to carry out the order.

Mr. Hempel referred to the invitation to visit the Union Pacific shops, and the president urged all to accept it. Mr. Ryan, he announced, would escort all who desired to accept the invitation.

The secretary reported that as soon as the rules and formulæ were printed they were forwarded to all technical publications, a number of which had noticed the book favorably, and sales had been made thereby. This action was taken at the suggestion of Mr. Patrick, with the approval of Mr. Goodwin.

The secretary also reported that the constitution and by-laws had not been printed owing to possible important amendments to be offered by the law committee.

Invitations had been received from St. Louis, Colorado Springs, Seattle and Atlantic City, and it was suggested that they be referred to a committee as was the usual custom, which would recommend a place for the next meeting of the association.

Letters of regret had been received from Mr. J. T. Johnston, one of the vice-presidents, and from Mr. Flavin, who had met with an accident. Mr. Arthur E. Brown was greatly disappointed in being prevented from attending the meeting, a strike keeping him at home.

The death of Mr. Wade, of El Paso, Tex., who died Feb. 19, 1910, was announced.

On a motion of Mr. Goodwin a list of those applying for membership was presented by the secretary, who reported the approval of the chairman of the executive board of all named thereon, and they were therefore in order for election. On Mr. Goodwin's motion, seconded in due form, the gentlemen whose names were read were elected members of the association.

The president announced the following committees:

AUDITING COMMITTEE.

Mr. J. H. Smythe.
Mr. W. H. Laughridge.
Mr. C. E. Berry.

COMMITTEE ON RESOLUTIONS.

Mr. George Wagstaff.
Mr. C. L. Hempel.
Mr. M. J. O'Connor.

The meeting was then adjourned until 9 A. M., May 24.

SECOND DAY.

The President: We will proceed with the work as laid out for the second day. The first thing we have before us is a report from Mr. Brown, of Louisville, who attended the Boiler Manufacturers' Convention. I am sorry that Mr. Brown cannot be with us, but the secretary has some report from him.

The Secretary: Mr. President, the secretary has no formal report. I received a letter from Mr. Brown stating that he would be here. He said that ex-President Wagstaff had so paved the way for his attendance at that convention that he was received with open arms; he wanted the members of the convention to understand that their representatives had been accorded every attention. The Manufacturers' Association in return has sent a representative of their association to this convention, Mr. James Farasey.

The President: Mr. Farasey is here as a delegate from the Manufacturers' Association. If he will come forward I will be pleased to give him the privileges of the floor.

Mr. James Farasey: Mr. President and gentlemen of the Master Boiler Makers' Association, it is certainly a great pleasure to be with you at this time. We were indeed glad to have Mr. Brown with us at our last convention, but when he says that the way was paved so well for him by his predecessor, Mr. Wagstaff, he is a little mistaken in fact. Mr. Brown is entitled to just as much credit as Mr. Wagstaff.

Now, gentlemen, there is practically no difference between your meeting here and the meeting of the Boiler Manufacturers' Association; you are here to advocate the best practices, the best materials, and everything that goes to protect the lives of people who are traveling. If I were to ask any man here which was the largest city in the United States, undoubtedly he would say New York; but that is not true. The largest city in the United States to-day is on the Pullman coaches of the different railroads in the United States. There are more people traveling in this country to-day, coming and going, on the different railroads than there are inhabitants in New York City. Upon you, and upon you alone, largely depends the safety of these people. You strive to get perfection so as to do away with the danger of explosions. Now, with the manufacturers we are working on the same lines—we want the best material and the best workmanship. We, however, are handicapped a great deal more than you. The men you represent are anxious to give you every assistance, no matter what; but the manufacturers are up against the general public, who is looking for the cheapest article it can get; what it gets is generally what it pays for.

Mr. President, I want to shake the hand of every man here. I am coming to your next convention. I feel doubly friendly toward everybody here for the reason that I was born in the same city in which this organization was born. I attended your meeting at that time when Mr. Wagstaff was your president. I won't interrupt your deliberations any further.

The President: I thank the gentleman personally for being present, and I hope he will feel free to come and go during our meetings, and the privilege of the floor is his at all times.

The subject of apprenticeship is next in order, and Mr. Wagstaff, I believe, is the chairman of the committee on apprenticeship.

Mr. Wagstaff: Mr. President and fellow members, my associates on my committee have given me a free hand in securing gentlemen to present the subject of apprenticeship, and through the courtesy of Mr. Deems, of the New York Central, we have Mr. Gardner with us. Mr. Frank W. Thomas, vice-president of the Santa Fe line, is also here, and Mr. C. W. Cross, who will show us some lantern slides illustrating apprentice boiler-making work on the New York Central lines. He will be followed by Mr. Gardner, who in turn will be followed by Mr. Thomas. The practical fellow will have an opportunity to discuss the subject later. I have the pleasure of introducing Mr. Cross.

After the reading of Mr. Cross's paper the president said: If Mr. Gardner is ready to produce the slides we are ready for them.

Owing to trouble with the electric current Mr. Gardner was delayed, and at the request of the president Mr. Thomas took the floor.

Mr. Frank W. Thomas: Mr. President, I feel somewhat embarrassed after Mr. Cross's able paper this morning, and after hearing his melodious voice and noting his good looks and winning ways. I noticed that he made the statement about the wandering habits of boiler makers, and in this connection I will say that I still have a friendly feeling towards the wandering boiler maker, as his travel enlarges his view and makes him a better man. I want to thank the president for this opportunity and for the remarks made on behalf of the apprentice boys. I interpret the remarks to mean that the apprenticeship boy is to have a chance, and that we are all going to give him the best opportunity we can, and if we do the boy trained in our own shop will be the best boy we can get for it.

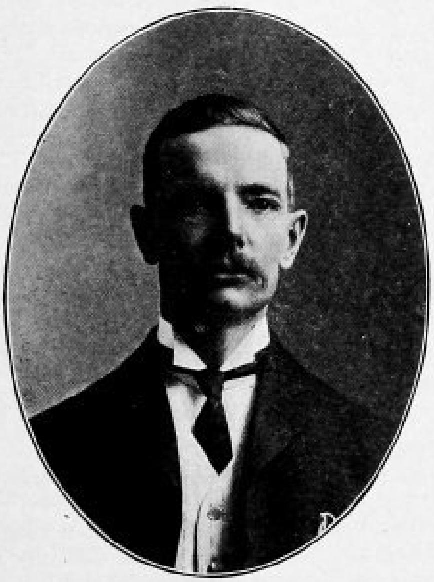
Mr. Goodwin said in referring to the remarks of Mr. Thomas and others: During my career with the International Master Boiler Makers' Association I have never seen anything more interesting or anything that should appeal to the members of this association more than what has been put before us in the last few minutes. This association should rise in a body and extend a vote of thanks to Mr. Gardner and the different officers of the New York Central lines for coming before us and giving us such a demonstration as they have. I move that we extend a standing vote of thanks to Mr. Gardner and the other officers here this morning. (Seconded by many and carried by unanimous rising vote.)

The President: The subject is now open for discussion.

Mr. Smythe: Mr. President and gentlemen, I didn't expect to be called upon, but my friend sitting by my side just whispered to be that he believed I was a pioneer along apprenticeship lines. Since the meetings of the Boiler Makers' Association we have got our minds broadened, especially when we come to recognize the fact that somebody ought to get the benefit of our knowledge and experience. At Bloomington, on the Chicago & Alton, we organized a class of apprentices. After 5 o'clock we invited the apprentice boys in the office and gave them some lectures. The journal, THE BOILER MAKER, made much of the fact, I am glad to say, and was proud when I found that it said we were on the right lines. This association has done a lot for us; before we were narrow, but I am proud to say that we have lost that narrowness. We are on the right line this morning, and when we are ready to give up our mission as boiler makers, and to lay down the mission that we have been called to, we will have lads coming up to take our place, and they will fill them better than we, and we can sit back in our easy chairs and say, "There is the result of our work—he is my student."

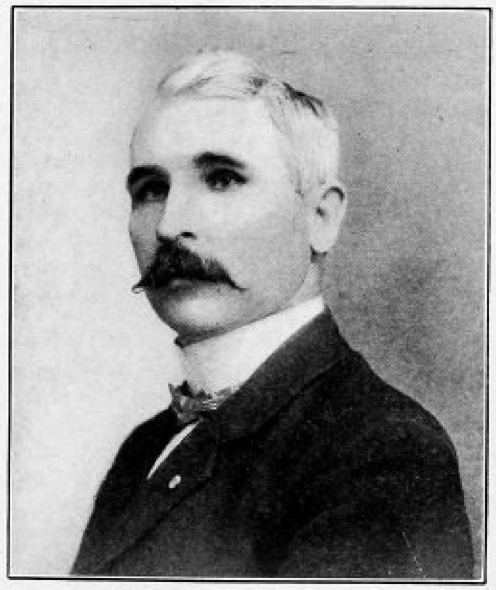
The President: This is a subject worthy of our careful consideration, and we are getting new thoughts to take home to our apprenticeship boys. I want to hear from some other members.

Mr. Hodges, Topeka, Kansas & Santa Fe: Mr. President and members of this convention, this is my first opportunity to attend an association meeting. I suggested to my superintendent that I desired to attend, for the reason that I would come in contact with the master minds among the boiler making industry. In the year 1884 I went into the boiler shops as an apprentice, and at that time the opportunities for training the mental faculties in the art of boiler construction were very crude. I realized the importance of a technical education; I dug into it and dug out. After I became a journeyman I felt my inability to cope with the requirements that devolved on me as a mechanic, so I traveled from shop to shop gaining information. Well, I tell you, gentlemen, every trade and industry is advancing at a high rate, the boiler making industry in the last ten years has advanced so that every young man must study to keep up or he will be a failure in it.



T. W. LOWE, THIRD VICE-PRESIDENT.

Mr. Laughridge: Mr. President and gentlemen, I am certainly glad that this association has given this subject more than a passing notice. The future of this organization depends on those that are coming after us. It is up to this organization to put forth every effort toward the training of the coming mechanics, mechanically and morally, and in this latter respect I am awfully glad to see that the boiler maker is better than he used to be. I made a remark coming over on the train that I had not met one of the old-time rounders for a good many years, but coming up the street I was buttonholed by one, and he began to ask me questions and impress me with the fact that he was a good fellow, and finally said, "Have you got a dime?" That class of boiler maker has gone, and this association has had a great deal to do with his going. I think each individual foreman should give his personal time to encourage the boys to be better mechanics. I think all the roads represented here that have no schools of apprentices, or even if they have schools, that it is up to the foreman of the boiler makers to interest themselves in the matter. On the road I am connected with we never had schools or an organized system of apprenticeship until about a year ago. We established the apprenticeship system, however, but didn't extend it to the boiler shops. They let the boiler shop people do as they pleased; but when they started a school I went around to those that took interest enough in the work they expected to follow as a business and told them, "Here is an opportunity that I and most of the older foremen didn't have; here is an opportunity for you to get a schooling that was not our opportunity." The boys meet three evenings a week. They wash up about a half an hour before the whistle blows and spend an hour in the school; and you would be surprised at the advance they are making in drawing, and the interest taken in what they are doing and what is going on about the shops as compared with what they did before. Before that when the whistle blew they were ready to run. The problem of boiler makers for the future is quite a serious one. We realize that it is dirty work mostly, and the boy that has had the advantage of a school education hesitates to go into the shops, and the only way we can do is to take the boys, even if they have not an education, and endeavor to give them one.



M. O'CONNOR, SECOND VICE-PRESIDENT.

Mr. J. H. Optenberg: Gentlemen of the convention, the question of the apprentice—the boy—being before you, perhaps something about the days when I began my time—forty-three years ago—may interest you. I was left alone in the world, and started to learn the trade in 1869, at fourteen, beginning at $4 a week, paying $3.25 for board and furnished my own bed, consequently I had 75 cents left. To make a long story short I had a hard time making both ends meet. Then the question came up of how was I going to learn the trade? I would have been very thankful to have met some of you gentlemen, such as the brother here who just gave the lecture. I even couldn't purchase a book, as I didn't have the money. I will tell you how I got a book. One of the men who worked where I was went away and forgot his rule book. I took its name at that time, and I happened to have a friend working in a book concern. I borrowed $2.50 of an older man that took an interest in me, and got the young man to order this book. That book is in existence to-day, although it is ragged and has been bound three times. My wife told me I thought more of that book than I did of her. Perhaps she was right. My education is limited, but I got it all myself. It is hard to get the boys of to-day to learn a trade. But we must be sure to find out if the young man is mechanically inclined; if so we should educate him in that line.

Mr. Thomas: The chief advantage of the modern apprentice school system is not to take care of the men of wonderful brain and wonderful determination as this gentleman, but it is the average boy that we have to deal with. The bright, brilliant boy will take care of himself. We cannot get out shops full of the bright and progressive boy, but it is the average boy that we get. Another point is putting the boy in the shop when he is not adapted to the work. The cardinal principle of our system is to ascertain in the first six months if the boy is fit to learn the trade. If he is not fitted for the work we try to put him at another trade, and if not fitted for that we dismiss him.

Mr. Gray: It seems to me that there is one thing that has not been touched on very much; and that is to get the apprentice boys to do the rough or more common jobs. I realize the necessity of teaching the boy the technical part of the trade. We have found that the most successful way is to take a boy, find out his shortcomings and the work upon which he will do the best. If he is adapted to boiler making at all more than likely he will be adapted to some special part of it. The hardest thing is to make the boy understand that there is no branch of the work not important for him to learn. If you don't teach him the importance of each subject you will not get the best work out of him. The boy likes to commence on the higher branches—each one is ambitious to become a foreman. We ought to teach the boys not only how to do the work but show them why it is done that way. Now, if you can get a boy in the shop who wants to know why he does things you have got something to work with. Give him what help you can.

Mr. Lewis: Mr. President and members, we have an apprenticed educational system. I come from the Lehigh Valley Railroad, and in our apprenticeship system our boys go to school on the company's time; part each Monday forenoon and part each Thursday forenoon, and it is compulsory for each apprentice to attend school. The educator or instructor makes a report to me and to our shop superintendent; that is, he gives it to me as a matter of courtesy. I am interested in the boys and I want to know who are the brightest boys we have. I believe the more interest I can take in them the better education they will get.

When we hire a boy we require him to pass an examination; not a very severe one, but the examination that the boys have to pass for the seventh grade in the public schools. We carry many apprentices, and when one goes out we put another on; our apprentices are limited in number. We have a boiler shop and tool room. The first four months the boy is put in the tool room. When the four months expire he goes to the ash-pan burner, and then into the sheet iron works, and so on until his four years are up. I think it pays the foremen to take an interest in this work—I know it does me. Only about two months ago we wanted a layer-out. I went up to one of our apprentices. I said, "Joe, do you think you can handle the laying out?" He said, "Mr. Lewis, I would like to, but I feel a little timid about it." I said, "I am going to stand by you, and I believe my assistant will help you all he can. He has a Cornell education, and has a diploma, and if you get next to him he will make a man out of you." He said, "I will try it." He has been on there for two months, and is doing excellent work. I tell you men it pays us to take an interest in the boys.

The President: Gentlemen, we are lapping over on time that belongs to another subject, and I would ask that you be very brief.

Mr. Goodwin: We are training the young men to-day who will be the master minds in the days to come in our profession. We know that so long as we take this interest in the apprentice we undoubtedly will receive the approval and appreciation of our superior officers. I want to suggest, Mr. President and gentlemen, that it would be a capital idea to publish the slides shown here in our proceedings, and distribute them to the different superintendents, who can see the interest manifested and read the opinions of the different members, and I, as a member of the executive board, suggest that we have the lantern slides reproduced in the proceedings of 1911 convention. I hope this matter will meet the approval of the members of this convention.

The President: I think it is in order to close the discussion now. I also think it advisable to continue this committee.

The Secretary: May I make a suggestion? It is that a committee be appointed of men who are engaged in this work, and that for the next convention they prepare a report. Such men as Mr. Thomas, Mr. Cross and Mr. ———— (who has an educational bureau on the Harriman system) to bring in a report at the next convention which will show the progress of the work. If the report should be statistical, and give the number of boys that have been turned out, etc., and what become of them, it would mean a great deal for the future of the apprenticeship department and of interest to the officials of various roads.

The president announced the next subject for discussion.

What Radical Departures are Being Made in Boilers and Fireboxes.

MR. JOHNSON, Chairman.

The secretary announced that Mr. Johnson was unable to attend and had no report.

The president introduced Mr. A. W. Whiteford, mechanical manager of the Jacobs-Shupert Fire Box Company, who illustrated his remarks with a number of slides. He said:

This is the first time in my life that I have been before a convention. If I don't put this thing on in the regular convention manner overlook it, and charge it up to my inexperience. I have been given the privilege by the committee to show by a series of slides the method of construction, arrangement, etc., of what is known as the Jacobs-Shupert firebox. You are probably more or less familiar with the plan or idea, as it has appeared for some time past in technical journals. I only want to take a moment to point out what is claimed for this firebox. More and more the matter of safety is being given attention. This is not only true in a railroad sense, or in a boiler sense, but it is true in the building sense. It should be the aim of every boiler maker, or, in fact, in any line of business, to perfect products. Economy is of prime consideration—nothing that is progressive is wasteful. There is no economy in extravagance. Safety, efficiency and economy are the three points I desire to make in the presentation of this subject, and I think the shortest and quickest way for me to get it before you is to put the slides in action.

In the slides just given I have shown only the boiler design and construction. The president has asked me to say a word about the manufacture of this box. It is made by the Luken Iron & Steel Company, Coatesville, Pa., the oldest iron and steel company in the United States. Their guarantee is behind it, and it is not made out of any kind of steel, but of material which is considered the very best selection for the purpose.

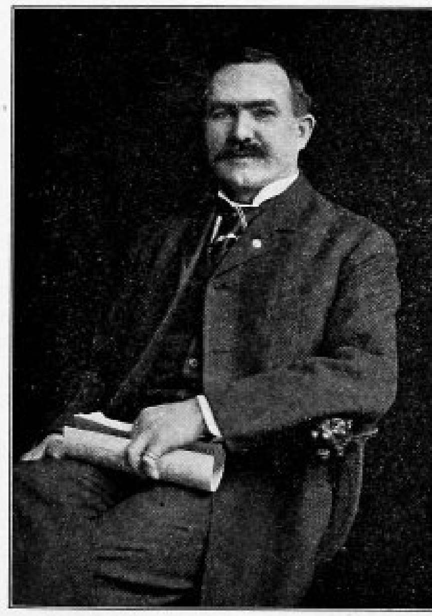
A vote of thanks was given to the Luken Iron & Steel Company, the Santa Fe Railroad, and the New York Central Railroad for their interest in the Boiler Makers' Association.

Mr. Fowler: I don't think that any one who knows will accuse me of not believing in new things, and one of the many new things that have interested me in the last few years is the Jacobs-Shupert firebox. The speech we have just heard in regard to it, I am very much afraid, is based largely on enthusiasm. Sometimes when a man gets enthusiastic he can prove ten times as much as anybody will believe, and he will believe ten times as much as can ever be proven. That is not saying a great deal against the Jacobs-Shupert firebox as it stands; some of the statements made, however, need a little further development. As far as the manufacturer is concerned we must all grant everything that has been said. There are no stay-bolts, but in regard to the safety, undoubtedly the construction of the Jacobs-Shupert firebox produces a safter box than the average ordinary box. If a rupture occurs—I can see no reason why a rupture on those sheets should not occur if they become overheated—the material must yield, and

JONES T. JOHNSON, FOURTH VICE-PRESIDENT.

it will come down and crack; but it has been stated that there is no probability of the sheet carrying a rupture clear through the whole length of the firebox. Ordinarily it is not apt to occur. We will grant all that, but on some other points there has been a lack of information given out. We know very little in regard to the comparative cost of the firebox, and when it comes to a matter of circulation it seems to me that we know still less. Great emphasis was placed on the obstruction to circulation in an ordinary firebox on account of the stay-bolts. If you will examine the Jacobs-Shupert firebox you will find that the water must come in from the front end of the firebox. Instead of circulating in an open space it has to go through a series of holes; you know all those holes put an obstruction in the way of circulation, making good circulation difficult. As a matter of fact is there a single man here, or is there a single man in the country or in the world, that knows exactly what the circulation of an ordinary firebox is? As far as my own information is concerned I have never heard of any definite experiments having been made. We know that it must necessarily be rapid, and we have made several experiments to show that under certain conditions water does not get within three-quarters of an inch of the sheet; that there is sediment rushing up; but what is the direction of the general current? How fast does the current flow? Where does it start to go up? We know absolutely nothing about it, and if the proprietor and manufacturer of this firebox ever made such experiments they have been remarkably reticent in regard to them. Now, it looks to me very much as though the circulation in the Jacobs-Shupert firebox must necessarily be very much less than in the ordinary firebox, and with the circulation less we know what that means in a bad-water district. I wonder what kind of a showing this firebox would make in water carrying 50 to 75 to 90 grains of solid matter to the gallon. If that scale settles on the boiler those sheets are going to get hot. If they get hot and the water is low they will come down, and you cannot make a firebox, of course, that will be fool proof. It looks to me as though it was going to be an exceedingly difficult firebox to wash out.

In regard to the statement made that the firebox can save 35 percent in coal it is simply astonishing. We have been working on locomotive boilers and efficiency for years, and the wildest claims that have ever been made for superheating, or any other one thing, as far as saving coal is concerned, never touched 35 percent. It seems to me there must be a displacement of the decimal point, that it might possibly be 3.5, but when it comes to 35 percent it will need a very large



FRANK GRAY, TREASURER.

amount of demonstration to show that that can be done. If such a thing were possible, or almost so, this firebox would wipe the ordinary fireboxes off of the face of the earth so quickly that you wouldn't have time to breathe. I am not talking in this way because I am opposed to the Jacobs-Shupert firebox. I bid it God speed, and if it can do better work than the ordinary firebox then take it and give it every chance in the world; but I do think that a firebox of that kind ought to be able to stand upon its own foundation and on its own merit, rather than ask us to believe things which are so far beyond anything that any of us have dreamed of before that the statements ought to at least be accompanied with more definite details of all the tests that have been made to prove that the circulation in the box is better than an ordinary box, or that the saving is greater than we are in the habit of considering possible with an ordinary box. The Jacobs-Shupert firebox is a good thing, but if it is one-fourth as good as they claim it will need no pushing, but will come to stay, and be the standard firebox on all roads in the country.

Mr. Whiteford: The gentleman asks for information. I will give my card to any one here and any question you want to ask or any statement you want to have proven, if you will write to me at New York, or come over there, I will take you over the road where the firebox is now in operation, and give you any demonstration you want, and it won't cost you a cent. That is all I can do.

The President: If there is nothing further on this subject we will proceed on the next, which is "Standardizing of Shop Tools." Mr. John D. Tate is chairman. Is there any report?

The Secretary: There is no report, simply a note of regret of inability to attend the convention sent to Mr. Smythe.

Mr. Wagstaff: I make a motion that the subject be passed along and the next subject taken up. (Seconded and carried.)

The President: The next subject is the "Standardizing of Pipe Flanges for Boilers and Templets for Drilling Same."

As Mr. Crombie, the chairman of the committee that was to report on this subject, was absent, it was moved and carried that it be passed.

A move was made to adjourn, when Mr. Hempel announced a surprise, and all received orders to follow the leader at 7:45 that evening for a jolly good time, and everybody was assured that nobody would starve to death or go thirsty unless struck dumb. Adjournment was made until 9 o'clock the next morning.

THIRD DAY.

The President: The subject we were to take up this morning was "What Are the Advantages and Disadvantages of the Use of Brick Arches and Arch Pipes in Locomotive Fireboxes?" As the chairman, Mr. German, is not yet here we will proceed with the next subject, "What Can be Done to Produce Better Circulation in Marine Return Tubular and Vertical Boilers?" Mr. Henry L. Wratten chairman.

Mr. Wratten having sent in a report it was read; on motion it was accepted and ordered published in the proceedings.

Mr. Young read the report of his committee on "What Are the Advantages and Disadvantages of the Use of Brick Arches and Arch Pipes in Locomotive Fireboxes?"

Mr. Beck followed Mr. Young, and after his report was listened to it was moved to accept both papers.

Mr. Austin: In one of the papers just read the gentleman speaks of some of the arches being placed against the flue sheet, tightly up against it; and he also described what I would call the standard way. It has always been our practice to place the arch 4 or 8 inches from the flue sheet. Is there is any advantage in placing the arch up against the flue sheet? If so, what is it? I imagine that a front end would not clean so readily with the arch placed against the flue sheet. There has been a decided improvement in the form of the brick arch and size, so that now it can be conveniently and easily handled and placed or displaced, where, previous to the last year or two, it has been a big, heavy, dirty job to move one arch. Many are oposed to it. I have in mind the old style of arch.

Mr. Berry: On the Lake Shore we have a new style brick arch of a wider type from which we derive great benefit. If you want to do work on the flue sheet you can take out the center section, which rests on the two center bars. If your brick has to be moved, instead of moving the whole brick arch you use pieces from 14 to 20 inches in width, and there is a saving of expense. It is easier for the round-house men to handle and repair. We are using it on the Lake Shore as a standard and it has given good results.

Mr. Gray: I understand this to be a composite subject, and it calls for the "advantages" and "disadvantages." I would like to know both sides.

Mr. Kelly: I wasn't satisfied in my own mind as to the statements about the brick arches, so I went to each terminal; put on overalls and went into the fireboxes; but I want to tell you I was thoroughly convinced when I got through that when an engine is drafted properly that the brick arch against the flue sheet is the proper place, and it is a big advantage with the corner of the brick cut out. This winter, in our division between Omaha and Chicago, we started to put the brick arches against the flue sheet, and some of our men thought it would be the better way, so we divided it up about half and half, and we ran a test, and the engines with the brick arch 6 inches away from the flue sheet leaked in the bottom, and we had to pull up three or four times, and we never touched the other. The brick arch up against the sheet with the corner open is the proper thing to keep the flue tight, I think.

The President: What space did you have between the flue sheet?

Mr. Kelly: There was a small opening along the side. Some of the arches didn't have that opening, but it didn't seem to make any difference.

Mr. Harthill: On the Lake Shore we put our brick arches up against the flue sheet; having them tight on the side as well as the flue sheet we get better combustion of gases and it eliminates our flue trouble. All our brick arches are put up close against the side sheets and also the flue sheet. We put them within 18 inches or 20 inches of the crown sheet.

Mr. Newgirg: I have had personal experience with the brick arches that Mr. Kelly spoke about. We first set the arch about 6 or 8 inches from the flue sheet, and it gave bad results; we had to repair the large type engines about twice a month, and sometimes oftener, and they would come entirely loose from the sheet, and the grates would stick and burn out; then we put them up against the sheet. This we found wouldn't expand our flues half as much and our grades didn't burn out as much as before, and we saved from 5 to 7 ton on a 160-mile division a round trip in coal.

A Member: You saved 5 to 6 tons of coal over a 160-mile division? About how much coal did you burn on that division before the arch was put in?

Mr. Newgirg: Before the arch was put in we burned all the way from 18 tons, and after that we burned all the way from 12.

Mr. Laughridge: I think we should call on Mr. Wagstaff, who has been in the brick-arch business; he is practical.

Mr. Wagstaff said that as he represented the American Arch Company he did not like to say much on the subject. He mentioned that the Pennsylvania Railroad Company was not at first in favor of brick arches, but after a time tried them, and now are using them. Many people do not like the arch, as they only know it in an old form, and there is always a question where you are going to put it, right up against the sheet 2 inches away or 4 or 6 inches. It seemed from Mr. Wagstaff's talk that each division would have to determine just where to put the arch; but that close up to the sheet was showing good results. It had to be remembered that arches took care and had to be looked after, as do all appliances. The life of the firebox added to the use of the arch and did not tend to crack the side sheets.

Mr. Young: Instead of the brick arches causing cracks they work just the reverse. A more even temperature in fireboxes is maintained with the brick arch than without it. I don't think there is any question but what the brick arch is a good thing for the side sheets, but they must be properly applied and properly taken care of. Our people feel as though we couldn't get along without them. If there is anybody here that wants to get information on the brick arch let them talk to the engineers on the C. M. & St. P., where we have had occasion to send out engines without the arches, and the engineer would come back hollering his head off because the engine burned so much more coal and wouldn't steam. Those things speak for themselves.

Mr. Malley: It seems to me that we are avoiding the point exactly. There is no use of coming here and telling us how to place a brick arch in a firebox. What benefit is derived from a brick arch, if any? What coal is saved? The first question our chief will ask is, "How much does the brick arch save?" Let us have something about how much coal is saved, the maintenance of the arch while in the firebox, how often the arch is removed on account of having to calk your flues.

Mr. Lewis: These last suggestions call for the right thing concerning brick arches. We have 860 locomotives and don't use them. I want to know about what saving there is in them. Then there is the cost of tools to be considered. How much would that be? Probably $25,000 a year for 860 engines. After we applied the brick arches we have got them to attend to, and that is going to take more labor. Now, can we save enough fuel in the operation of our locomotives to offset the costs? I will have to be convinced of a good many things before I can go back to my superiors and say, "Yes, sir, apply the brick arches, because by so doing we will save $10,000 or $50,000 a year." If I can tell him that then we will put the arches in right away. Where the brick arches have been put in I know from experience that they have cracked the side sheets, and have sometimes had a tendency to make the crown bolts leak. It may be that there is something on the market now to offset all these things. We know from our experience that arches have cracked the side sheets.

Mr. Kelly says that they applied their arches 4 or 5 inches from the flue sheets formerly, and now they apply them right up to the flue sheet. In making that change did he make any change in the drafting arrangement at the front end?

Mr. Kelly: Yes, sir.

Mr. Young: The proceedings of the last convention gave all the figures taken on the New York Central and the saving of coal on each division. The present committee didn't think it was necessary to give them again.

Mr. Reddy, Danville, Ill.: The point Mr. Malley, of Springfield, has made was well taken. At the present time we are running a test with the American Arch Company's arch. I am not in a position to give you any figures now, but by the time we convene next year I will be able to state whether the brick arch is a good thing, and whether it will pay to put it in or not.

As Mr. Malley said, there is no use of coming here and saying the brick arch is a good thing unless we can have something to substantiate that statement. It looks to me as if the committee should bring the data here to show what benefit can be gained by using the brick arch. The questions are: "Can it save coal?" "What advantage does it give us in reference to running repairs?" I don't know that the brick arch will crack the side sheets any more than without it, but I do know that if you run your brick arch too close to the crown sheet it gives trouble. I also know that if you let your arch come in contact with the sheet you are also going to have trouble.

Mr. Kelly: If our members will look over the tests that have been reported in the master mechanic proceedings they will soon clear their minds. Has Mr. Fowler any data that will enlighten us on this subject?

Mr. Fowler: I have nothing that will give actual figures, only the general impression is that the brick arch does save coal. Of course, if it didn't it wouldn't be a valuable thing. There were some experiments on the left bank of the Rhine a good many years ago, and the brick arch was carried somewhat to an extreme. There they lined a firebox with brick so that there was no heating surface in the firebox at all. They succeeded in getting better evaporation through the tubes without the firebox than they had previously with it; the reason was that the combustion was so very perfect that the coal was completely burned and there was no smoke whatever, but there were practical difficulties with that device. The brick would shake down, etc., and it cost them more than the saving in coal. All the figures that I have go to show there is a saving in the brick arch as far as the coal is concerned.

Mr. D. A. Lucas: I have had quite a little experience with brick arches. The brick arch is a good thing in the right place. In order to determine the right place, we have investigated pretty thoroughly, and have decided that there is nothing in a brick arch in a bituminous burner with a shallow firebox. We got up against it in trying to get the proper fire under the arch with our shallow firebox, and we decided that we didn't need the arch in bituminous burners, while in our lignite burners it has proved a success and a good thing. The question of applying the arch is a big point. The open arch with a space along the side sheets and opening in the flue sheets is effective. We took eight engines of the same class on the same run and gave them the benefit of the arch on seven of them, and took the arch out of one in fifteen months, and the engine without the arch beat the engines with the arch for coal per mile.

In the fifteen months it made 92,000 miles, and when it came into the shop it was on account of machinery and not on account of her firebox. I can't agree that a brick arch creates a more even temperature over the firebox. With a shallow firebox it is almost impossible to get an arch on a slope so that you can fire coal and keep within 16 inches of the crown sheet. When you get within 14 inches you have trouble with the crown and side sheets for a distance along the center. If we can get an arch that we can apply in a shallow firebox and maintain the fire up under it at all times we will have a good thing, but when you have a dead fire under the arch your sheets will leak more than without it.

Mr. Young: Was your arch open on the side sheets and away from the flue sheets?

Mr. Lucas: Our arches are applied solid, so we can get space between the flues and grates. We have tried it with the opening and without the opening. The brick arch may be all right, and I know it is all right when open at the flue sheet and laying on the circulating tubes in a deep firebox. We are having good success with the arches in our lignite burners, and have had good success with the deep firebox, but we haven't been able to get any success with the shallow fireboxes with a solid brick arch the way our company applies it.

Mr. Gray: Points have been brought out in the reports of the advantages of the brick arch. What we want to know is about the disadvantages—what the cost would be on the maintenance of the arch tubes and bricks and the difference in the length of time it takes to care for the engine in the roundhouse, with and without the arch, and the difference in fuel consumption. I move that the committee be extended a year, and that it bring in a report covering both sides of this question.

The President: The motion before the house is that the brick arch subject be carried over for another year, and that the committee be instructed to get statistics from different roads showing the different classes of boilers and report.

A Member: I oppose the motion; we are wasting a whole lot of time, and I am sorry for you gentlemen who are not in favor of the brick arch, taking it from every possible standpoint. I am not an enthusiast, but I know what I am talking about, and I am not selling brick arches, either. I feel very friendly towards this association. It is my first visit among you, and when it comes to getting in boiler work or taking care of the locomotive boiler I know what I am talking about, and men here know that. The brick arch, I have found by actual test, will save about 14 percent; it will save a ton of coal for every 100 miles of road it goes over. It costs something to maintain it, like every other thing; but that maintenance must be up to the standard and be first class in order to get the best results. Side sheets crack with it and without it. The trouble is not with the arch, the trouble is the water condition; and anybody who has studied it knows that when you filter your water or keep your boilers clean you will stop the cracking, whether it is the brick arch or whether it is the coal, or what it is. We have all kinds of coal and all kinds of engines and all kinds of water. All of us must use judgment. Go to the engineers running these engines and the firemen, and ask them if they like the brick arch, and they will say, "You bet; they save coal!"

Mr. Lewis: I don't want any one to get the idea that I don't think the brick arch pays in fuel; but does it save enough fuel to offset the cost? That is the point. I know there are engineers who have never operated an engine without a brick arch, and wouldn't run one without it unless forced into it. We have engineers that don't want brick arches; we must be independent of what the engineers or firemen say or think.

The President: The proposed amendment in regard to this subject is that the committee bring in a detailed and statistical report on the subject, and that the committee also be increased by five. (Carried.)

The President: The motion is that the committee be continued another year. (Carried.)

It was suggested that a representative of a brick arch company be made a member of the committee.

The President: We will take up the subject, "What Are the Advantages or Disadvantages of Using Oxy-Acetylene Process in Making Repairs to Boilers?" Mr. Courtney, chairman.

Mr. Courtney and Mr. Bruce read their papers, which were accepted, and the subject opened for discussion.

Mr. R. W. Clark, of Nashville, Tenn., who had not been able to make himself heard, was granted permission to send in a letter to the secretary of the association.

Mr. D. A. Lucas: We have a portable oxy-acetylene plant and we have had good results with it. I am welding on new half-side sheets, filling staybolt holes and setting in new mud-right corners. We are having the finest kind of success on the up and down cracks and cracks in the top of the flue sheets. Some of the work has been in service eight months. We use water on each side of the crack to prevent heating the sheet as much as possible. We have done several jobs of welding castings. We have started welding pitted flues. I think oxy-acetylene welding is the coming thing; and it is a grand success.

Mr. Doarnberger: I would like to ask Mr. Lucas, "Do you make a success of welding flue sheet bridges?"

Mr. Lucas: Yes.

Mr. Doarnberger: How do you take care of welding your flue bridges?

Mr. Lucas: We have found cracked flue bridges and I have welded probably a dozen. I had the flue removed and a V taken out at 45 degrees, leaving a 1/8-inch opening, and filled that bridge up a little more than flush and filed the flue hole out, and I had no trouble afterwards.

Mr. Doarnberger: You didn't have any effects from contraction on the adjacent bridges after you got through?

Mr. Lucas: I took out three flues and welded the bridges and we had no bad effects.

Mr. Kelly: Has any member had experience on a round-front flue sheet? On the front flue sheet we have not been successful. We would weld one succesfully and we would crack two or three. We have not given up, though, and we shall go ahead with experimenting.

Mr. Guiry: We have had acetylene welding in our shops for the last three years. As Brother Doarnberger has stated, we have had a great deal of trouble with the bridges. We would weld up one and the next would crack. We have not made a complete success of each job; we have failed with some. Our last job was on a side sheet, and we put corrugations as close as possible to the weld; when it was completed it didn't show a patch of any kind and it don't show a leak. I have an idea that the corrugation will do more good than anything else, but we have a good deal to learn, and I think it will take a few years before we are really successful.

Mr. Bailey: There is one principle about oxy-acetylene welding that doesn't seem to have been taken up very thoroughly—that of crystallization. You can pre-heat the work and anneal, and that is the greatest help we have. If you can bring the work up to a red heat you will find it is the biggest help to you; but in some cases, of course, that doesn't apply. The apparatus itself has very little to do with success; it is the man using his judgment and being experienced.

Mr. Harthill: I have been using oxy-acetylene welding for ten months; the first three or four times we failed. From that time we have had about 90 percent of success. We corrugated our patches, starting with a corrugation of 1 3/8. I found it too rigid, so increased it to 1/2 inch in height and 2 inches wide, with a 45-degree angle. If we weld a side sheet we put no corrugation at all, but leave the patch 3/8 of an inch long—it will pull up 3/16th of an inch. We also weld cracks in mud-ring corners with success. We have reduced the cost of applying some patches about 15 per cent. Since we have adopted the corrugation we haven't had an engine come back, and we started that last November.

Mr. Henry J. Raps: We are not using our welding machine at the present time, although two years ago we welded a number of patches, and I think we had success with about 50 percent of what we did. We have had good success in welding up door flanges and bells and links and cast iron brackets. We did weld some patches that didn't do well. We have had our best success with small engines. I believe the point brought out with reference to corrugation is a good one. So far as annealing is concerned, we did that. It didn't seem to be the thing. I don't know why welding shouldn't be all right and a success if you have the right kind of operator.

Mr. Lucas: Has any member had an experience in welding in a complete set of flues?

A Member: The Santa Fe welded in a full set of 391 flues, and got four round trips out of it; it was all right with the standard setting.

Mr. Hodges: I was requested by the superintendent of our shops to take hold of the welding apparatus and see what I could do with it. Up to that time we had welded most of our superheated flues and had had success. We had an order calling for the Shupert fire-box and about 300 9 1/2-inch flues. We got them all welded in that boiler, but didn't weld them in perpendicular; we dug down deep with the flame, as deep as we could go. You can go down within about 1/8th or possibly 3/16ths of an inch; and let that flame dig down and you can see the metal mount up like water, but if it goes over it will run off. An experienced operator knows just when to remove the blaze and let the metal run back in the hole. The trouble you are having, I am sure, with reference to welding flues perpendicularly, is that you don't get down in deep enough.

Now, as to our success—we have had a lot of failures. We have tried to weld cracks in the top of the flue sheet, but haven't been successful. One thing has added to our failures quite a good deal, and that is that we have gas for experimental purposes only, and the gases haven't had that evenness of flow at all times in order to produce the proper flame. We have had good results with the spring backs around the mud-ring and in the crown sheets, but we have had difficulty with cracks when coming in contact with the cold air. We also have had trouble on the side sheets and on the flue sheets. We are putting up a large plant to enter upon this work in an extensive manner, and when we get an equal flow of gas, which is absolutely necessary and essential to good work, I believe we will obtain better results.

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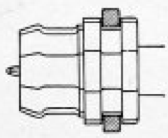
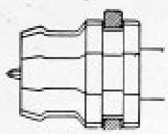
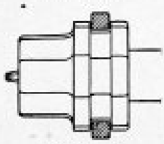


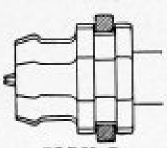
FORM A



FORM B

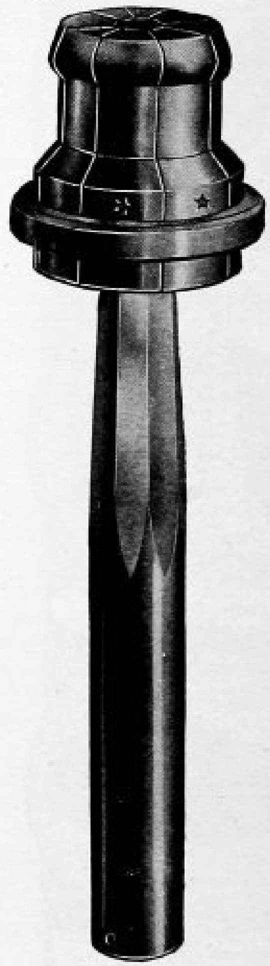


FORM C
For Hot Work



FORM D
For Hot Work

FOR OPERATION BY AIR MOTOR



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MOBERLY, MO.

The President: I am sure we would all be pleased to have Mr. Sedman have the privileges of the floor for a few minutes.

Mr. Sedman: Gentlemen, accident brought me here. I have never been to a meeting of mechanical men where I have seen so much interest taken in the work. No matter where I have gone I have seen two or three discussing their troubles, exchanging ideas and suggestions. I don't know of any meeting where you can gain more information than right here; you all try to learn and get something from the other fellow that you don't know, and I believe here is the place to do that. I would like to make one or two suggestions. One is the boiler feed. I can prove conclusively that our old method of boiler feeding is absolutely wrong. I believe that you can stop a lot of these boiler troubles by a different method of boiler feeding. Another subject is the ash-pans in the front end. We have hardly a railroad in the country but what is meeting losses in the front end, and whether the ash-pan is to blame or not they are blamed. Then there is the damage by setting fires. This subject could be given a great deal of thought. I want to thank you one and all for this privilege.

Mr. O'Connor moved a vote of thanks to Mr. Sedman, which was carried. Also that the question of boiler feed should be taken up in the regular order for the ensuing year.

The President: The next subject is the report of the committee on law.

Mr. Laughridge, acting for Mr. Hempel, chairman, read the proposed changes in the constitution.

The report was accepted, and placed before the convention for ratification or rejection.

The following changes were adopted: Section 2, Article 12, to read as follows: "The annual dues shall be $2 per year, payable in advance on April 1 of each year. The word "International" was dropped from the title of the association. The selection of the place of meeting was placed in the hands of the executive board.

FOURTH DAY.

The president called the convention to order at 9:30.

The President: The first discussion is on "Best Method of Applying Flue, Best Method of Caring for Flues While Engines Are on the Road and at Terminals, and Best Tools for Same." Mr. D. A. Lucas, chairman.

Mr. D. A. Lucas: Gentlemen, this paper was considered by the majority of the committee, and in offering it we hope it will open up a full discussion. I have samples and records here to defend my side of the story. I am in favor of heavy, wide copper ferrules, and by their use you can double your mileage in a bad-water district. Some of you may have districts where you can apply flues in any way and get good mileage. I have samples here, and if anybody wants to examine them or ask any questions I am ready to answer. I had a paper from Mr. John German, of Kankakee, Ill., a year ago. I don't know whether he wants me to present it now or not, but here it is, with his blue prints.

It was moved and carried that the report be received and opened for discussion.

The President: I want to ask the gentlemen of the convention to keep as close as possible to the subject so that we may get over all the ground possible.

Mr. Lucas: To sustain my argument on flues and the use of wide and heavy copper ferrules I say we went into the matter very carefully and adopted the heavy copper, and it had proved most satisfactory under all the conditions. There are conditions on our system where flues not so treated will give us good mileage; but, on the other hand, there are conditions where they must be so treated or we wouldn't get no mileage at all. We make a certain ferrule, and with it we get double the mileage under the worst conditions. It is an inch wide; made of 40-pound copper to start with, and we increase the weight as the hole is enlarged. I have two joints here with the copper covering an extra half inch in length. This is kept warm by the hot water in the boiler. With the first bit of cold air that strikes the flue without this joint the flues will usually begin squirting. This joint prevents that, and what we commonly call "simmering" is practically done away with. We had calked as high as 90,000 flues in a month, but since we have adopted the wide copper altogether we have eliminated much of that work. I had the first old pipes cut off that we used with the wide and heavy copper, and applied them to an engine in a district where we could get only four to six months' service when working the flues to death, but with the heavy and wide copper we got eighteen months' service under the same conditions. One member thought I was stretching it when I said we doubled the mileage in changing the copper. We had one engine make 7,000 miles with the copper the width of the sheet. All we did to it was to renew the flues and apply the wide, heavy copper, and it made 96,000 miles. You will get even better results as your sheet grows older and your copper gets heavier.

Mr. Goodwin: I would like to know whether Mr. Lucas has had experience with the iron lining of the ferrule on the firebox.

Mr. Lucas: I have not.

Mr. J. F. Finucane: I ask the gentleman if he has tried a heavier copper the same width as the light copper?

Mr. Lucas: The narrow copper is the same weight as the wide copper.

Mr. Finucane: I have had experience with the light and heavy copper with good and bad water, but I did not increase the length. I got the results you spoke of. I prefer a narrow copper, because the wide copper keeps the water away from the sheet. I understand the wide copper keeps the flue from slipping. The way it looks to me is, if slipping takes place, it will take place on the front flue sheet. On the Southern Pacific on the east end we have bad water. We use a 40-pound copper east of Houston; west of Houston we get bad results. At San Antonio and at El Paso we use 60-pound copper. We used 20 and 30-pound copper a few years ago, and got twelve to fourteen months out of the flue; now we get twenty-five or thirty by doubling the thickness of the copper.

Mr. Lucas: Mr. Finucane says that the wide copper holds the water away from the flue sheet; if you expand your flues and get mud and scale behind them you don't get the proper effect of the water.

Mr. George Austin: I am personally in favor of the wide copper ferrules. I have a theory—it is not original, I got it from an old boiler maker; it is that to get the benefit of wide copper you have to keep it clean. Thickness does not cut quite so much figure as width; you have to remember copper is a conductor of heat, and as it becomes scaled it loses its efficiency as a conductor. Knocking the dirt off will restore that efficiency; that is my clean theory.

Mr. M. H. Newgirg, Boone, Ia.; In 1908, on the Iowa Central, where we had a bad-water district, we used 40-pound copper ferrules. An engine would go out and make about 7,000 or 8,000 miles and the tubes would then require expanding, and then she wouldn't make a round trip, and you couldn't get in the firebox. We finally experimented with wide copper; we put in a set of flues with ⅝-copper, and we were able to double our mileage with less than one-half our previous flue troubles. The trouble with the short copper is that when you expand your flues you start your copper on an outer motion, which lets the water reach the bottom of the copper and flue, and you get a lot of stuff in there that you don't want. While with wide copper ferrules you make a joint at the back, and after you get it expanded you have a tight joint, so when your flue contracts you still maintain the joint at the back edge; at least that has been my experience with wide copper.

Mr. Conrath: In using wide copper ferrules be sure you don't bead them out. You can easily do this with the ⅜-copper; also be sure your copper is tight, just so your flues will come in snug and fit in the firebox. With an inch and a half round bar of iron you can open up a copper ferrule and get a nice fit, and then your copper will close and make a joint, preventing sediment from getting between the copper and the tube. It is a bad mistake to leave any sediment so it can work in the joint. As long as you can prevent this it will be a big help to the tube. Copper expands more than iron and steel, and consequently it helps to make a joint on the flue. This action settles the question why a copper ferrule is used.

Mr. McKeown: We used wide copper some years ago and we have also used the wide copper, brazing it on the flue. We have now come down to a copper five-eighths wide for ½-inch sheet. For some years after we started to use the wide copper our sheets were only 2⅝-inch centers for 2-inch flues; but to-day we are making them 2¾ inches to 2⅞ inches, giving more circulation.

A Member: How heavy is that copper?

Mr. McKeown: About 18-pound copper.

Mr. Lucas: One word more. It stands to reason that if copper is brazed on the flue, when contraction occurs the flue will take the copper with it, and you will still find a leak.

Mr. Wandberg: This flue business is very close to me, as I am in the bad-water districts of Minnesota and Iowa. I understand there are members present from the New York Central lines and from other Eastern roads that have gotten away from the old flue sheets entirely and adopted a new one, and it will be of interest to hear what results they are getting. I understand they are reducing flue sheets down to 1¾ inches and 1¼ inches, and that they are using wide and heavy copper. Trouble with flues is one of my greatest difficulties, and especially in our bad-water districts. If our modern boilers are spaced so that we have ¾ to ⅞ space between the flues, I do not have as much trouble with them; but I had a type of boiler that was spaced 9/16, and I found it impossible to run with our water. We used the same boilers, except the spacing was made ⅞, and we had very little trouble with it. Wider spacing gives better circulation for our bad water. Flues should be spaced so that you can get in and clean them. With our water and the 9/16 or ⅝ spacing we will fill up in thirty days. I have boilers on several divisions, and when they come in you wouldn't think there was a flue in them. I lay a good deal of the trouble to shaking when we had the old-style ashpan.

Mr. Raps: It may be of interest to know of the experience we had with the wide copper ferrule. Some years ago—I was then with the Northwestern people—we were induced to try it. We equipped a large number of our engines with wide ferrules on one side. We had blue prints made, and each wide ferruled flue was marked on them. We could not find any difference between the wide copper ferrule and the narrow, and one side played out in about the same time as the other. I am not reflecting on Mr. Lucas, but just giving my experience.

Mr. Kelly: Some years ago we tried a wide copper ferrule, half and half, on various runs. We saw no difference, and I must say that the greatest trouble with leaky flues is bad water, and the next trouble is, the spacing is not wide enough, and another trouble is the feed water. The feed is a most important thing. After you get other conditions right, your purifying plants, wide spacing, etc., yet have the feed water improperly applied by the locomotive engineer or fireman, you could come and argue for fifteen years and you would still have the same trouble. When, however, you get the feed water changed you will have something that helps matters.

Mr. A. R. Hodges: I have put in copper fireboxes complete and removed them, and where the water spacing was cut down to ⅝ I found I had leaky flues just the same. When they gave up using copper flue sheets, because of the cost of copper, they still wanted to get a soft joint between the flue and the sheet. Copper went into all the little defects in the sheet as well as the flue and formed a tight joint. By this means they were trying to have copper flue sheets without having a copper flue sheet. As to spacing, I have taken a 2¼-inch flue and welded it on a 2-inch flue and on that a 2¼-inch flue, and by that means I increased the water space around the flue. Still the flues leaked. I know that in good-water districts it is very easy to keep the flues tight, while in bad-water districts it is difficult. Before I came to the Santa Fe I put in two fireboxes in boilers of the same type and class and with spacing just the same. They went out on the same run alternately, and one of the boilers had to renew the flues in the fireboxes in eight months, while the other ran sixteen months under exactly the same conditions, so the engineer has something to do with it after all.

Mr. Cook: About two years ago we put a special appliance for feed water on the boiler of a large engine in the heavy freight service; it was our first experience with the feed going into the dry steam space above the waterline. With this appliance we had the best success; the engine so fitted gave little trouble with its flues. Our people have adopted a turret; it is put on top of the boiler between the sandbox and the bell. There is a valve that shuts it off at any time. We put a heavy engine carrying 200 pounds pressure in service last August with a new back flue sheet supplied with a Baker reducing valve, and tested it to the limit, and it is in service to-day, giving less trouble than any other engine we have, and it is entirely due to the feed water. We have the same water, of course, and nothing was done with it except to feed it into the boiler. When all our engines on the road have been equipped with this device, or some similar device, 50 percent of our flue trouble will be done away with.

The time for this subject being up the discussion was closed and the following one announced by the president: "Steel vs. Iron Flue. What Advantages and What Success in Welding Them and the Effect of Tube and Maintenance."

Mr. Raps: The acting chairman of the committee said I would suggest that the committee be continued, as I know that Mr. Linderman, the chairman, is making some very interesting experiements in welding and can promise a good report next year.

After the report was read it was moved that the subject be opened for discussion.

Mr. Goodwin: I rise for information. I see that it is claimed that on one side of a boiler referred to, fitted with iron and steel tubes, the accumulation of scale was greater on the steel than on the iron tubes. I ask on which side was the injector on that particular engine?

Mr. McKeown: On the left side.

Mr. Goodwin: All the water that was fed to the boiler went in on the steel side, then.

Mr. McKeown: We have two injectors—one on the left side and one on the center line of the boiler.

Mr. Goodwin: Do I understand that it is usual to work the injector on the engineer side?

Mr. McKeown: They work the injector on the engineer's side most.

Mr. Hodges: And invariably, when it is possible, the engineer likes to have the fireman work the water. Mr. McKeown says that the injector on the right side was used the most. From the experience I have had and from conversation with engineers I find, as a rule, the fireman works the water and the engineer keeps his injector open in case the left side fails.

Mr. McKeown: As a general thing the engineer works the right-hand injector most. That is why, probably, there is a little more scale on the steel flue.

Mr. Goodwin: In applying the tubes did you weigh them before they were applied? You weighed the new steel and iron tubes when you took them out, and in that way you found there were more scales on the steel than on the iron.

Mr. McKeown: It was by weight that we got at the matter; you couldn't notice very much difference with the naked eye.

Mr. Goodwin: When you applied them the second time do you remember whether the steel weighed more than the iron?

Mr. McKeown: I believe the steel was heavier.

Mr. Raps: I think I owe the gentlemen of the convention an explanation. I understood that there was no report, and I naturally supposed that nothing on this subject would be brought before this meeting. That is how I came to make the remark I did make.

Mr. Kelly: Some three years ago we started dealing with iron and steel flues, and our experience with them is that we cannot get an iron flue that will stand expanding without splitting. The material in the iron flue seems to be all right, but it is simply impossible to maintain engines in service without splitting the flues in the prosser of expanding. With engines coming right from the locomotive works we have trouble. Seamless steel flues I prefer. Our experience with beading all kinds of flues is that the iron has a shade the best of it. I don't believe in using a big sledge hammer. From my experience I recommend an iron flue with a steel safe end.

Mr. McKeown: I hear people speak of steel flue with regard to welding, that they couldn't weld them, that they spread, and all that sort of thing. We have used not only the spellerized, but the Shelby, and we have had no trouble in welding them at all.

Mr. Lucas: We have made several tests of iron and steel tubes and have several under way. We are getting good results out of both materials.

Mr. McKeown: We have an engine running now with one side steel lined and the other side copper lined. It has been in service about three months and is doing pretty well.

Mr. Kelly: Are those seamless steel?

Mr. McKeown: Yes.

Mr. Kelly: What gage?

Mr. McKeown: About sixteen.

Mr. Kelly: You have no trouble with them at all?

Mr. McKeown: None.

Mr. J. H. Smythe: Men who represent production ought not to say much, but should simply sit and listen; but there was a point that causes me to rise. Now, for the life of me I do not understand why it costs more to take care of steel tubes than it does the iron.

Mr. Goodwin: I think you have got that reversed.

Mr. Smythe: Yes; I beg your pardon. I wanted to say it that way, but how in the world are you going to separate the cost? When you put a man in to take care of a set of tubes is he going to report the time he works on each side? It seems to me that it is pretty hard for him to do. I thank you for being allowed to ask the question.

Mr. McKeown: Mr. Smythe, we have a blue print of the flue sheet and all flues are numbered 1, 2 and 3 from the center line. The steel flues are on the right side and the iron flues are on the left. Our boiler makers are thoroughly instructed to note what flues they repair and note the time required for the work. We also have them note the time required to look after the tools. The men are cautioned to note the time they work on the left or right side and we mark on the blue print what is done on each side.

Mr. A. Green: We have been using steel safe ends and flues for the last five years, and before that we used iron. We find that the steel gives the best service. The steel flue is here to stay and I think the iron flue is a thing of the past. In bad-water districts you can hardly handle the iron flues.

Mr. Wandberg: I handle and work about as many flues as any one man present, and I have to use a lot of bad water. I don't agree with some of the remarks, especially with Mr. Kelly's, when he claimed an iron flue wouldn't stand without splitting. I am under the impression that the flue Mr. Kelly refers to is simply an iron body flue. We use steel safe ends on our flues with a deep space, and we have no trouble with them splitting on either end. The Iowa coal we use has a large percentage of iron, and unless we clean out the flues before the expander is put in we experience trouble inside of the flue sheet. We have had a number of flues burst in that way. As far as the iron flue standing up and working, with the steel safe ends, there is no difference, but the iron flue has a little the best of the steel when it comes to pitting.

Mr. Conrath: I ask Mr. Kelly, what is his experience with spellerizing on the iron?

Mr. Kelly: The test was in favor of the iron, but it was so little you could hardly notice it after careful inspection.

Mr. Conrath: How did the tubes test out in the bad water between Missouri Valley and Sioux City?

Mr. Kelly: I can't recall what you refer to.

Mr. Conrath: Engines Nos. 202 and 109 on the Wyoming Northwestern.

Mr. Kelly: I can't recall the case.

The President: The claim made for the Jacobs-Shupert firebox certainly sounds good. A few years ago we started out with the steel tube and we have been getting results. The first steel flues we put in are still in the service after a little over six years' use. One or two sets have come in pitted. We have iron flues furnished us twelve or thirteen years ago and a great many of them are still in the service; some have been scraped and some are pitted. During that time we had steel tubes of all makes in the service, some for twenty-nine months, and still doing business. We have iron flues just as long in service doing well. We have both iron and steel tubes in service forty-five months and doing good service; so I say there is good in both materials, and only years can show what the actual life of a steel or iron flue will be. I claim the life of an iron tube is about twelve years. Iron tubes have beaded through in fourteen months and steel in about the same time. You can get good results from either.

Mr. Laughridge: We have been using steel flues for seventeen years and I think we are pioneers in the business. About six years ago we tried a couple of sets of iron tubes; they lasted ninety days. We were getting about eight months out of the others. The Pennsylvania Railway in the same locality had the same experience. Pitting is local. We don't have any either on iron or steel, but we have a heavy encrustation of lime; after one trip the tube is covered all over as if whitewashed. We have had seventeen years' experience with iron and steel tubes, and we are not going to change to the iron tube.

Mr. McKeown: As to flues splitting, whereabouts do they split; at the boiler top or front, or front flue sheet?

Mr. Wandberg: The bad flue is invariably where there is the heaviest pitting—at the bottom side of the flue. The brother remarks that the pitting is local; he also stated that a scale is formed on the flue and that it gave the flue no chance to pit. I don't agree with that.

Mr. McKeown: In our division there is very little pitting. We have some, but find it on the bottom side of the flues toward the front flue sheet and door, not on top or at the back.

Mr. Conrath: Pitting is due to poor circulation. Water will not circulate below 160 degrees. I find that the most pitting is at the front end. It is due to the low temperature in the front end.

Mr. Chapman: I disagree with the statement that pitting is due to the circulation. The circulation ought to work on all railroad boilers alike, when you are working under similar conditions. On the part of the Union Pacific where I am pitting does not occur in the front at all. We have flue that pit only in the first 18 inches of the fire-box. I don't believe it is the circulation at all.

The President: Pitting is due to local condition and electrolysis.

Mr. Gray: Down in Chicago we use all kinds of iron and steel flues. I have been able to discover no difference between the different kinds of flues as to caulking, but we have experienced difficulty with steel flues breaking off at the weld. This don't always occur the first time the flue is set, but sometimes when it is welded up, and in the welding. We weld them several times. After running eight or nine months the flue will suddenly break off at the second weld. It seems as though when violent contraction takes place it snaps the flue.

Mr. Kelly: Will Mr. O'Connor answer that question about the test on the Northwestern with reference to pitting, in connection with engine No. 202?

Mr. O'Connor: In No. 202, passenger engine, the flues were removed on account of machinery principally; the engine had made 103,000 miles, I believe. I had steel flues on the right side and iron flues on the left. I took the steel flues out of the boiler first, then removed the left side. I applied the rattler in the same way to each. Six steel flues pitted so that they had to be thrown away, and on the iron side there was forty-nine thrown away. No. 202 was running on the Eastern Division. On the Western Division we had an engine with steel and iron flues. The iron flues gave us, as far as pitting is concerned, better results than the steel, but in general our steel flues gave us the best service. I took particular pains to get this information because I was chairman of this committee and I wanted to get all the details in regard to the use of the engines. I went into the firebox myself before the flues were taken out to thoroughly examine the beads. I found that the steel flues retained their strength better than the iron flues. On the western end of our road, the Wyoming Division, I had a man who gave particular attention to it, and his report to me was that the left-hand side—the iron side—leaked more than the right steel side. We had good success with our iron flues in certain water, and in other waters our steel tubes gave us the best results. We had less pitting in some districts with the steel and just the reverse in other districts. These conditions were brought about by the water.

A Member: Do you use steel safe ends or iron ends?

Mr. O'Connor: Both; on our large and heavy power we use steel. We use iron flues and body flues—the 16-inch flue—cut for 14-foot boiler. We cut them up for use on our smaller power, but on our larger power we use steel ends. Those I mentioned were entirely new flues.

Mr. Conrath: There were fourteen steel against forty-six iron. I think I have the record on that, and there was only nine thrown away.

A Member: Why do you use steel on your large power?

Mr. O'Connor: In one sense we get better service in the firebox end, and our general orders from Chicago headquarters are to that effect.

The discussion was closed.

The President: The next topic is the report of the committee on the "Best Method of Staying the Front Portion of Crown Sheet on Radial Top Boilers to Prevent Cracking of Flue Sheet in Top Flange." Mr. Kelly is chairman.

The report being read by Mr. Kelly, Mr. Wagstaff moved that it be received and open for discussion.

Mr. A. D. Lucas: Two years ago we were having trouble with top and radial stay flue sheets cracking. We were putting in two experimental flue sheets, and in putting them in we left the flange and flue sheet standing instead of bending at right angles. Those flue sheets have been in service two years, and are in perfect condition. No flue hole comes any closer than 3 inches from the edge of the radius, so that it has a good stiff backing at the top of the sheet to offer a certain amount of resistance. We are applying now eye-bolts with a spring stay hanger and getting good results. We have done away with four rows and applied two. We get the best results with the eye-bolts and solid brass. With holes fitted with two rows instead of four you can do away with the tee bar. The ends of our tee bar seem to come down and form a pocket in our crown sheet with the tee bar on.

Mr. Optenberg: We all know that expansion and contraction in the boiler has to be overcome. The minute you get a leak the question comes up, what causes it? If we have a flue sheet that is on a flange of very short radius expansion has go to go somewhere; and with the smaller radius we find our flange ends crack. The larger radius we have in the flange the more spring there is and the longer it will last. The longest life of the Adams furnace is between eight and ten years. Eleven years ago I put in a set of these furnaces, and I looked out to get a large radius on the flange of those furnaces where they come together. The result was that those furnaces have been in use eleven years, while the furnace I took out was in use only nine years, and it was patched in three or four places. On the furnaces that have been in use eleven years there isn't a patch, and it is simply the result of having a proper radius.

Mr. Green: We use the ¾-inch radius and a 6-inch radius, and the three-quarter radius has given us the best result. On the Lake Shore they are putting in the small three-quarter radius.

The President: With your furnace there is no work done on it. All the damage is due to contraction and expansion. With our flues we work on them daily.

The discussion was closed and the following was taken up:

"Cause of flue holes in back flue sheet elongating and a report of the committee on prevention for same." Mr. Kelly.

After hearing the report of the committee, and there being no discussion, it was received, and the president called for the next committee report on "Standardizing of blue prints for building boilers." Mr. Laughridge.

There was no report, and after a short discussion the committee was discharged.

The president asked for report of committee on law. Mr. Laughridge.

Mr. Laughridge reported as follows: It was recommended that the word "International" be eliminated, and that the name of the association be "Master Boiler Makers' Association." Recommendation adopted.

The committee's report was as follows on the subject, Mr. Goodwin announcing that some of the subjects discussed should be continued into next year. After several suggestions from members the programme was completed as below, the last three subjects being added to the committee's recommendations:

"Best method of applying flues; best method of caring for flues while engines are on the road and at terminals and best tools for same."

"Steel vs. iron flues. What advantages and what success in welding them and effect of length of tube and maintenance?"

"Best method of staying the front portion of crown sheet on radial top boilers to prevent cracking of flue sheets in top flange. Cause of flue holes in back flue sheet elongating and a preventive for same, and effect of the use of combustion chamber."

"What are the advantages and disadvantages of the use of brick arches and arch pipes in locomotive fireboxes?"

"What can be done to produce better circulation in marine return tubular and vertical boilers?"

"What are the advantages and disadvantages of using oxy-acetylene process in making repairs to boilers?"

"Apprenticeship."

"Feed water, etc., and the results obtained."

"When is a locomotive boiler in its weakest condition?"

"Smoke prevention."

"Spark arresters."

"Superheating steam."

The report of the auditing committee, Mr. Laughridge, was read and approved, and the committee discharged.

The executive committee handed in a synopsis of its report, and the chairman, Mr. Goodwin, said that the association's condition was most satisfactory.

Under the head of miscellaneous business the question of just how far membership in the association went was discussed; but it seemed to be the general desire that every master boiler maker in any branch of the boiler business should be welcomed and made at home.

Mr. Goodwin, for the executive board, offered a resolution that a committee be appointed to keep the publication, "Rules and Formulas," up to date. Carried.

The committee on resolutions report was accepted, and ordered spread upon the minutes of the meeting, and the committee was discharged.

Business matters of the association were discussed and settled, and the association proceeded to elect the following officers:

President—George W. Bennett, general foreman boiler maker, N. Y. C. & H. R. R. R., Albany, N. Y.

First Vice-President—James W. Kelly, general foreman boiler maker and boiler inspector, C. &. N. W. R. R., Oak Park, Ill.

Second Vice-President—M. O'Connor, general foreman boiler maker, C. & N. W. R. R., Missouri Valley, Iowa.

Third Vice-President—Thomas W. Lowe, chief boiler inspector, Canadian Pacific Railroad, Winnipeg, Manitoba.

Fourth Vice-President—John T. Johnson, boiler inspector, A. T. & S. F. R. R., Los Angeles, Cal.

Fifth Vice-President—Andrew Green, general foreman boiler maker, Big Four, Indianapolis, Ind.

Secretary—Harry D. Vought, 95 Liberty street, New York City.

Treasurer—Frank Gray, foreman boiler maker, C. & A. R. R., Bloomington, Ill.

EXECUTIVE BOARD.

W. H. Laughridge, chairman, foreman boiler maker, Hocking Valley R. R., Columbus, Ohio.

James Crombie, foreman boiler maker, Sawyer & Masey Company, Hamilton, Ohio.

B. F. Sarver, foreman boiler maker, P. R. R., Fort Wayne, Ind.

B. J. Murray, foreman boiler maker, Erie R. R., Meadville, Pa.

E. W. Rogers, foreman boiler maker, American Locomotive Company, Paterson, N. J.

E. W. Young, boiler inspector, C. M. & St. P. R. R., Dubuque, Ia.

J. A. Doarnberger, master boiler maker, N. & W. R. R., Norfolk, Va.

Charles L. Hempel, general boiler inspector, U. P. R. R., Omaha, Neb.

A. E. Shaule, foreman boiler maker, D. M. & N. R. R., Proctor, Minn.

REPORT OF THE COMMITTEE ON RESOLUTIONS.

To the Officers and Members of the Master Boiler Makers' Association:

Your committee on resolutions beg leave to submit the following for your consideration, with a recommendation for its adoption:

The Master Boiler Makers' Association, in convention assembled, herewith spreads upon its records this expression of its high appreciation of the happy manner in which its comfort, enjoyment and entertainment of its members and their families has been promoted during the fifth annual convention of the association in the charming and progressive city of Omaha, Neb.

A further pleasure is experienced in bearing testimony to the comforts afforded us during our brief sojourn in this metropolitan gateway to the Middle West. It has afforded us an exceptional opportunity to personally understand the proverbially broad, generous and delightful hospitality só freely extended by Western people to those who are fortunate enough to become their guests, and of which we had only an inkling. We now perfectly understand what it is that has at all times and under all circumstances given the West and its people an enviable and matchless reputation in this regard and the justifiable pride they take in their institutions, their manifold social attractions, the spirit of enterprise and determination that has brought substantial growth and prosperity and insured to future generations the unlimited enjoyment of the material benefits of human existence.

These thoughts and sentiments were prompted by the invocation of the Rev. Frederick T. Rouse, pastor of the First Congregational Church; the kindly welcome and greeting extended by His Honor J. C. Dahlmen, mayor; Mr. James E. Haverstick, chairman executive committee of the Commercial Club of Omaha; Mr. C. E. Fuller, superintendent of motive power and assistant general manager of the Union Pacific Railroad; Mr. E. W. Pratt, assistant superintendent of motive power and machinery of the Chicago & Northwestern Railway; Col. T. W. McCullough, of the Omaha *Bee*, and which have since been emphasized by personal experience that will always serve to make our stay in Omaha a pleasant memory. The best that we could possibly have expected has been more than realized, and we will return to our homes and daily avocations with deep regret that we could not remain longer to further extend our knowledge of what the West is and what it is doing, and of Omaha, its people and its business activities and accomplishments. In this connection we find occasion to refer with pleasure to the Rome Hotel, to commend its management and its excellent accommodations for convention purposes, and to thank its managers for having done so much to make our stay agreeable.

We wish also to express our sense of special indebtedness to Mr. John F. Deems, general superintendent of motive power, rolling stock and machinery of the New York Central lines, and to Mr. W. F. Buck, superintendent of motive power of the Atchison, Topeka & Santa Fe Railroad, in making it possible for the papers on the subject of apprentices to be presented in a manner so comprehensive and illustrative as to meet with the highest appreciation; also to the officials of the Atchison, Topeka & Santa Fe Railroad for a demonstration of the Jacobs-Shupert boiler, and to the courtesy of the Monarch Visible Typewriter Company for the complimentary use of a machine for convention purposes.

We are deeply indebted to the members of the Supply Men's Association, individually and collectively, for the happy, as well as successful, manner in which they have provided creature comforts and those social divertisements which are always a source of relief to mental and physical strain. Our convenience and enjoyments have evidently had their constant personal solicitude, and as beneficiaries thereof we find occasion for congratulation and grateful acknowledgements, and which has been especially pronounced in the presentation of gold badges to past presidents emblematic of their offices.

How thoroughly the importance of the position that our association occupies before the world is understood, and how our work is recognized as of widespread value, has been demonstrated by the liberal space and close attention accorded our proceedings by the daily newspapers of Omaha. We desire to thank them very heartily for this mark of their consideration, and with equal effect we would accord a meed of praise to the technical press, especially THE BOILER MAKER, *Railway Age* and *Railway Journal* and their representatives, for the liberal recognition we have always received from them.

A matter of pride and gratification is the stability of the Women's Auxiliary, and which through the attendance of its members has been a source of perpetual sunshine, zest and happiness at our convention. Woman is man's radiant and inspiring companion and counselor, and so long as he keeps by her side he is assured of protection, guidance, and whatever measure of success he attains by honest, conscientious effort.

Finally, that our work may have that graceful finish which a rightful and just recognition of merit insures, we make special acknowledgment to the officers of the association who during the past year so carefully and efficiently conducted its affairs, with due regard for its greatest welfare and best interest, and whose reward comes in consciousness of duty well performed and the splendid success of this convention, which is the crowning feature of their able administration.

GEORGE WAGSTAFF,
M. O'CONNOR,
C. L. HEMPEL,
Committee.

Boiler makers and friends in attendance at the convention were the following:

A. Hedberg, with C. N. W., F. B. M., Winona, Minn.
C. E. Fourness, with C., M. & St. P., B. Insp., Milwaukee, Wis.
E. E. Rapp, T., St. L. & W., Chief B. Insp., Frankfort, Ind.
D. C. Buell and lady, with Union Pacific, Chief Educ., Omaha, Neb.
C. Parks, wife and sister, So. Pac., B. Insp., Omaha, Neb.
A. Sharpe and wife, with Amer. Abell Engine & Thresher Co., F. B. M. Toronto, Can.
J. Handley, with Term. R. R. Assn., F. B. M., St. Louis, Mo.
M. E. Wells and two daughters, with Wheeling & L. E., Asst. M. M., Brewster, O.
T. J. Reddy, with C. E. Ill., F. B. M., Danville, Ill.
E. E. Aires and wife, with T. & O. C., B Insp., Kenton, O.
J. Connor and wife, with U. P. R. R., Chief Clk, Omaha.
E. W. Young and wife, C., M. & St. P., B. Insp., Dubuque, Ia.
Robt. U. Wolfe and wife, with City of Omaha, B. Insp., Omaha.
Geo. Fishcher and lady, with C. & W. I. B., F. B. M., Chicago, Ill.
E. H. Hohenstein, with C., R. I. & P., Gen. B. Insp., Horton, Kan.
Oscar Rydman and wife, with Northwestern, F. B. M., Huron, S. D.
C. J. Reynolds, Pittsburg, Pa.
M. H. Newgirg, with C. & N. W., F. B. M., Boone, Ia.
C. Bigham, with C., B. & Q., F. B. M., Lincoln, Neb.
W. G. Stallangs, with I. C. R. R., F. B. M., McComb, Miss
John Greene, with I. C. R. R., F. B. M., E. St. Louis, Ill.
John Harthill, with Lake Shore, F. B. M., Cleevland, O.
M. Hobson, with U. P. R. R., F. B. M., Kansas City, Kan.
E. J. Nicholson, with C. & N. W., F. B. M., Milwaukee, Wis.
H. Sherping, with C. & N. W., F. B. M., Clinton, Ia.
A. M. Dustin, with M. & St. L., F. B. M., Minneapolis.
Gus. Mihlisen, with A. T. & S. L., Asst. B. Insp., Topeka, Kan.
Geo. Austin, with A. T. & S. L., B. Insp., Topeka, Kan.
B. W. Bowers, with Toledo Term., F. B. M., Toledo, Ohio.
E. R. Chapman, with U. P. R. R., F. B. M., Cheyenne, Wyo.
Peter Eck, with I. C. R. R., F. B. M., Mattoon, Ill.
G. J. Hatch and wife, with U. P. R. R., M. M., Omaha.
P. E. Toohey and wife, with U. P. R. R., F. B. M., Evanton, Wyo.
J. J. Vest, with U. P. R. R., F. B. M., Denver, Col.
M. J. Dacey, wife and sister, with U. P. R. R., F. B. M., Green River, Wyo.
J. E. Quinn and wife, with U. P. R. R., F. B. M., Rawlins, Wyo.
J. T. Finucane and wife, with South. Pac., F. B. M., Houston, Tex.
C. L. Wilson and wife, with Ill. Central, Gen. F. B. M., Memphis, Tenn.
W. N. Stark, with K. City South., Gen. F. B. M., Pittsburg, Kan.
J. E. Cook, wife and daughter, with B. & L. E., F. B. M., Greenville, Pa.
John Troy and wife, with Pere Marquette, F. B. M., Saginaw, Mich.
J. J. Turner, wife and child, with B. & O. C. T., F. B. M., Hammond, Ind.
C. J. Bauman and wife, with N. Y., N. H. & H., F. B. M., New Haven, Conn.
J. L. Bascom, with U. P. R. R., F. B. M., Ellis, Kan.
C. C. Lichty, with N. Y. Cen. Lines, F. B. M., Van Wert, O.
L. O. Moses, with K. & Mich., F. B. M., Middleport, O.
J. J. Ryan and wife, with L. & N., F. B. M., Covington, Ky.
Nicholas Emch, with N. Y. Central, F. B. M., Toledo, O.
L. M. Stewart and wife, with Atlantic Coast Line, F. B. M., Waycross, Ga.
John J. Orr, with Lackawanna, F. B. M., Scranton, Pa.
C. N. Nau and wife, with C. & Ind. South., F. B. M., Hammond, Ind.
J. J. Mahoney and wife, with U. P. R. R., F. B. M., Laramie, Wyo.
Theo. Tottenhoff, with U. P. R. R., F. B. M., North Platte, Neb.
Geo. Beland, with Erie, F. B. M., Hornell, N. Y.
G. M. Rearick, with B. & Sus., Gen. B. I., Galeton, Pa.
Jas. Bruce, with Frisco Lines, F. B. M., Kansas City, Kan.
M. S. Courtney, with Great Northern, G. B. I., St. Paul, Minn.
Geo. L. Fowler, Consulting Engineer, New York City.
Chas. L. Thomas, with U. P. R. R., F. B. M., Grand Island, Neb.
J. F. Beck, with G. R. & Ind., F. B. M., Grand Rapids, Mich.
Jas. Doran, with Santa Fe, B. Insp., Lajunta, Col.
A. C. Dittrich, with M., St. P. & S. S. M., F. B. M., Minneapolis, Minn.
John McKeown and wife, with Erie, F. B. M., Gallion, O.
Alfred Cooper and wife, with St. J. & G. I., G. F. B. M., St. Joseph, Mo.
C. A. Nicholson, with Southern, F. B. M., Atlanta, Ga.
C. F. Petzinger and wife, with Cen. of Ga. Ry., F. B. M., Macon, Ga.
Hugh Smith, with Erie, F. B. M., Jersey City.
A. R. Hodges, with Santa Fe, G. F. B. M., Topeka, Kan.
R. W. Clark, with N. C. & St. L., F. B. M., Nashville, Tenn.
J. A. Doarnberger, with N. W. Ry., M. B. M., Roanoke, Va.
C. W. Buffington, with B. & O., F. B. M., Garrett, Ind.
Henry J. Wandberg and wife, with C. M. & St. P., F. B. M., Minneapolis, Minn.
F. M. Smith and wife, with Southern, F. B. M., Princetown, Ind.
L. Borneman and wife, with C., St. P., M. & O., F. B. M., St. Paul, Minn.
Robt. Crimmins and daughter, with Big Four, F. B. M., Mattoon, Ill.
T. A. Jameson and wife, with B. & S. W., F. B. M., Bristol, Va. and Tenn.
Bernard Wulle and wife, with Big Four, Asst. G. F., Indianapolis, Ind.
J. A. Coxedge, with Mo. Pacific, F. B. M., Hoisington, Kan.
H. M. Barr and wife, with C., B. & Q., M. M., Sterling, Col.
P. E. McIntosh, with P. M., F. B. M., Grand Rapids, Mich.
M. J. Guiry and wife, with Great Northern, F. B. M., St. Paul, Minn.
Andrew Greene, with Big Four, G. F. B. M., Indianapolis, Ind.
H. J. Raps and wife, with Ill. Cen., F. B. M., Chicago, Ill.
Wm. Kinzell and wife, with U. P., F. B. M., Council Bluffs, Ia.
C. R. Kurrasch, with L. S. & M. S., F. B. M., Kankakee, Ill.
J. B. Smith, with P. & L. E., F. B. M., McKee's Rocks, Pa.
J. C. Keefe, with T. & O. C., F. B. M., Bucyrus, O.
S. E. Westover and wife, with Col. & Wyo., Gen. F., Pueblo, Col.
R. J. O'Neill, with Col. South., F. B. M., Denver, Col.
C. D. Powell, with B. & O. S. W., Gen. B. I., Cincinnati, O.
W. H. Laughridge, wife and daughter, with Hocking Valley, F. B. M., Columbus, O.
A. H. Conley and wife, with Pa. R. R., F. B. M., Olean, N. Y.
Thos. F. Power, with C. N. W., F. B. M., Chadron, Neb.
D. G. Foley, with D. & H., G. F. B. M., Green Island, N. Y.
Dan. Coughlin and wife, with Erie, F. B. M., Hornell, N. Y.
M. W. McCoy and wife, with Big Four, F. B. M., Wabash, Ind.
J. J. Madden and wife, with C. R. I. & P., F. B. M., Fairbury, Neb.
Frank Gray and wife, with C. & A., F. B. M., Bloomington, Ill.
C. J. Elk, with B. & O. S. W., F. B. M., Washington, Ind.
C. L. Hempel, wife and two daughters, with U. P. R. R., Gen. B. I., Omaha, Neb.
Thos. Lewis, wife and daughter, with Lehigh Valley, F. B. M., Sayre, Pa.
A. E. Shaule, with D. M. & N., F. B. M., Proctor, Minn.
M. J. O'Connor, wife and daughter, with C. N. W., F. B. M., Mo. Valley, Ia.
J. P. Malley, with Frisco Lines, G. F. B. M., Springfield, Mo.
F. E. Berrey and wife, with Erie, F. B. M., Cleveland, O.
J. W. Kelly, with C. N. W., G. B. I., Oak Park, Ill.
W. Plowman and wife, with Big Four, F. B. M., Urbana, Ill.
D. A. Lucas and wife, with C. B. & Q., G. F. B. M., Havelock, Neb.
Harry D. Vought, with I. M. B. M. A., Sec'y, New York City.
J. J. Mansfield, with Central, Chief B. I., Jersey City, N. J.
R. M. Williams, wife and daughter, with A. C. L. R. R., F. B. M., Rocky Mount, N. C.
David A. Stark, wife and two daughters, with Oregon Short Line, B. I., Ogden, Utah.
A. N. Lucas, with C., M. & St. P., G. F. B. Wks., Milwaukee, Wis.
C. W. Cross, with N. Y. Central, Supt. App., New York.
H. Gardner, with N. Y. Central, Asst. Supt. Apprentices, New York.
A. A. Akins, with G. W., F. B. M., Oelwein, Ia.
W. H. Hopp, with C. M. & St. P., F. B. M., Dubuque, Ia.
P. McDermott, with C., R. I. & P., F. B. M., Valley Junction, Ia.

The following members of the Supply Men's Association were present:

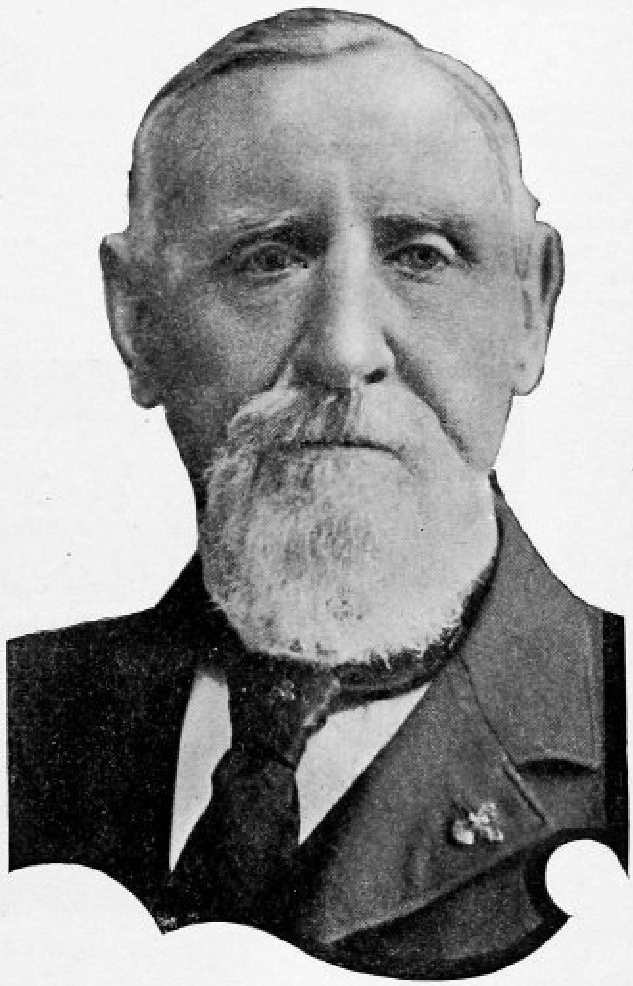
Geo. J. Thust, with Kirby Equip. Co., Mgr. Globe Seamless Tube Co., Milwaukee.
E. Payson Smith, with Stand. Ry. Equip. Co., Salesman, St. Louis.
C. A. Carscadin, with Kirby Equip. Co., Vice-Pres., Chicago.
O. Monnett, with Power, Western Editor, Chicago.
H. A. Varney, with National B. Wash. Co., Salesman, Chicago.
E. B. White, with National B. Wash. Co., Supt., Chicago.
W. C. Bell, with National B. Wash. Co., Mech. Eng., Chicago.
C. B. Moore, with Amer. Arch Co., Mgr., Chicago.
Chas. A. Coons and wife, with Amer. Arch Co., Salesman, Omaha.
C. F. Palmer, with J. Faessler Mfg. Co., Sales Mgr., St. Louis.
Geo. E. Sevey, with Otis Steel Co., Ltd., Salesman, Cleveland.
E. W. Rogers, sister, son and wife, with Amer. Loco. Co., F. B. Dept, Patterson, N. J.
D. J. Champion and brother, with Champion Rivet Co., Vice-Pres., Cleveland.
Chas. Humpton, with Parkesburg Iron Co., Salesman, Parkesburg, Pa.
W. M. Wilson, with Flannery Bolt Co., Salesman, Chicago.
Geo. Slate, with THE BOILER MAKER, Adv. Mgr., New York.
S. F. Sullivan, with Ewald Iron Co., Manager, St. Louis.
John Smythe and wife, with Parkesburg Iron Co., Boiler Expert, Parkesburg, Pa.
G. E. Howard, with Flannery Bolt Co., Salesman, Pittsburg.
Geo. N. Riley and wife, with Nat'l Tube Co., Agent, Pittsburg.
Tom R. Davis, with Flannery Bolt Co., Salesman, Pittsburg.
J. T. Goodwin and wife, with Nat'l Tube Co., Boiler Expert, Pittsburg.
Thos. Kirby, with Kirby Equip Co., President, Chicago.
Fred Gardner, with Jos. T. Ryerson & Son, Salesman, Chicago.
J. P. Moses, with Jos. T. Ryerson & Son, Salesman, Chicago.
J. G. Kirby, with Jos. T. Ryerson & Son, Salesman, New York.
H. H. Linton, with Jos. T. Ryerson & Son, Salesman, New York.
E. C. Cook, "Railway Journal," Prop., Chicago.
J. T. Stafford, with Crucible Steel Co. of A., Salesman, Chicago.
R. T. Scott and wife, with Ind. Pneu. Tool Co., Salesman, Chicago.
W. L. Laib, with Hanna Eng. Works, Sec'y, Chicago.
John P. Hoelzel, with Pittsburg S. & B. Co., Mgr. Sales, Pittsburg.
F. W. Severance, with Severance Mfg. Co., Sec'y and Treas., Glassport, Pa.
T. G. Smallwood, with Chic. Pneu. Tool Co., Salesman, Birmingham, Ala.
John Campbell, with Chic. Pneu. Tool Co., Salesman, Chicago.
B. E. D. Stafford, with Flannery Bolt Co., Gen. Mgr., Pittsburg.
J. D. Farasey, with Amer. B. Mfg. Assn., Sec'y, Cleveland.
H. S. Nixon, with Chambersburg Eng. Co., Salesman, Chambersburg, Pa.
P. J. Conrath and wife, with Nat'l Tube Co., B. Expert, Chicago.
J. W. Williams, with Brown & Co., Pittsburg, Salesman, St. Louis.
Chas. Kennedy, with Brown & Co., Pittsburg, Salesman, Chicago.
H. W. Finnell, with Carbon Steel Co., Asst. Sales Mgr., New York.
L. R. Phillips, with Nat'l Tube Co., Salesman, Chicago.
J. H. Cooper and wife, with Dearborn Drug & Chem. Co., Chicago.
Christopher Murphy, with Carter Iron Co., Salesman, Chicago.
Harrison Davies, with Kirby Equip. Co., Salesman, Milwaukee.
J. H. Optenberg and wife, with Optenberg Iron Wks., President, Sheboygan, Wis.
Geo. Wagstaff, with Amer. Arch Co., Boiler Expert, New York.
Paul Harders, with Jos. T. Ryerson & Son, Salesman, Chicago.
Geo. M. Bailey, with Linde Air Products Co., Sales Eng., E. Chicago, Ind.
W. E. Marvel, with Detroit Seamless Steel Tubes Co., W. Sales Mgr., Chicago.
J. C. Templeton, with Oak Grove H. & M. Co., Mgr., Cameron, Wis.
G. A. Woodman, with Kirby Equip. Co., M. E., Chicago.
C. E. Walker, with Chic. Pneu. Tool Co., Mgr. R. R. Dept., Chicago.
Thos. Aldcorn, with Chic. Pneu. Tool Co., E. Sales, New York.
Wm. H. Basse, with Jas. T. Ryerson & Sons, Salesman, Chicago.
A. N. Mueller, with J. T. Ryerson & Son, Salesman, Chicago.
L. P. Mercer, with Parkesburg Iron Co., Sales Mgr., Chicago.
Geo. A. Dickson and wife, with Pittsburg Steel Products Co., Sales Mgr., Chicago.
Carter Blatchford, with Tyler Tube Co., Sales Agt., Chicago.

Fatal Tube Blowout in Winsted, Conn.

A fatal accident occurred at the woodworking plant of J. H. Rowe in Winsted, Conn., in April. The owner, Mr. Rowe, sustained severe injuries and lived only a few hours. The cause of the accident was a defective tube. The boiler is of the locomotive type, having sixty 3-inch tubes, and is used for heating the shop and dry kiln, and carried from 40 to 50 pounds gage pressure. It has been in the Rowe plant for eighteen years, and was an old boiler when installed. Upon examination it was found that four tubes in the bottom row and two in the second row from the bottom were stopped with pine plugs, which had been driven in with no rod running through the tubes to hold them in place. The stem on the handhole plate was badly corroded and looked as if it had not been taken out in years. The safety valve was of the ball and lever type, and an effort to raise it showed that it was stuck fast. I learned from an employee at the plant that the boiler had never been cleaned to his knowledge since being installed. —*Power*.

Death of Mr. James Lappan.

Just as we are going to press we are informed of the death of Mr. James Lappan, of Pittsburg, in his seventy-seventh year. Mr. Lappan was one of the best-known boiler manufacturers in the country, and few men in the trade had more friends. Mr. Lappan came from Ireland in 1844. For some years he was boating in the waters about Pittsburg, but in 1854 started in the boiler making business, and was connected with it up to the end. He was the first president of the American Boiler Manufacturers' Association.



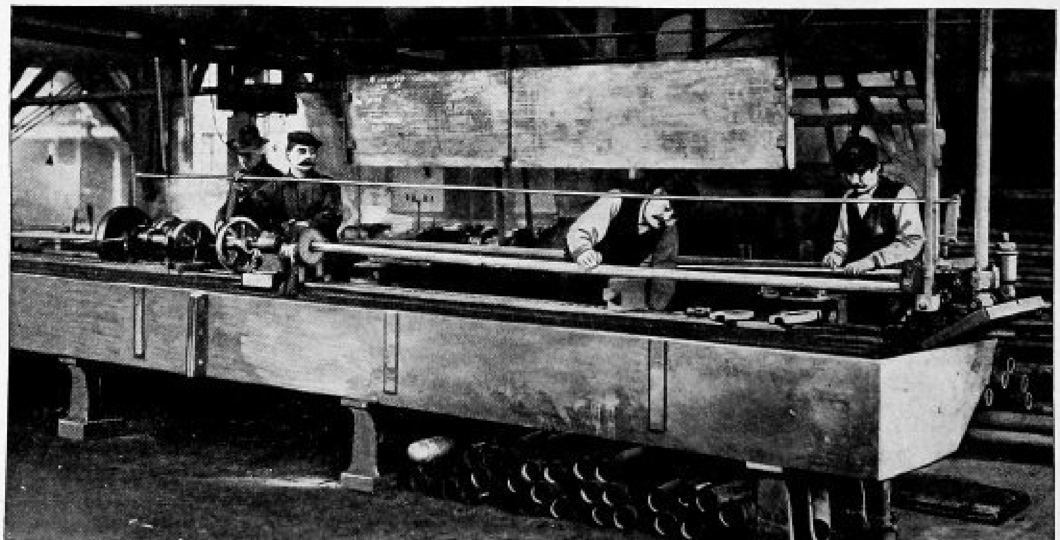
MR. JAMES LAPPAN.

The Development of Locomotive Tubes and their Treatment.

BY F. N. SPELLER.*

The tube industry owes much to the railroads for its development; in fact, the invention of lap-welding may be traced to the necessity which arose on the building of George Stevenson's first locomotive for a tube which would be safer and stronger than the butt-welded tube, the only one made at that time. Since Stevenson's day the manufacture of locomotive tubes has increased in quantity and quality as the demands of railroad service became more exacting, and the whole tubular industry was no doubt favorably affected thereby. Seamless steel tubes were introduced about 1886, and established a new strength and ductility and endurance under many conditions of service. Later on a satisfactory grade of soft steel was produced which could be lap-welded like charcoal iron, and this also has been much improved, so that we now have practically three classes of tubes for locomotive service—charcoal iron (lap-welded), steel (lap-welded), and seamless steel. Charcoal iron formerly was made from a special grade of pig iron in a small blast furnace using charcoal fuel. The product of this furnace was charged into the refinery, where about one-half of the impurities were oxidized and fluxed away, the metal being subsequently treated in lots of 300 pounds or so in a slightly modified type of the old catalan forge with charcoal as fuel. The use of so much charcoal has necessarily been stopped, and in many other respects the manufacture of charcoal iron for tubes has of late years been considerably modified. Of these changes we are not in a position to speak, for, as it was evidently impossible for obvious reasons to continue the manufacture of charcoal iron strictly along the old lines, we abandoned the making of charcoal iron tubes about two years ago in favor of lap-welded and seamless steel, which had by that time been proved a fit substitute, and in some respects decidedly superior to the older material.

A TEST FOR DUCTILITY.



TESTING TUBES UNDER HYDROSTATIC PRESSURE.

You all understand, of course, that when we speak of steel in this paper it refers more to the method of manufacture than the finished product, as the steel used in the manufacture of tubes, as a matter of fact, is a purer form of iron than that made by the charcoal process, and like the older metal cannot be tempered.

A special grade of Bessemer steel was at first used in the

* Metallurgical engineer, National Tube Company, Pittsburg.

manufacture of lap-welded tubes on account of its superior welding quality, but later on had to be abandoned, as, under some conditions, it was found to develop brittleness in the beads after the tubes had been in service some time.

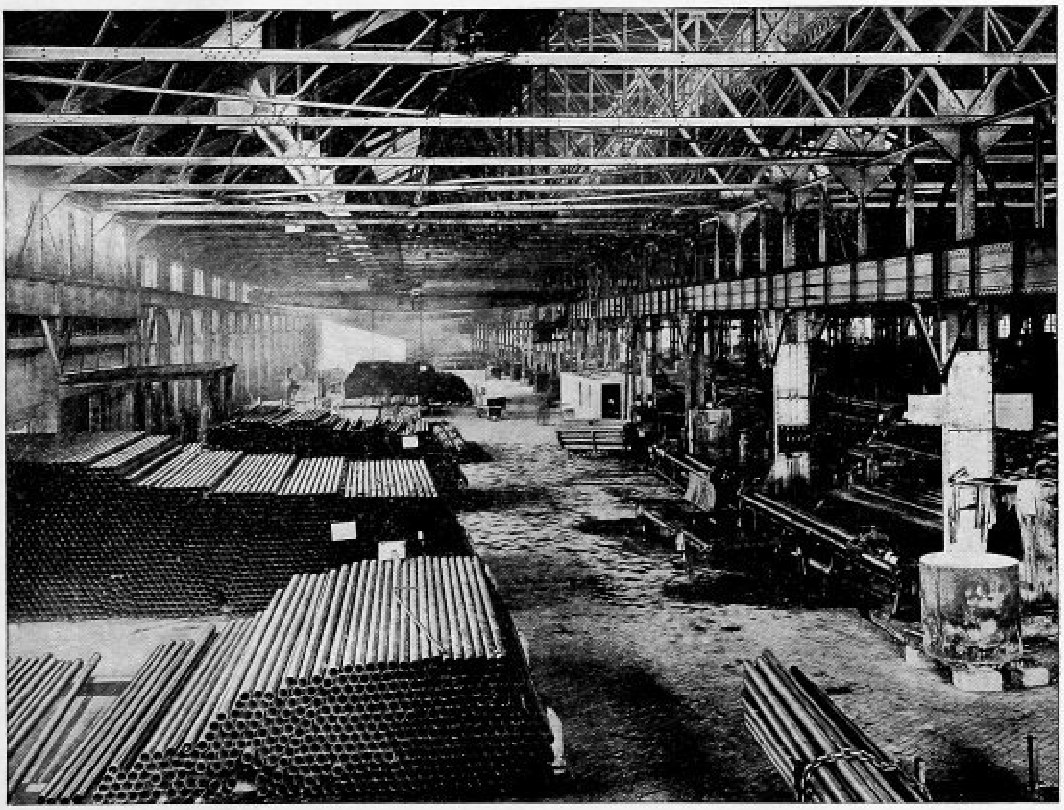
The substitution of basic open-hearth steel low in carbon, and with less than .05 percent phosphorus and sulphur, has been found after more than two years' trial to entirely do away with any tendency of this kind, and as now made there is little difficulty in securing a strong weld with this steel.

Seamless and lap-welded steel tubes are now made from practically the same grade of soft basic open-hearth steel. The process of manufacture of lap-welded tubes is illustrated and described in the photographs which follow. Your visit to the seamless mill this afternoon has given you a fairly good idea of that process.

It is a good thing for manufacturers and consumers to get together as we are doing this evening and learn each other's troubles. Perhaps out of the discussion to which we are leading up something of value to both sides will result. Let us then take up what seem to be the main points requiring attention in the locomotive tube in order that it may give the best service under modern conditions.

1. *Resistance to Corrosion.*—The manufacturer should furnish a tube in the best possible condition to withstand corrosion and pitting; that is, the metal should be as uniform in composition and density as it is possible to make it. Much can be done to lessen the tendency to pitting by proper attention to the making of steel and the way it is worked. We have been experimenting on this problem now for several years, and have gone to considerable trouble in the matter of testing and inspection of material and in the process used for manipulating the steel so as to produce a tube which will resist corrosion as well as iron can be made to do so, and judging from the reports of comparative service tests which have been received, steel so made is, in this respect, at least the equal of the best charcoal iron.

After all, however, the solution of this problem is largely in the hands of the user. Iron or steel will corrode in spite of anything that can be done if certain material is in solution in the water, particularly dissolved oxygen or carbonic acid. By the removal of these harmful agencies corrosion may be reduced to practically nothing. It is generally understood nowadays that water conditions have everything to do with corrosion, and the simplest solution of the problem is to treat the water with the object of making it as harmless as possible. The development of the modern tube to withstand corrosion and the treatment of water have together practically eliminated this trouble, so that it is rarely the case that tubes fail nowadays through pitting.



ONE OF THE NATIONAL TUBE COMPANY'S WAREHOUSES.

2. *Leaking in the Flue Sheet.*—The construction and handling of the engine has so much to do with the trouble experienced from leaky flues that it is difficult to determine how much, if any, of the responsibility for this should be placed on the tube material. If railroad engineers will tell us what qualities are required in the tube to make it hold tight in the flue sheet we will be glad to follow their suggestions as closely as possible. At the present time the steel tube is made as stiff as possible consistent with the best welding quality and ability to stand up successfully under expansion and beading in the tube sheet.

3. *Strength and Ductility of Material.*—The tube should be of such quality as to stand repeated tightening in the flue sheet without cracking or showing undue evidence of fatigue, nor should these weaknesses develop during the life of the flue in service. The material found best adapted to give these properties is a special grade of soft open-hearth steel carrying not over .05 percent phosphorus or sulphur.

4. *Weldability.*—The quality of the metal and method of

handling are equally important in safe ending. Soft steel has been found somewhat harder to weld than charcoal iron, but it has been greatly improved in this respect. The necessity for a good welding quality steel is of first consideration in making locomotive tubes so that they may be easily safe ended, and this point has received a great deal of study, especially in the manufacture of lap-welded tubes where it is, of course, one of the first essentials to manufacture. Charcoal iron carries considerably more impurities than soft open-hearth steel, and these impurities form a self-fluxing mixture which facilitates welding. Railroad specifications have been so tightly drawn on composition in some cases as to work against the production of a good quality of steel for locomotive boiler tubes by calling for unnecessarily low phosphorus and sulphur. There is now very good reason to think that a mistake has been made in this direction, and that the general welding quality of the steel would be much improved, and the steel at the same time would lose nothing in other respects, if the maximum phosphorus and sulphur limits were both raised to .05 percent. With producer-gas, now generally used of necessity, it is a very difficult matter to keep the average sulphur in the heat below .035 percent, and in order to remove this sulphur in the open-hearth furnace the steel has to be held and worked in such a way as to frequently leave it dry and difficult to weld.

Before the steel can be welded in practice a fluid cinder must be formed on the surfaces which are to be united. If the metal is heated too far above the point at which this cinder should flow it will be burned and destroyed. We endeavor to have the range of temperature between the cinder-forming and burning points in the steel as wide as possible, so as to assist in lap welding and give the largest margin of safety in safe ending. Considering the variety of the requirements it seems to us that the compositions of the metal should be left largely to the discretion of the manufacturer, so far as is consistent with a certain specified standard of physical quality in the finished tube. We frequently go to the trouble of rephosphorizing for the purpose of improving the fluxing and welding quality of our steel.

The method of safe ending, we have said, has as much to do with obtaining satisfactory results as the material, but we will not attempt to lay down specific rules as to construction of the furnace and heating, for many of the practical shop men present who are welding flues every day are much more able to discuss this side of the problem. However, there are a few broad principles on the heat treatment of tube steel which should be taken into consideration. The preliminary heating of the body tube preparatory to flaring out the end should be carried to a bright orange color, judging by good shop light, 1,750 degrees F. In the case of steel on steel, if the body tube is allowed to cool black after heating to this temperature and inserting the safe end the grain structure will be refined and the metal put in much better condition for the welding operation which follows. Moreover, if the pre-heated body tube is returned to the furnace without cooling, the metal may be crystallized or burned before the safe end has been heated hot enough to weld. Should there be any considerable difference in thickness between the safe end and body tube, it is evident that there is again a risk of overheating the one before the other is sufficiently heated to weld. If the body tube is returned to the furnace while red-hot, and the safe end is at the same time a gage or two heavier, there is, of course, all the more chance of crystallizing or burning the body tube at or near the weld. Taking unnecessary risks of this kind often explains subsequent failures which should not be charged up to the flue maker.

It is not unusual for a flue welder who has never handled steel to have trouble for a few days. Remembering the above above points, and using his experience to the best advantage as to the condition of his furnace, the character of the flame, temperature, etc., the average man will soon be able to do equally reliable work with steel as with charcoal iron, as the experience of welders all over the country will show.

5. *Uniformity of Material.*—This is a quality which the tubes should have in a high degree, both as to physical and chemical porperties. There is no difficulty as to the average steel tube nowadays standing the master mechanics' tests made on one sample out of each hundred tubes. We have, however, recently designed a machine to make the flange, crushing down and flattening test on each end of every tube in the manner shown. This gives assurance, both as to the character of the metal in each individual tube and also, in the case of lap-welded tubes, as to the welding quality being satisfactory. Steel tubes are now made in one grade of material, suitable for either body tube or safe ending.

Having briefly considered the subject from the standpoint of the manufacturer who is striving to produce the best tube that can be made for locomotive purposes, we will be glad to get the benefit of the experience of practical railroad men who have been following up this matter, to whom we must look for the final word on the tube question.

The Boiler Manufacturers' Meeting.

The convention of the American Boiler Manufacturers' Association will be held at the Hotel Brunswick, Boston, Mass., July 10, 11, 12 and 13, 1911.

The Boston entertainment committee of the New England Association of Boiler Manufacturers will consist of Duncan D. Russell, of the James Russell Boiler Works, South Boston, Mass., chairman; James E. Linch, of the Hodge Boiler Works, East Boston, treasurer; Joseph M. Robinson, of the Atlantic Works, East Boston; James C. Stewart, of the Stewart Boiler Works, Worcester; George F. Lawley, George Lawley's Son Corporation.

The supply men's auxiliary committee will consist of Harry G. Porch, Lukens Iron & Steel Company; Wilbur Sargent Licke, of the Carnegie Steel Company; George H. Lloyds, Central Iron & Steel Company; James J. Sullivan, Champion Rivet Company; James L. Towle, Chicago Pneumatic Tool Company; James J. Kilellea, Worth Bros. Company; Columbus Dill, Ashton Valve Company; George F. Musgraves, Star Brass Company.

Mr. Frederick B. Slocum, of the Continental Iron Works, Brooklyn, N. Y., chairman of transportation committee, will take care of all reservations for accommodations at steamship lines between New York and Boston, if notified immediately.

The explosion of a boiler on the Southern Pacific at Bryn Mawr, Cal., killing the fireman and severely injuring the engineer, again calls attention to the failure of locomotive fireboxes. Were it not for the sadness of the constant occurrence of firebox explosions they might be termed monotonous, and certainly with the acknowledged danger greater care should be exercised in the design and inspection of this particular part of the boilers so that this long list of accidents should be curtailed.

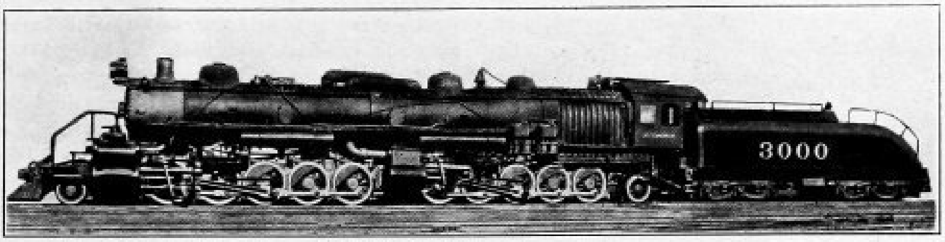
French boiler shops are described as being incontestably superior to German and American as far as careful work is concerned. The short life generally required of locomotives in the United States renders carefully finished work less necessary.—*Page's Weekly.*

A MONSTER LOCOMOTIVE FITTED WITH JACOBS-SHUPERT FIREBOX.

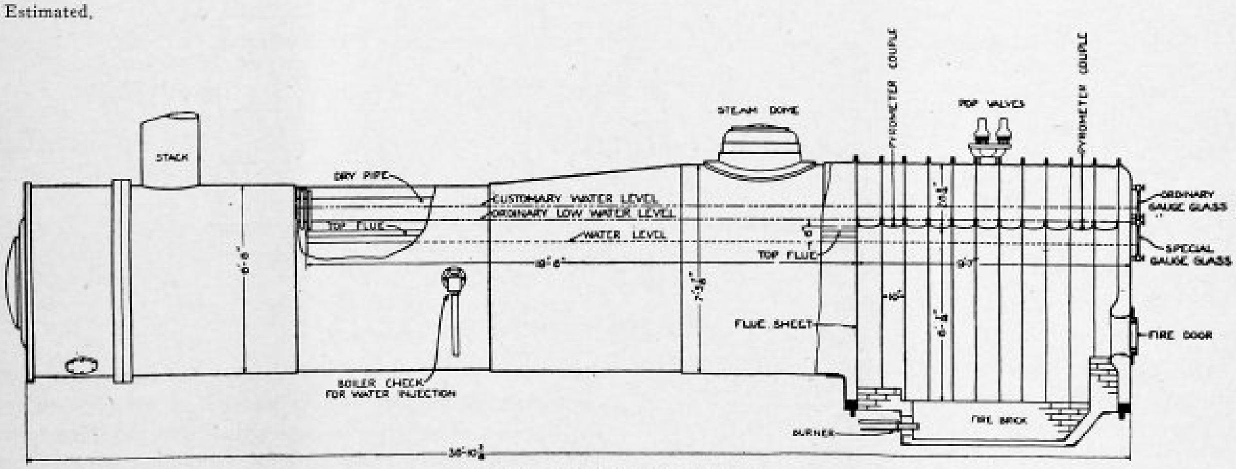
The Atchison, Topeka & Santa Fe road has built a huge locomotive, which we illustrate. Its dimensions are as follows:

Type	2-10-10-2
Cylinder arrangement	Mallet compound
Cylinder size	28" and 38" by 32"
* Weight on drivers	550,000 pounds
* Total weight of engine	616,000 pounds
Tender	250,000 pounds
Steam pressure	225 pounds
Tractive force	110,000 pounds
Tank capacity, water	12,000 gallons
Tank capacity, oil	4,000 gallons
Rigid wheel base	19 feet 9 inches
Heating surface:	
Boiler	3,920 square feet
High-pressure superheater	580 square feet
Low-pressure superheater	1,307 square feet
Feed-water heater	2,659 square feet

* Estimated.



LOCOMOTIVE EQUIPPED WITH JACOBS-SHUPERT FIREBOX.



PLAN OF THE BOILER AND FIREBOX.

In THE BOILER MAKER of January, 1909, page 16, also April, page 100, of the same year, and in December, 1910, page 355, we give descriptions of the Jacobs-Shupert firebox which is used in this engine.

From the first glance at this firebox it might be supposed that the numerous seams would give leakage troubles, but a most exacting test has shown that there is no fear on that score. A series of tests of this firebox was made by the Atchison, Topeka & Santa Fe Railroad recently, and we quote from it below.

The boiler was fired by oil. The usual working pressures of the boiler was 225 pounds. The pops were set as close to 225 pounds as practicable. Compressed air was piped to the stack in order to produce draft. Two pressure gages were used, one to check the other. A blow-off was fitted so that water could be reduced in the boiler. A second gage glass was attached to the boiler head to indicate the level of the water relative to the top of the crown sheet. This was observed by means of a telescope. Pyrometer couples were inserted in the steam space of the firebox, also in the second sections from the back and front of the firebox, indicating the temperatures of the crown sheet on the steam side. Observers taking readings were protected with a steel shell.

A hot crown sheet test was first made. The water was lowered in the boiler until it showed only 1 inch above the crown sheet. The crown sheet heated up gradually at an average rate of 67 degrees per minute for a period of ten minutes, at which time the temperature of the front section of the crown sheet was 1,125 degrees, that of the back section was 1065 degrees. The pressure was 230 pounds, and all the pops were blowing off. The water level was now 6 inches below the top of the crown sheet. A slight steam leak occurred a little below the pyrometer leads. The steam from the pops indicated that the crown sheet was getting hot, and the steam shown from the blow-off was considerably superheated. The water was then further blown off to 4 inches below the top of the crown sheet in three minutes, and at the rate of 1,210 pounds per minute. Two minutes after the crown sheet was bare the firebox showed effects of expansion, due to the heating of the crown sheet, by very slight openings in the stay sheets near the middle of the firebox. The leaks from these openings were very slight. Ten minutes after the crown sheet was made bare it was at a temperature of 1,125 degrees, and water at 60 degrees was forced into the boiler. Simultaneous with the injection of the water into the boiler the pressure dropped a few pounds, and the water fell in the lower gage-glass so that it was not visible. Eight and one-half minutes after the pumps were started the water was at the crown sheet, and the pressure at that time was 215 pounds. Within fifteen minutes after the close of the test the interior of the firebox was inspected. No distortion of sections nor opening of seams could be seen, but indications of an overheated crown sheet, that in a firebox of ordinary construction would cause a dangerous explosion, showed plainly. Close examination of the sections showed no distortion whatever in any portion of them due to being overheated. There were no leaks between any of the sections and no flue leaks. The crown sheet showed the characteristic blue color that accompanies overheating. The boiler tubes were not inserted in the back flue sheet in the usual manner, but were welded in by the oxy-acetylene process. This boiler had been in service and under test for a considerable period of time. During this time an experiment was made to determine the service that might be expected from welding flues into the back flue sheet.

As a result of the test the following deductions and conclusions are warranted:

1. The Jacobs-Shupert sectional firebox is stronger than an ordinary locomotive firebox.

2. The overheating of the crown sheet of the firebox does not decrease the holding power of the stay-bolts and rivets.

3. The sectional firebox is not subject to undue stresses due to changes in temperature.

4. The form of construction of the firebox gives protection from explosion in case of water being below the crown sheet.

5. The form of construction is such that in case of rupture the firebox will not be entirely torn apart.

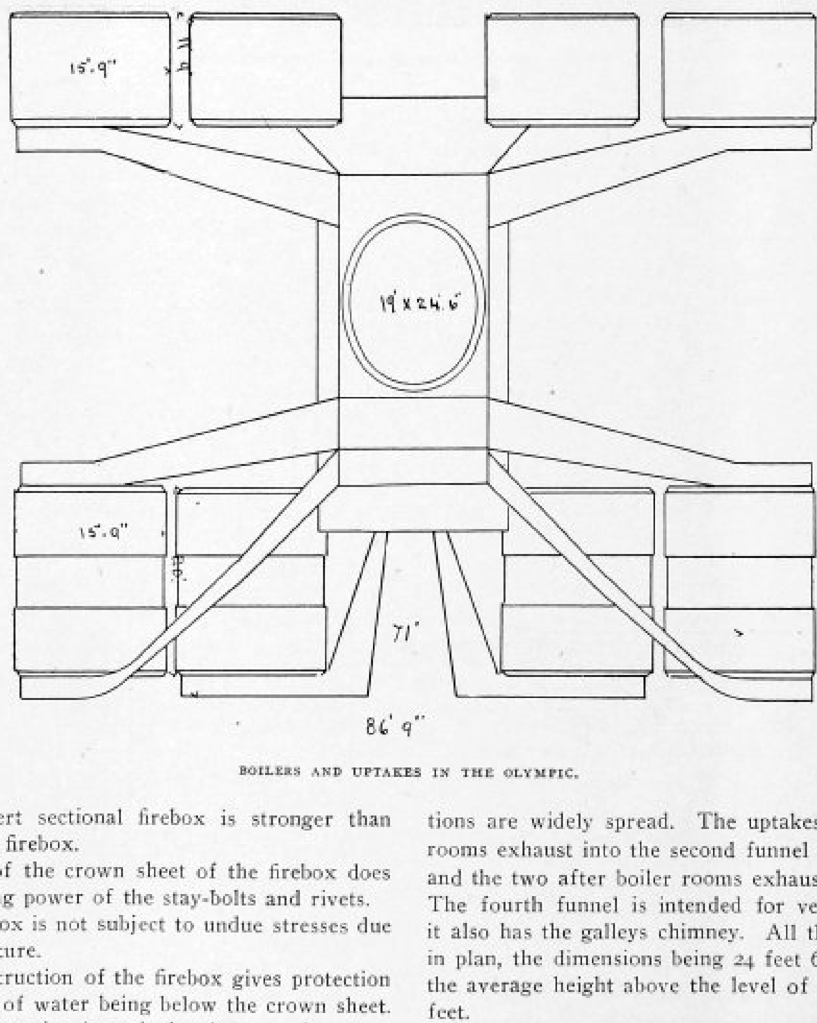
6. The test would have caused a violent explosion in an ordinary firebox with stay-bolts.

An air hammer should never be put in service without first being well oiled with a good grade of suitable oil; if it continues in service it should be oiled every two hours without fail. Pneumatic tools are like a human being; without the proper nourishment and care they will very soon be a total wreck.—*Compressed Air Magazine.*

A Big Laying-Out Job.

On the huge White Star steamship *Olympic*, which will arrive in the port of New York this summer, there are twenty-nine boilers in the ship with 159 furnaces. All boilers are 15 feet 9 inches in diameter. Twenty-four are double-ended, 20 feet long; five are single-ended, 11 feet 9 inches long. At each end there are three furnaces, all of the Morrison type, with an inside diameter of 3 feet 9 inches. The working pressure is 215 pounds. The boilers are in six watertight compartments, five boilers athwartship. The boiler compartment nearest the machinery space accommodates the single-ended boilers, so arranged as to be available for running the auxiliary machinery. Two boilers in each of two other compartments have separate steam leads to the auxiliary machinery, which includes the electric lighting installation. The electric output is 1,600 kilowatts. The other five rooms are fitted with the double-ended boilers. The uptake connections are widely spread. The uptakes for two center boiler rooms exhaust into the second funnel from the forward end; and the two after boiler rooms exhaust into the third funnel. The fourth funnel is intended for ventilating purposes, and it also has the galleys chimney. All the funnels are elliptical in plan, the dimensions being 24 feet 6 inches by 19 feet, and the average height above the level of the furnace bars is 160 feet.

We give two illustrations of the uptakes which connect the smokestacks with the boilers, and certainly this layout is most admirable, being extremely simple and yet of tremendous size. It is rather hard to get a good idea of just how large this work is, even with the figures before us, yet the imagination is helped when it is remembered that a 20-foot front house is a fairly good-sized city dwelling, and here the smokestack of this ship is 19 feet by 24 feet 6 inches, and there are four of these. The spread of this uptake, as will be noticed in Fig. 2, shows an over-all dimension of 71 by 72 feet.



BOILERS AND UPTAKES IN THE OLYMPIC.

How Things are Done in Texas.

Notice.—As all freight offices, and many other houses, close Saturday afternoons during the summer months, we will close our office and shops at 12:30 P. M. on Saturdays during the months of May, June, July and August. Customers desiring shipments or men for repair work on Saturdays will aid us greatly by having their orders reach us early in the day. However, for urgent cases, as in breakdowns, you can get in communication with us by telephoning Tofte Boiler & Sheet Iron Works,

Houston, Tex., May 1, 1911.

The Compound Curve Layout in March Issue.

EDITOR THE BOILER MAKER:

I take the liberty of writing to you in regard to one of your laying-out problems. You will notice in your March, 1911, issue that Mr. Clarence Reynolds shows a pipe with a compound curve, and it is very important that every layer-out should understand this piece of work. Whether Mr. Reynolds or I have made a mistake I cannot say, but I fail after a long study of the drawing to get a proper understanding. You will see that Mr. Reynolds plainly states that the line 14-15, Fig. 2, has to be equally divided. I would ask you to take a pair of small dividers and go over this line, which he states must be equally divided, and see what you can make of it. I would like to know whether I must be governed by his sketch or by his statements, as they do not correspond. I am greatly interested in this particular layout, and would thank you very much if you could give me some light in regards to this. It is the first time I have failed to understand your journal, and I would be pleased if you could in some later issue explain it a little better. WILLIAM LOCKYER.

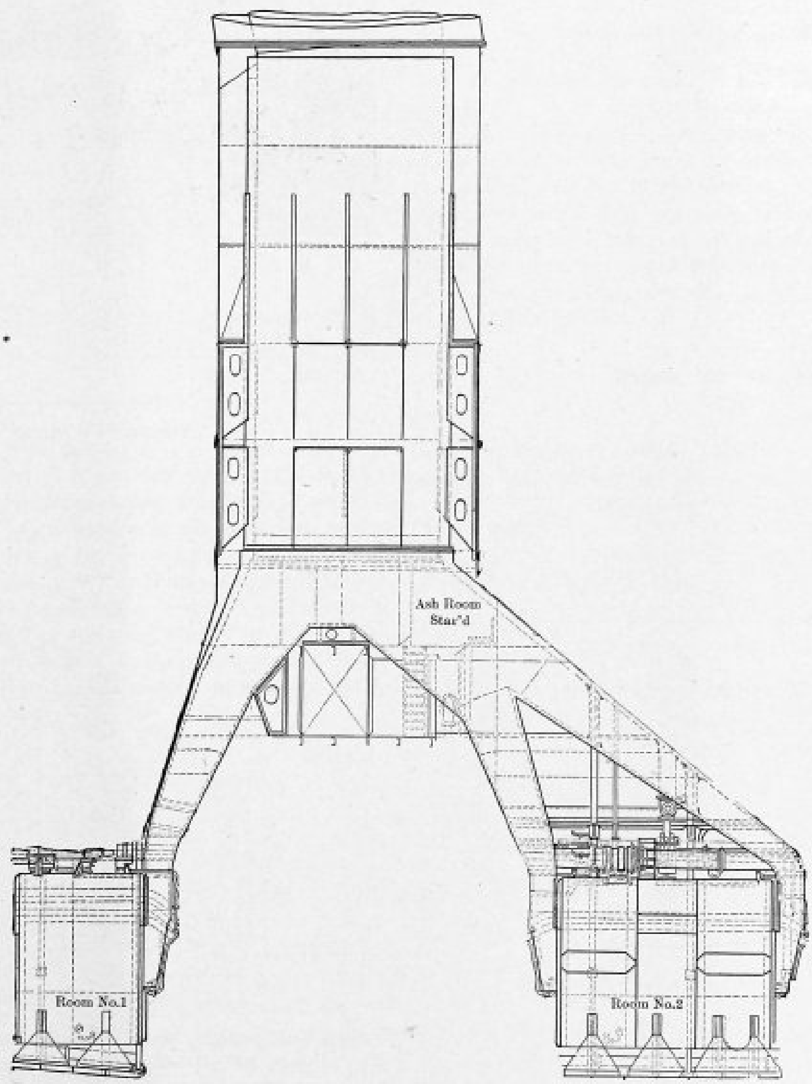
Oak Park, Cal.

Patch for a Locomotive Firebox.

EDITOR THE BOILER MAKER:

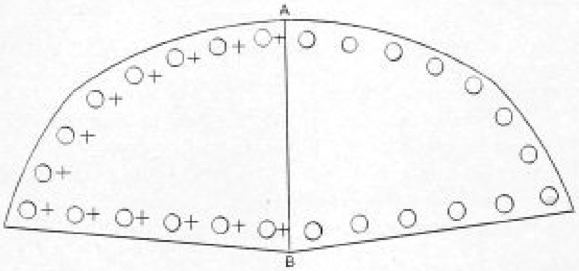
The corners of the locomotive fire-box bottom usually require patching while the boiler is still comparatively new. This is made necessary, in part, by the ashes that collect in these corners and the constant calking required, also where there is bad water, grooving and pitting is sure to take place. The patches for the corners are gotten out and made fast for such repairs in the following manner:

After scraping smooth the surfaces, lay off the patch-bolt holes and center them good and deep. If ¾-inch patch-bolts are to be used the pitch should be as close to 1¾ inches as conditions will permit. Next take a piece of common wrapper paper of convenient size and hold it snugly on the corner, pressing over its surface with your thumb, especially at each



ONE OF THE OLYMPIC'S STACKS.

center punch mark, or a light tap with the peen of a hammer will locate the center marks on the paper. Do the same to the holes in the mud-ring; then place your paper on the sheet piece to be used for the patch—say 3/8 inch thick—and mark off all the holes. As the patch is to be bent through 90 degrees on the line *A-B*, as shown in sketch, Fig. 1, the holes on one side of the line *A-B* should be drawn over approximately the thickness of the plate; that is to say, 3/8 inch, as indicated by



LOCOMOTIVE FIREBOX PATCH.

the X marks in sketch. This is done to overcome the difference in the thickness of the plate used.

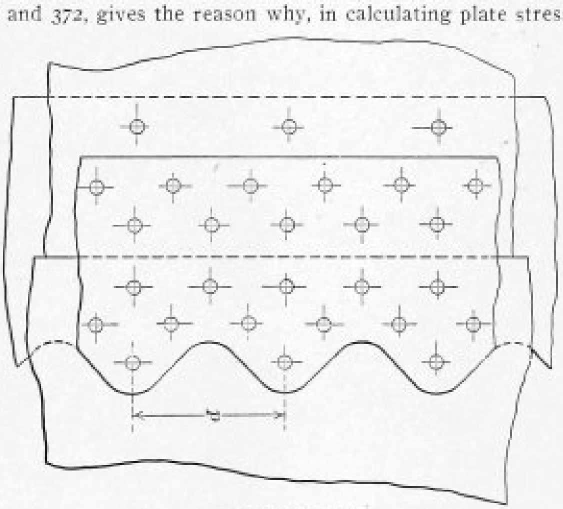
Have the holes for the patch-bolts 1/8 inch smaller than the patch-bolt; bevel and trim about 1-inch lap on the right side flange; heat it evenly all over to bright red and bend to fit; then pin the bent patch up in place and drill through the holes for patch-bolts, remembering to give the drill press man a patch-bolt to ream and countersink the holes in the patch by, which should be reamed 1/32 inch larger than the bolts used.

Hornell, N. Y. W. E. O'CONNOR.

Triple-Riveted Joints.

EDITOR THE BOILER MAKER:

In your December issue of 1910, Charles J. Mason, on pages 371 and 372, gives the reason why, in calculating plate stresses,


TRIPLE-RIVETED JOINT.

using a triple-riveted joint, the outer row of rivets has one rivet less in every pitch. Many of the readers, I think, would be interested to know why the outer strap is smaller than the inner strap.

By using twice as great pitch in the outer row as in the inner rows it becomes difficult to calk the strap, and if the pitch is greater than eight times the diameter of the rivet it is nearly impossible to calk. This is why some engineers cut out the straps, as shown on bottom of the illustration. But this adds to the cost. It is common to shorten the outside strap, as shown; but as the inner strap requires no calking it may be left long.

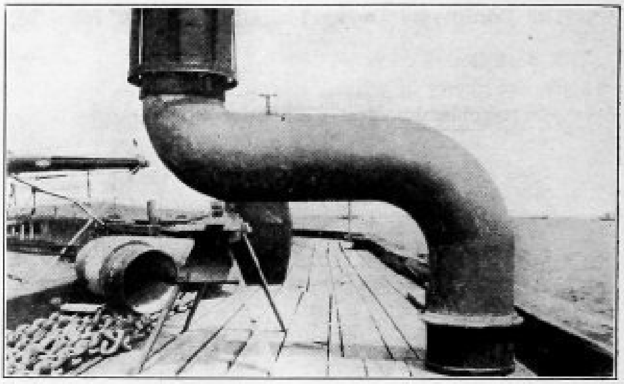
By making the outer strap shorter the rivets in the outer row become only single shear against double shear, but this is no great loss. JOHN JASHKY.

Graz, Austria.

A Neat Smoke Stack.

EDITOR THE BOILER MAKER:

In the May issue you ask for photographs. I wish to submit picture of some sheet iron work I have just done. The print shows the auxiliary smokestack for the auxiliary schooner yacht *Atlantic*. The two stacks are 16 inches inside diameter


A NEAT SMOKE STACK JOB.

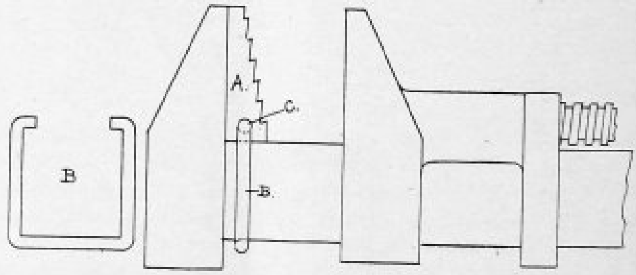
of No. 14 sheet iron. Note the difference in the neck of the two ells in the stack. JOHN A. HIGGIN.

Greenport, L. I.

Another Wrench Trick.

EDITOR THE BOILER MAKER:

I read about the monkeywrench and the philister head screw and then the monkeywrench with the set screw for gripping piece, and I thought I would send you what our boss uses. He has to send us out to do all sorts of things, and a whole kit of tools is pretty heavy. I am a "cub" and have to carry it, so I know, and not to have to carry pipe tools he made a little block, which I show in sketch, and mark it *A*. This is made of tool steel, and he made a length about 8



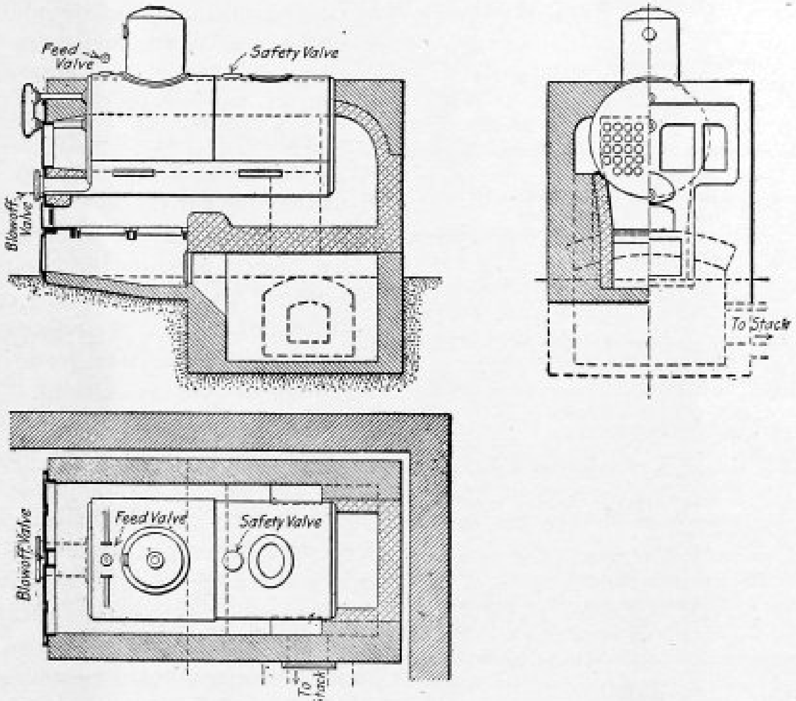
ANOTHER WRENCH TRICK.

inches long in the planer. Then he cut it up to the width of an ordinary 10-inch monkeywrench head, and hardened them. They worked first-rate on pipe but kept falling out, so I took one and annealed it, and drilled two holes in the lower end—one is shown at *C*. Then I bent up the piece of stubs wire, as shown at *B*, and filed up the corners so that it would fit around the bar of the wrench, and spring into the two holes *C*. This worked fine, and kept the piece from tumbling out. Most of the boys get these little "grips," as they call them, and keep them in their tool box, and the boss does not say anything, because they save him a lot of money.

"CHIEF CUB."

Boiler Setting in Sweden.

Herewith is a design of a horizontal tubular boiler setting which is used very extensively in Sweden with satisfactory results. The bottom sheet of the boiler is in one piece; thus there are no seams with rivets exposed to the action of fire on the outside and mud (sediment) on the inside of the plate. The cover of the cleaning nozzle (the nozzle is connected to the lower front part of the boiler) can be taken off and the sediment scraped and washed out. A lamp can be brought into the boiler through this opening, and nearly the whole of the bottom sheet and the bottom part of the lower row of tubes can be inspected. The boiler is set with an inclination toward the front; the blow-off valve is placed on the clean-out cover, oftentimes the feed valve too.—JOHN ZEUERLUND in *Power*.

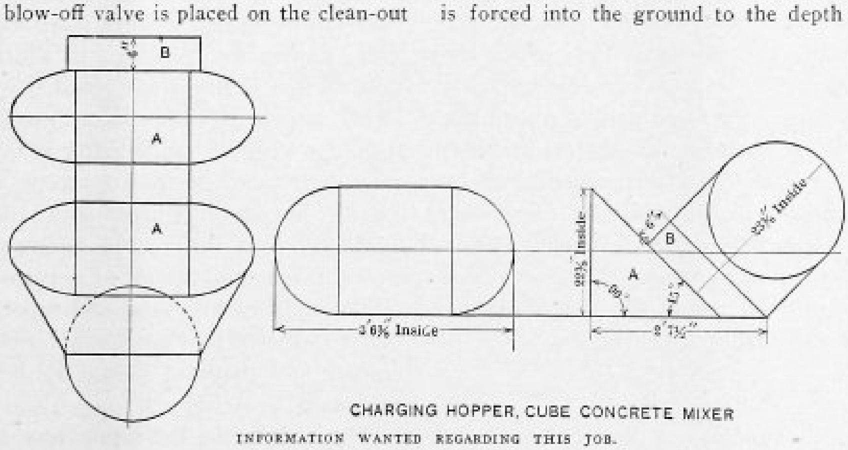


SWEDISH METHOD OF SETTING A BOILER.

A New Market for Boilers.

A new use has been found for steam, and a new market has been opened to the manufacturer of boilers. Having experimented for years with methods of sterilizing the tobacco beds, to rid them of the weeds and insects which are such a menace to the young plants, the tobacco growers in the vicinity of Windsor, Conn., have adopted the idea of using steam. It has been found that by going over the beds with live steam they are sterilized better than by any of the older methods. The tobacco growers in the Connecticut Valley are just completing sowing their beds. Many of them, before planting the seeds, sterilized the beds with steam, and from experiments heretofore made it is expected that good results will be obtained.

Years ago tobacco growers experimented in sterilizing the tobacco grounds by drawing "brush" onto them and burning it, but this proved to be detrimental to the growth of the seed. The method adopted this year is much different. A boiler is set at a convenient place alongside the bed and steam is generated and fed by pipes to the beds. A funnel-shaped arrangement is attached to the end of the pipe, and the steam is forced into the ground to the depth of 6 inches or more. This process is carried on throughout the bed, and is done with such thoroughness that the heat remains in the ground for over three hours.



CHARGING HOPPER, CUBE CONCRETE MIXER

INFORMATION WANTED REGARDING THIS JOB.

Who Will Answer This?

EDITOR THE BOILER MAKER:

I'm sending you herewith a drawing of which I would like to have some reader of THE BOILER MAKER to give a method of laying out piece *A* and *B*. CLYDE E. PRING.

Gorgona, Canal Zone.

The Boiler Maker

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

NOTICE TO ADVERTISERS.

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

To Our Subscribers.

We have just received notice from the Post Office Department that after June 30, 1911, periodicals for delivery in certain States are to be sent by fast freight instead of with the mail, as has been done in previous years. We make this announcement in order that subscribers who receive their magazines very late may extend their thanks to the United States Post Office Department for the delay. If any of our readers know of a yoke of oxen or any antiquated pair of mules that are useless for any other purpose, we suggest that they communicate with the Post Office Department, notifying it that these animals are for sale, and suggesting that as long as the Department is endeavoring to economize, regardless of the convenience of citizen voters, these animals be purchased for use in delivering the mails, and thus save the cost of fast freight.

In going over the proceedings of the convention of the Master Boiler Makers' Association just held in Omaha, we are much struck and pleased with the intense earnestness of all the members and the thorough appreciation of how important is the boiler maker's work, not only as it relates to the safety of thousands, but as it pertains to the great traveling public, as without serviceable boilers the entire country's transportation business would practically cease. The attendance was excellent, and the discussions were not perfunctory, but right to the point. Throughout all of them ran the same consistent, practical desire for concise and exact information. No one was diffident in telling of failures as well as successes, and this spirit is of the utmost value in a body of men who are strenuous doers. They make a good deal of noise, it is true, in their work; but every blow struck, if not a conscientious one, may be sounding the death knell of someone, and of this fact there was no lack of appreciation. Again, no man present was niggardly with his knowledge. Experience which would guide a fellow craftsman was generously and amply given, and when there was a difference of opinion it was not of the schoolboy variety, but like men to men.

Most noticeable and most satisfactory was the intense interest taken in the question of apprenticeship. No subject was more carefully considered, and the experiences of the past, as related by some of the members, showed there was grand good material in the make-up of the association. The value of better training for the coming boiler maker was thoroughly grasped, and by none better than those who, in their early life, had no advantages save what they pounded out with their good right arms. Perhaps no subject was ever better put before an association than was this, and we feel sure the wisdom shown in continuing its discussion next year will bear fruit.

In the matter of Federal laws governing the inspection of boilers, a broad view was taken with a spirit of not only to follow the letter of the law, but a hearty co-operation with its spirit looking towards practical results.

The detail of construction of locomotive boilers was most interestingly discussed, and in it we have the great point to be aimed at. As a rule, it will be found that the design of boilers is all right, but some little detail causes the trouble. In short, what the association wanted to know and what it was striving for was light, which would enable members to make the products of their hands better in every way; and there was clearly no desire to accept anybody's "say so" merely, but absolute proof was called for.

We think a little more allowance should be made for different conditions of service under which various appliances are used and reported upon. It must be remembered that because a fur coat is no good in the climate of Panama it should not be condemned for use in Alaska.

The change in the name was a wise move, as the word "International" really meant little or nothing, and the "Master Boiler Makers' Association" seems to us to be thoroughly explanatory and most dignified. Many interesting subjects were arranged for the next convention. The investigations and consequent reports on them will be of much practical value. We trust the convention will be called earlier in the month, so that THE BOILER MAKER would not be delayed in its June issue, as is the case this year.

LEGAL DECISIONS OF INTEREST TO BOILER MAKERS.

Necessity for Seller of Purchased Boiler to Have It Inspected.

The defendant contracted with a salt company to furnish an evaporating system for manufacturing salt. The apparatus consisted in part of a system of four steam cylinders or boilers, called "effects" A, B, C and D, into which exhaust steam from the salt company's plant was to be introduced; provision also being made for the introduction of live steam now and then when needed. These "effects" or boilers could be worked in conjunction, in part or separate, by a valve system, so that the pressure on each would be made equal. The plaintiff was to put an expert in charge of the operation of the evaporator system until a test was successfully made. The salt company employed the plaintiff to take instructions from the expert, in order to learn how to operate the system if it was accepted. For six days the expert had been instructing the plaintiff in the operation of the plant, when one of the boilers burst and the plaintiff was injured, for which he sued the manufacturing company. The jury found that the defendant was negligent in respect to the casting which burst; that it was imperfectly constructed, and that the defendant knew of the defect; that the casting had become weakened by repeated expansion and contraction, due to heating and cooling, and that the cause of the casting exploding was turning live steam into effect A, but that it would not have exploded had it not been imperfectly constructed. Judgment for the plaintiff was affirmed on appeal. The court held that the plaintiff was a servant of the manufacturing company, to whom it owed ordinary care. It was the continuing duty of the defendant to use ordinary care to provide the plaintiff with a safe place to work and safe machinery and appliances, and to make proper inspection thereof, notwithstanding that it was testified that it was not customary to inspect boilers after they had been shipped by the manufacturers, except by pressure, as was done. The testimony showed that the boiler head was not examined or tested except by hydraulic and steam pressure. While the defective boiler head was painted, the jury evidently believed, and the appeal court thought justly, that by the exercise of reasonable care in actually examining into the soundness of the casting, instead of assuming it, the defendant might have ascertained its defects and prevented the injury.—*Wise v. Sugar Apparatus Mfg. Co., Kansas Supreme Court.*

Necessity for Warning of Dangerous Employment.

The plaintiff, a blacksmith, was engaged in fitting a new piston rod into a hollow piston head of a small second-hand engine in the defendant's works. He and another workman were heating the piston for the purpose of shrinking it onto the piston rod. Unless the precaution is taken to make a hole in the piston to permit the escape of steam, formed from water which may leak in, and gases generated by the great heat, this process of shrinking on the head is a dangerous one, and is known to be so by those familiar with the business. No vent was made in the present case, and the head exploded, injuring the plaintiff and, killing his fellow workman. The foreman of the blacksmith shop knew of the danger, and did not communicate it to the plaintiff or direct any one else to do so. The plaintiff testified that he did not know of this particular danger. It was held that if the foreman directed the work to be done by heating the piston head without giving warning of the danger, he was negligent and his negligence was that of his employers. Judgment for the plaintiff was affirmed on appeal.—*Klauder-Weldon Dyeing Mach. Co. v. Gagnon, Circuit Court of Appeals, Second Circuit.*

Injuries from Explosion of a Locomotive Boiler.

An action was brought against a railway company for damages for the death of an engineer caused by the explosion of a locomotive boiler. The defective condition of the boiler which exploded was alleged to be the cause of the explosion. There was a mass of testimony brought forward to the effect that the crown sheet of the boiler had been burned about ten days prior to the explosion while it was in the roundhouse. Other evidence conflicted with this. The boiler was patched on the flange joining the flue sheet and the crown sheet. The patch was placed on the outside of the firebox, and the plaintiff's witnesses declared that it should have been placed on the inside. One of the principal points was whether the patch had been properly put on.

After the explosion a part of it remained attached to the crown sheet, showing that it had been torn apart. Whether this flange was cracked before the explosion took place was a mooted question. Several flues had been removed, and it was a question whether this had not weakened the boiler.

It was shown that the boiler had been leaking badly for some time previous to the accident, and it was conceded by both sides that the flues did leak and had been frequently calked. After the accident it was found that three radial staybolts designed to support and strengthen the crown sheet were missing from the wrecked boiler. Whether they were broken off before or after the explosion became an issue. One of the defendant's witnesses testified that they had cut them off after the explosion, and his testimony was corroborated.

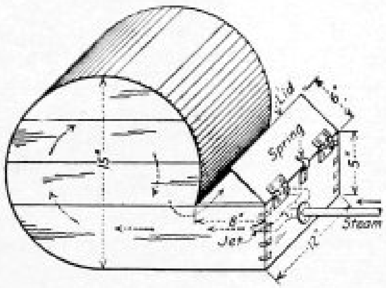
It also became a question whether or not a portion of the boiler should not have been removed before the patch was put on. The defendant claimed that putting on the patch over the defective part of the boiler strengthened it, and further claimed that the explosion was caused by the engineer allowing the water to get so low it did not cover the crown sheet. The testimony was most conflicting, and the case depended almost entirely on expert testimony and on the question whether it belonged to the class where the facts are to be stated by the experts and the conclusion is to be drawn by the jury, or to the other class, where the expert states the facts and gives his conclusion in the form of an opinion which may be accepted or rejected by the jury. The court decided that it belonged to the latter case, the judge evidently holding that the jury might know all the facts and yet not be able to draw a conclusion from them. Judgment for the plaintiff was affirmed. The evidence was in sharp conflict throughout, and that for the plaintiff, it was held, was amply sufficient, if the jury believed it, to support a verdict in their favor.—*Copenhagen v. Northern Pacific Railway Company, Montana Supreme Court.*

Injuries from Insecure Attachment of Steam Pipe.

A nightwatchman was engaged in the switchyards of a railroad company, along with two other men, in caring for three engines, their duties being to keep up sufficient steam to keep the pipes from freezing. He was returning to his engine after adjusting a difficulty for which his help had been required by the other men, when the supply pipe, or hose, which was attached at one end to a goose-neck under the engine and at the other to a feed pipe from the water tank, blew off at the goose-neck, struck him on the leg and fractured it. He sued the railroad company for damages. The supply pipe was of rubber; always contained some water from the tank, and its function was to convey water to the engine. One of the principal duties of the workmen was to keep up sufficient steam in the engine and so adjust it as to force the steam through the supply pipe into the tank to prevent the water in the supply pipe and other pipes from freezing. The goose-neck was of metal, enlarged at the end, and the pipe was fastened by being slipped over this enlargement and held by a metal clamp adjusted by a screw in a manner similar to the attachment of a nozzle to an ordinary lawn hose. The plaintiff claimed that the hose was not properly attached and secured to the goose-neck at the shops. The defendant claimed that the plaintiff negligently permitted the steam to get down and the water to freeze in the pipe. It was held that it was not necessary for the plaintiff to allege in his petition that he could not in the exercise of ordinary care have known of the defect. Want of ordinary care would have constituted contributory negligence, which was for the defendant to allege and prove if he relied upon it. The case was one entirely of fact, and the jury found that the pipe was improperly attached. Judgment for the plaintiff was therefore affirmed.—*Stevens v. Missouri K. & T. Ry. Co., Kansas Supreme Court.*

Engineers' Washing Machine.

Many forms of steam washing machines for washing over-



ENGINEERS' WASHING MACHINE.

alls, etc., have been made by the man on the job that have given more or less satisfaction.

The washer shown in the drawing herewith uses steam only, and will wash a garment, no matter how dirty, in two minutes. The garment is soaked in soapy water, and, without wringing, is placed in the washer and the steam turned on. When the garment attains a speed of between 45 and 60 revolutions per minute, enough steam has been turned on. If one is particular the garment might be rinsed a little after washing.

The width of the front lid is 2 inches narrower than the opening. The sides of the washer, also the cross-piece through which the pipe to the jets enters, are made of 1-inch dressed lumber. A strip of galvanized sheet metal, 14 inches wide, and long enough to go around the bottom and circular sides of the machine, is nailed to the edges of the wooden sides and cross-piece. The cover is made of the same material and is fastened by hinges to the cross-piece.

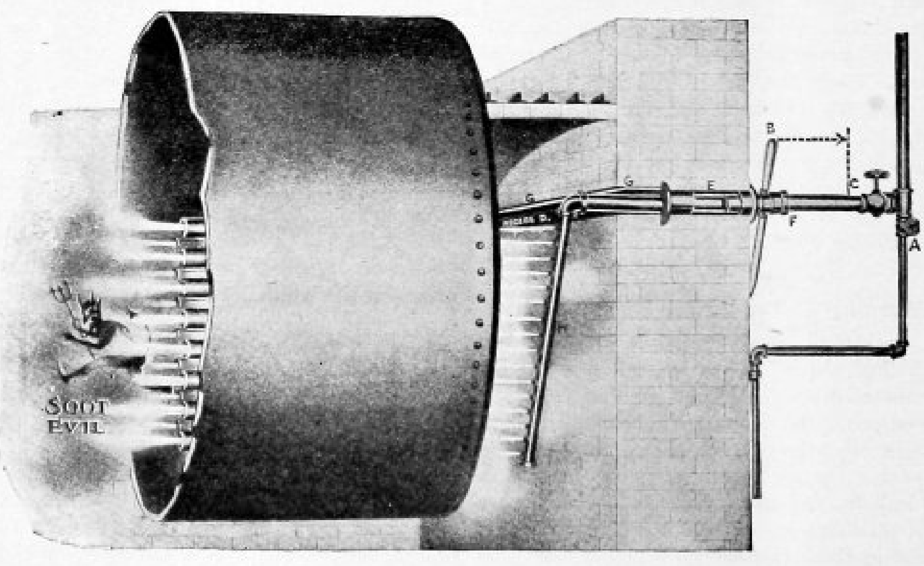
When the garment has been placed in the machine and the steam turned on, the garment follows a path shown by the arrows. The steam follows a circular path the same as the garment, but escapes through the opening in the front, while the garment drops directly in the path of the jet of steam from the nozzle and is driven around again.

It is not necessary to construct the machine watertight.—LOUIS T. WATRY in *Power*.

ENGINEERING SPECIALTIES.

The Vulcan Soot Cleaner.

The Vulcan Soot Cleaner Company, Steinway building, Chicago, is putting on the market the Vulcan soot cleaner. When it is remembered that one-hundredth of an inch of soot on a boiler tube will make its resistance equivalent to 10 inches in thickness of metal, the value of keeping such tubes cleaned needs no argument. The Vulcan cleaner is always on duty. It can be used, if necessary, every hour. How it is applied can be seen from the illustration. The apparatus consists of a movable blow-pipe containing many nozzles, so spaced as to make it impossible to miss a tube, as it is swung in a half circle across the entire tube area and discharges jets of dry steam directly into every tube, always blowing with the draft.

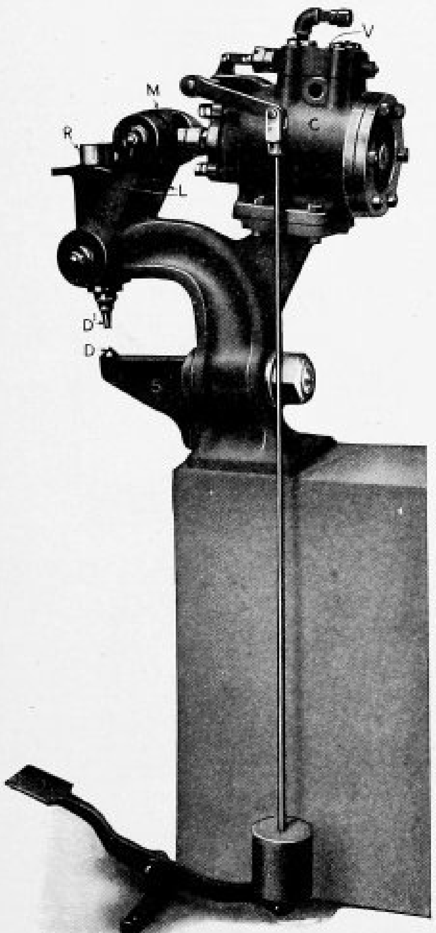


THE VULCAN SOOT CLEANER.

Allen Riveter for Sheet Metal Work.

The engraving shows a riveter recently furnished by the John F. Allen Company, 370 Gerard avenue, New York City, for sheet metal work. It is one of the smallest riveting machines built by this company, having 7½-inch reach, variable gap, and 5½-inch cylinder.

It is designed for sheet metal work where the rivets used run from 1/16 to ¼ inch diameter, and are driven cold. The stake "S" is easily removable, in order to permit of other stakes, suitable to the work in hand, being used. This materially increases the range of the work that can be handled, and will be found a great convenience, as stakes can be made of any shape or size at comparatively small cost to suit the most unusual and difficult jobs. The machine can be operated by foot pedal, as shown in the illustration, or by hand lever, as may be desired. The work to be riveted is placed with the head of the rivet resting upon the holding-on die "D," so as to bring the end of the rivet in line with the upper die "D-1," which usually stands about ½ inch above the top of the rivet. By pressing the foot on the treadle, air of from 60 to 100 pounds pressure is admitted to cylinder "C." This causes the piston to move forward and the side links "L" and middle links "M" to assume a position parallel to the axis of ram



NEW ALLEN RIVETER.

"R." The ram carrying the upper adjusting die "D-1" is thereby forced down upon the end of the rivet, forming a head with one stroke. By relieving the foot pressure on the treadle, the slide valve in valve chest "V" reverses the motion of the piston, and this returns ram "R" to its original position ready for the next rivet. It is claimed that the number of rivets that this riveter can drive within a given time is dependent upon the operator, as the time consumed by the machine in driving the rivet is practically negligible, and that the amount of air consumed per rivet does not exceed one-fifth of a cubic foot.

The machine is noiseless in its operation, and can be placed in any convenient location in the shop without in any way interfering with other equipment. If preferred it can be operated by steam.

PERSONAL.

C. H. Gerrard and M. P. Herter, who have been operating the American Boiler Works at Louisville, Ky., have added largely to their equipment, and now have an up-to-date boiler shop.

Fred. D. Avery, formerly foreman boiler maker of the Boston & Maine shops, Keene, N. H., has been promoted to general foreman boiler maker of the Boston & Maine shops at Concord, N. H.

A. B. Stearns, foreman boiler maker, has resigned from the Boston & Maine shops, Concord, N. H., to look after his extensive farming interests.

G. E. Brookshaw, who has been with the Southern Railway Company at Spencer, N. C., has been promoted to be foreman boiler maker of the Aberdeen & Asheboro Railway at Biscoe, N. C. Mr. Brookshaw was with the Southern Railway Company for eight years.

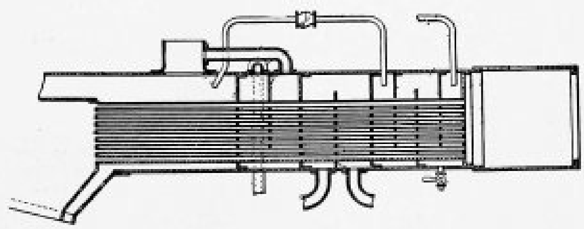
SELECTED BOILER PATENTS.

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

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

989,781. STEAM GENERATOR AND REHEATER. FRANK A. HAUGHTON, OF HIGH BRIDGE, N. J.

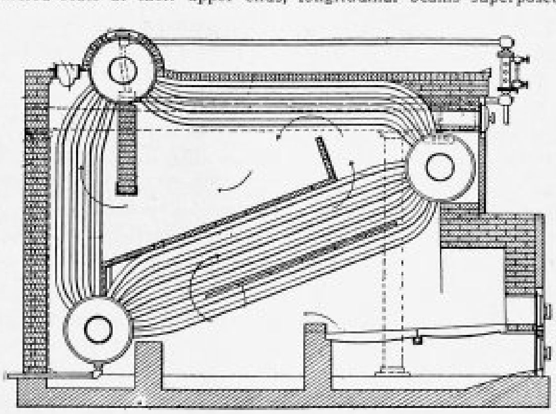
In a fire-tube boiler, the steam generator, and in tandem therewith, a steam superheater, a steam reheater, and a feed water preheater, an



inlet for water to the preheater, connections from the preheater to the generator, and from the generator to the superheater, an inlet for steam to the reheater and an outlet therefor, and fire tubes extending through all of the said elements forming continuous passages for the products of combustion.

990,622. STEAM GENERATOR. J. P. BADENHAUSEN, OF SEATTLE, WASH.

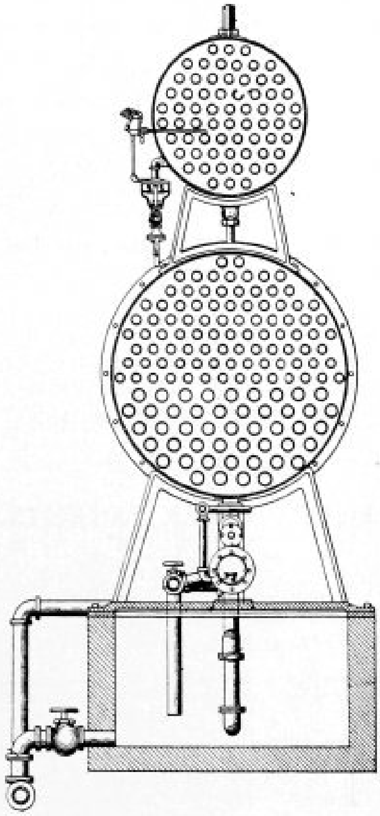
A steam generator comprising uprights having longitudinally-disposed channeled seats at their upper ends, longitudinal beams superposed on



the said uprights and disposed in the said channeled seats thereof, saddles resting on the said longitudinal beams, hangers connected with the beams, and spaced drums connected together and communicating with each other; one of the said drums resting in the said saddles, and another drum being connected to the said hangers.

990,482. WASHING AND FILLING SYSTEM FOR LOCOMOTIVE BOILERS. ROBERT L. GIFFORD AND IRVING COWLES, OF CHICAGO, ILL.

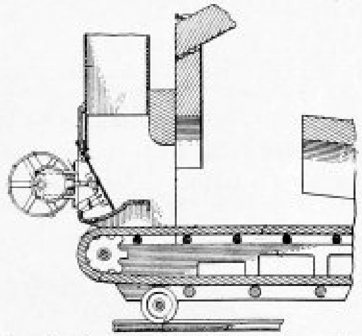
In a washout and refilling system for locomotive boilers, the combination of a sealed vat for receiving blown-off products, a blow-off main connected therewith, a water heater having steam-circulating space in communication with the upper steam space of said vat, means for



creating and maintaining a partial vacuum in the steam spaces of the vat and water heater substantially continuously during the period a locomotive boiler is blown off into said vat, and suitable circulating and conducting means for circulating refilling water to be reheated through said heater and conducting it to the roundhouse stalls.

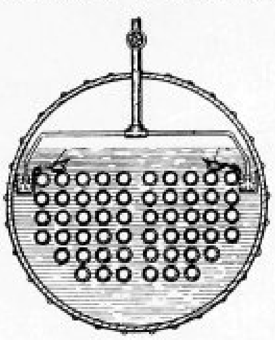
987,911. FURNACE. HERMAN A. POPPENHUSEN, OF EVANSTON, AND JOSEPH HARRINGTON, OF RIVERSIDE, ILL.

In a furnace, in combination with a substantially horizontal, traveling, fuel-supporting grate, the front end of which projects outside of the furnace, a hopper located above the front end of said grate, said hopper



having end walls and a front wall and an opening at the rear above said grate, a swinging member hinged to said front wall, and a bottom wall curved rearwardly and upwardly from said front wall and terminating in a ledge located at a distance above the grate whereby the fuel is caused to fall upon said grate in a loosely-scattered condition.

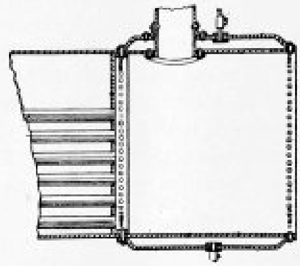
987,710. BOILER-SKIMMER. BYRON EPSOM FOSS, OF CHICAGO, ILL.



The combination with a tubular boiler of a trough inserted between the tubes and the side of the boiler; an inclined apron resting over said tubes and leading to said trough; a blow-off pipe extending into said trough; and a guard pan on said pipe and having entry spaces adjacent the bottom of said trough.

989,938. FEED-WATER HEATER AND SMOKE-BOX PROTECTOR. CHARLES S. ALLEN AND BENJAMIN F. CRONEY, OF DES MOINES, IOWA.

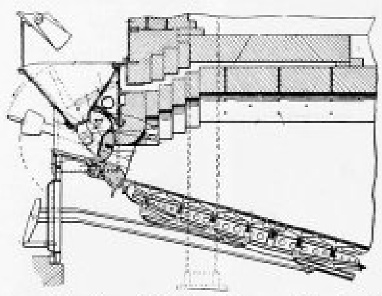
In a steam boiler having a smoke box, the combination of a lining mounted within and spaced from and concentrically of said smoke box, said lining formed with expanded end portions riveted to said smoke box, a smoke stack extending through said smoke box and lining and



communicating with the interior of the lining, an integral flange on said smoke stack riveted to said lining, a flanged collar on said smoke stack riveted to said smoke box, exhaust steam pipes extending through said box and lining and communicating with the interior of the latter, a valve-controlled water supply pipe communicating with the bottom of the space between the smoke box and lining, and a valve-controlled water feed pipe communicating with the top of the space between said smoke box and lining.

988,123. FURNACE. WILLIAM McCLAVE, OF SCRANTON, PA.

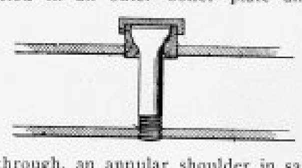
In a furnace formed with a fire chamber having a fuel opening, a



dead plate arranged in line with the bottom of the fuel opening, a row of fire bricks arranged along one edge of the dead plate, a plurality of expansion blocks arranged along one edge of said fire bricks, and a pivotally-mounted door arranged to have one edge rest on said expansion blocks when in a closed position.

987,431. STAY-BOLT FOR STEAM BOILERS. PATRICK J. CONNORS, OF GREENVILLE, PA.

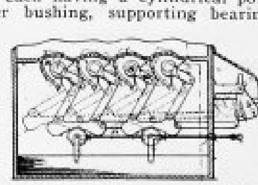
In combination with a stay-bolt having a threaded inner end and a head upon the other end thereof, said head having a rounded shouldered portion adjacent to the bolt and provided with a flat outer face, said flat outer face being further provided with a square central lug projecting therefrom whereby the bolt is screwed in place, said lug being adapted to be sheared off even with the flat face, of a removable bushing detachably fitted in an outer boiler plate and provided with a



passageway therethrough, an annular shoulder in said passageway forming with said bushing a socket to co-act with the rounded shoulder portion of the bolt head to form a ball and socket joint, said passageway curvedly flaring outwardly from said shoulder in opposite directions to the opposite ends of the bushing, said shoulder being positioned nearer the inner end of the bushing and substantially in the plane of the center of the outer boiler plate, and a flat closure cap fitting exteriorly upon the bushing and over and parallel to the top face of the head of the bolt and lying spaced from the flat face of the bolt when the cap is screwed down upon the bushing, and a side movement of the bolt being limited by the position of the cap upon said bushing.

987,945. GRATE. HENRY BENTON, OF ELIZABETH, N. J.

The combination with an angular grate-bar shaft, bushings for the ends of said shaft, each having a cylindrical portion and a stop at its end next the other bushing, supporting bearings for said bushings,



grate-bar sections on said shaft between said stop ends of the bushings, each comprising a hub and separable body portion, said sections being contiguous to each other and to said bushings, and removable members between said supporting bearings for the bushings and the said end stops of said bushings.

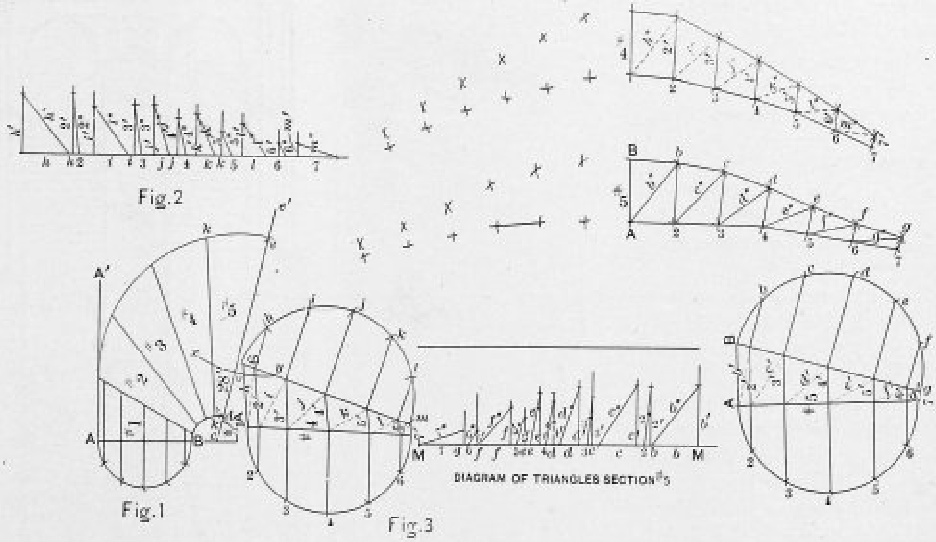
THE BOILER MAKER

JULY, 1911

PATTERN FOR SHIP'S VENTILATING COWL.

BY JOHN COOK.

To get out a cowl of this description, we start by drawing a base line and erecting a perpendicular line from point *A*, Fig. 1, extending it indefinitely. The diameter of the base, assuming it to be 14 inches, is marked off to the right of this line, establishing the point *B*. The radius of the throat is next determined by taking ¼ of the diameter of the base, or 3½ inches, which is marked off on the base line, to the right, from point *B* to point *c*. From *c* erect a line with an inclination, to the right, of 80 degrees. From the base line, with one point of the dividers on point *c* and the other at *B*, draw the throat line until it intersects the inclined line at point *d*. The mouth of the cowl is laid off on the inclined line and is found by taking twice the diameter of the base, which gives us 28 inches. With this distance from point *d*, we establish the point *e*. We are now ready to draw the outline of the back. We take a radius of one and one-half times the diameter of base, in this case 21 inches. With the trams set to 21 inches strike an arc from point *e*, and with the one point of trams on the perpendicular line, strike another arc, cutting the one made, establishing the point *o*. From this point draw out line of the back.



LAYOUT OF A SHIP'S VENTILATING COWL.

The throat lines are now divided into five equal spaces, and these points connected by lines as in Fig. 1, thus dividing the surface into 5 sections, each of which is developed by triangulation. The development of one or two sections will serve to show the method employed for all. To avoid confusion of lines, we will transfer No. 5 section, where *ABg7* represents the section. Bisect *Bg* and *A7* and, with these points as centers, draw a semicircle on each side which will represent a half-plan of each end of section. Divide these semicircles into a convenient number of spaces—in this case, 6. Project these points in the semi-circle by lines to *A7* and *Bg*. (It is best to letter the lines on *Bg* and figure the lines on *A7*.) Connect those points as shown; then draw the dotted lines connecting *A* with *b*, 2 with *c*, 3 with *d*, and so on until all the points have been connected.

Beginning with the line *Ab*, letter and number each line, as *b2'*, *c3'*, *d4'*, *e5'*, *f6'*, *g7*. At any convenient place draw a straight line as shown at diagram of triangles for section 5, and erect a line perpendicular to it. Take the length of dotted line *b'* and transfer it to the perpendicular line, as shown at *b'*. Likewise take the line *b* on semicircle and transfer it to base line, as shown at *b*. Connecting these two points, we have a right angle triangle, and the hypotenuse, or line *b"*, is the true length of *b'* in elevation. We now erect another perpendicular line and transfer the line marked 2. On it, as shown, take the length of the line 2 in plan of small end and transfer it to line *b* in plan of large end; take the difference in length of the two lines and mark it off on the base line from the intersection of the perpendicular line, as at 2*b*; connect the two points and we have another right angle triangle of which the line 2" is the true length of line 2' in elevation. This process is now repeated by erecting another perpendicular line and transferring the length of line *c'* to it, and taking the difference of lines 2 and *c* of plan and transferring it to base line as before. The points being connected, we have another right angle triangle, the hypotenuse or line *c"* being the true length of the dotted line *c'* in elevation; this process is repeated untill all the true lengths of the different triangles have been found, after which we are ready to proceed with the development of the pattern.

In any convenient place draw a line any length; on this line lay off the distance from *A* to *B* in elevation, this being the true length of the center line; next, with dividers, take the distance from *B* to *b* on large semicircle and strike arcs on each side of *B*; then, with trams set to the length of the hypotenuse that represents the true lengths *b'* in elevation as at *b''* of triangles, and with *A* as a center, intersect the arcs made from *B*; then, with *A* as a center and dividers set from *A* to 2 on small semicircle, scribe an arc and intersect it at 2, as shown on pattern. With trams set equal to the hypotenuse of the next triangle, and *B* as a center, scribe another arc, cutting the one made from *A*. This process is repeated until all the points are taken and true lengths are got. It will be understood none of the perpendicular lines on diagram of triangles are used except the end ones, as from *A* to *B* and 7 to *J* (Fig. 2). A line traced through these points gives us the development of the required pattern. This line is the rivet line; laps must be allowed and care taken that the divisions and centers are correct. The sections should be raised a little so as to form a true arc, gradually diminishing each side. A raising hammer is the best to use on this. If the cowl is made of galvanized steel the joints could be soldered after riveting; if made of black iron the rivets will have to be close together to make a good job. I have marked in sketch two sections, No. 4 and 5, with diagram of triangles for each.

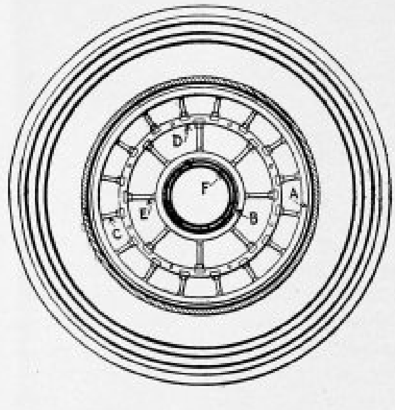
Novel Boiler Construction.

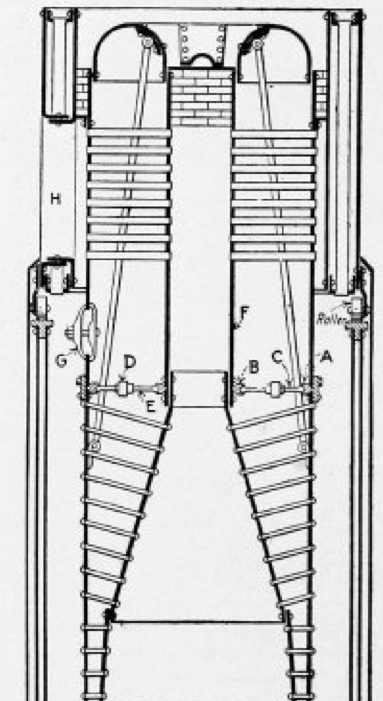
While visiting a small boiler shop, I was shown a boiler that had features which were extremely novel. The boiler was destined for a mountainous part of the country where fuel was scarce and dear, and where transportation of the boiler from place to place would be difficult.

The accompanying illustration shows a sectional view of the boiler, but is drawn from memory and from such description as was detailed to me, and, therefore, is to be considered as simply portraying the chief features and not as accurately setting forth the constructional details. The boiler can be divided into two sections, at the joints *A* and *B*. The lower half of the strap at *A* is riveted and calked in the usual manner, but the upper half is only bolted on and is not calked. The joint is made tight by means of a triangular-shaped cast iron ring, which fits accurately into the V-slot machined at the intersection of the two halves of the shell. The ring *A* is cut slightly larger than the inside diameter of the shell, like the packing ring of a steam piston.

Before being snapped into position a narrow strip of a flexible alloy is placed in the bottom of the groove. When in place the packing ring is evenly set out by the bolts *C*, bearings for which are furnished by the built-up wheel *D*. The inner ring *B* is set by the bolts *E*, and the band *F* is riveted on to complete the joint at this juncture. The ends of the setting-out bolts are upset and rounded to fit into recesses in the packing ring to allow flexibility in case of unequal expansion of the inner and outer shells. Details of the bolts, wheel and packing rings are shown in the plan view. Some of the braces of the upper half connect below the joint to the shell of the lower half. On some of these braces are turnbuckles of a special make, which are used to raise the upper half clear of the other when dismantling the boiler. The two halves of the shell are guided to a correct position by two keys (not shown). Access to the interior of the boiler is obtained through a manhole, the position of which is shown at *G*.

As this boiler had to be operated under economical conditions it was necessary to have a large heating surface proportionate to the grate surface, which was difficult to provide without making the boiler too bulky. The designer, however, hit upon the plan of using a one-tube economizer for heating the feed-water. By this means the waste gases are utilized to a certain extent, but the heating surface of the boiler is materially increased by compelling the gases to return along the outer shell before entering the economizer. But the economizer so covers the boiler tubes as to prevent access for





SECTIONAL VIEW OF NOVEL BOILER.

cleaning them. To offset this the economizer was set on rollers, and a long but narrow door *H* cut in it. By disconnecting two unions, one on the feed-water inlet and one on the outlet, the economizer can be revolved entirely around the boiler, thus bringing the door opposite each row of tubes. The economizer is set on a framework of T and angle-iron, around which is a covering of sheet iron.

The more one studies the design of this boiler the more he recognizes the ease with which it can be thoroughly cleaned and repaired.

While this boiler may be expected to operate with a fair degree of economy, considering its type, there are several doubtful elements in the construction which the reader will doubtless perceive.—R. O. RICHARDS in *Power*.

Solving a Right Angle Triangle Graphically—Relationship of the Four Factors and Easy Method of Solving Problems in Trigonometry—Examples. *

A right-angle triangle consists of four factors—base, altitude, hypotenuse and angle. The accompanying diagram shows at a glance the relationship of these factors and affords a method of solving problems in trigonometry without the use of mathematics.

The following problems, represented by the heavy dotted lines, will illustrate how this is done:

Problem 1. The base of a right-angle triangle is 5.7, the angle is 33 degrees; what is the altitude and hypotenuse?

Solution: Start from 5.7 on the "base" scale, thence vertically up to line representing 33 degrees, thence horizontally right to 3.7 "Altitude." Or from the same point, up, parallel to the curved guide lines to 6.8 "Hypotenuse."

Problem 2. The hypotenuse of a right-angle triangle is 6.8, the angle is 33 degrees; what is the base and altitude?

Solution: Start from 6.8 on the "Hypotenuse" scale, thence down parallel to the curved guide lines, to line representing 33 degrees, thence vertically down to 5.7 "Base." Then on from the same point, horizontally, right to 3.7 "Altitude."

but greater accuracy can be had when the outside scales are used.

For extreme sizes, large or small, the decimal can be moved either way, but must be moved an equal number of points in each scale.

Problem 4. The base is 285, the angle is 33 degrees; what is the altitude and hypotenuse?

Solution: Move the decimal two points to the left and start from 2.85 on outside "Base" scale, thence vertically up to line representing 33 degrees, thence horizontally right to 1.85 on

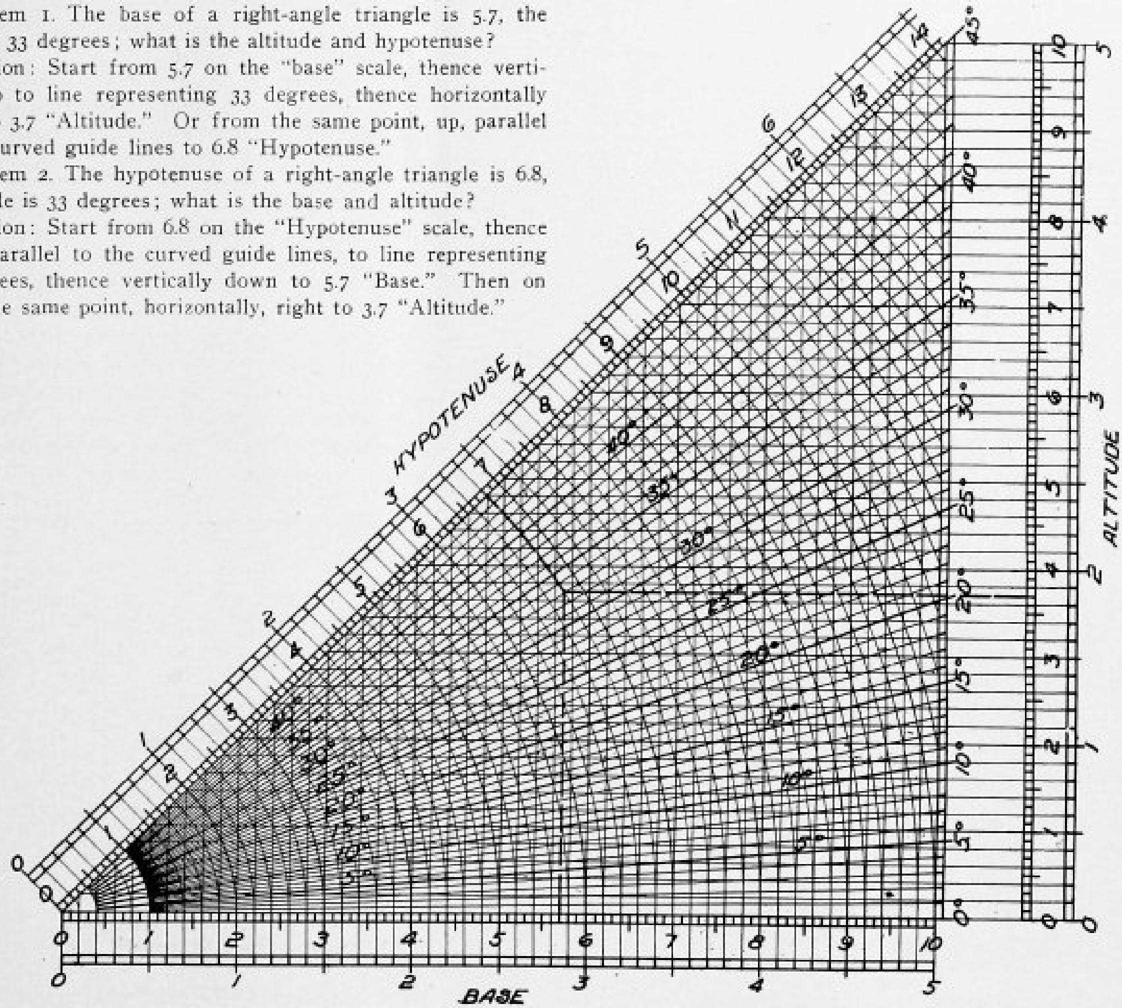


DIAGRAM FOR GRAPHICAL SOLUTION OF PROBLEMS IN TRIGONOMETRY.

Problem 3. The hypotenuse is 6.8, the altitude is 3.7; what is the angle and base?

Solution: Start from 6.8 on the "Hypotenuse" scale, thence down parallel to the curved guide lines to a point, horizontally, left from 3.7 on the "Altitude" scale, which point is on line representing 33 degrees angle, thence vertically down to 5.7 "Base."

Either set of scales can be used, the idea being to use whichever set throws the work farther from the five sub-divisions of the lower left angle.

Problem 4. The base is 2.85, the angle is 33 degrees; what is the altitude and hypotenuse?

Solution: Start from 2.85 on the outside "Base" scale. thence vertically up to line representing 33 degrees, thence horizontally right to 1.85 on the outside "Altitude" scale, thence up parallel to the curved guide lines to 3.4 on the outside "Hypotenuse" scale.

This problem could have been solved on the inside scales,

* By F. S. Beckett in *The National Engineers.*

the outside "Altitude" scale. Move the decimal two points to the right, back to the original position, which gives the correct answer—185 altitude.

From the same point, thence up, parallel to the curved guide lines to 3.4 on the outside "Hypotenuse" scale. Move the decimal two points to the right back to the original position, which gives the correct answer—340 hypotenuse.

Boiler Manufacturers' Convention.

Boiler manufacturers should note that the annual convention of the American Boiler Manufacturers' Association will be held at the Hotel Brunswick, Boston, Mass., July 10, 11, 12 and 13, 1911. The proceedings of this association have always proved of great interest to those concerned in boiler design and construction, and the attendance of all members is earnestly urged at this meeting in order to maintain the high standard of the work of this association.

Development of a Frustum of a Right Cone When the Apex is Unattainable.

BY I. J. HADDON.

Draw the lines *X Y* and *A a* at right angles to each other, with *B* as center and radius equal to half the diameter of the base, describe the semi-circle and divide it into six equal parts, as shown.

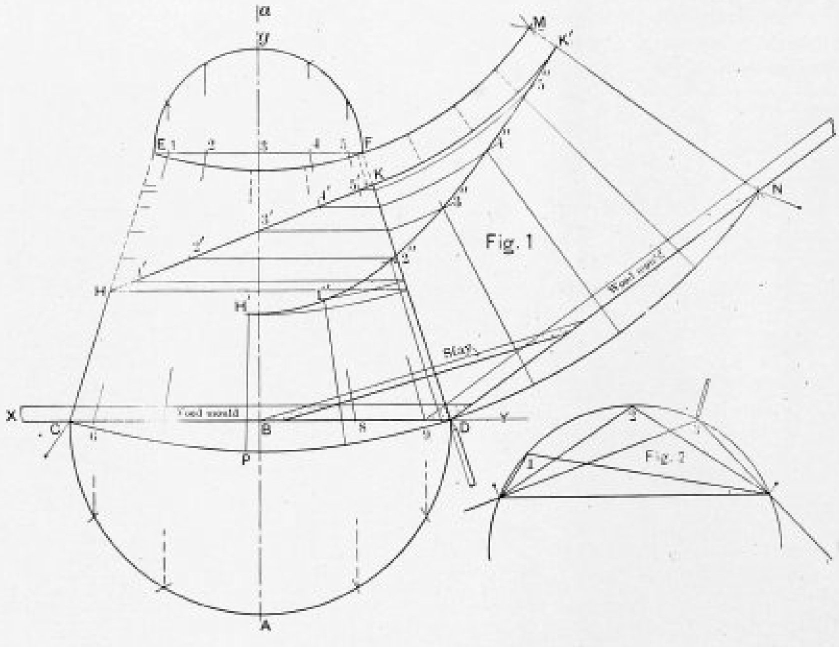
Draw the line *E F* parallel to *C D* at any convenient distance above where the frustum is to be cut off, at an angle; then with 3 as center and radius equal to half the diameter of the top of the frustum, describe the semi-circle *E g F*, and divide it into six equal parts, as shown; join *E C* and *F D*. From the points obtained on the semi-circles drop perpendiculars to the lines *E F* and *C D*, as shown in 1, 2, 3, 4, 5 and 6, 7, *B*, 8, 9. Draw the line *H K* at the angle required. Draw lines from 1 to 6, 2 to 7, 4 to 8 and 5 to 9, crossing the *H K* in 1', 2', 3', 4' and 5'. Draw lines through *H*, 1', 2', 3', 4', 5', *K* parallel to *C D* until they cut the lines *E C* and *F D*, as shown.

With *D* as center and radius *D E* draw the arc *M*, and with *F* as center and radius *F E* cut the arc in *M*. With *F* as center and radius *F C* draw the arc *N*, and with *D* as center and radius *D C* cut the arc in *N*. Join *N M*.

Make a wood mould as shown, allowing one edge to touch the line *C D*, and the other edge to touch *D N*; each piece should be made long enough to reach from *C* to *N* in a straight line; put a stay on these, as shown, to keep the angle at *D* rigid. If a pin or any convenient article is held at *N* and *C*, as shown, and the mould is moved along from *D* to *N* and *D* to *C*, but touching the pins at *N* and *C* at all times, a pencil held at the point *D* would describe a curve, just as if it were drawn with radius equal to the apex of the cone, irrespective of whatever distance that may be.

Place the point *D* of the mould onto the point *F*, and let the two sides of the mould touch the points *E* and *M*, and if pins were held at *E* and *M* the arc *E F M* may be described in a similar manner. Having done so much, calculate the circumference of the top and bottom of the frustum by multiplying the diameters by 3.1416, then measure around from *N* towards *C* and *M* towards *E* one-half their respective circumferences, and divide each half into six equal parts, and connect them by lines as shown; these will then be rolling lines. Put the mould with the point *D* onto the marks already obtained on the line *D F*, and allow one side of the mould to touch the mark that was drawn parallel to *C D* on the line *E C*, and the other side to cross the line *M N*; hold a pin on the line *E C* and another on the line *M N*, and draw curves as shown, cutting the rolling lines in *H'*, 1", 2", 3", 4", 5" and *K'*. Connect *H' P*, and draw a fair curve, by using a thin lath, through *H'* to *K'* as shown, then *P*, *H'*, *K'*, *N* will complete one-half of the development. To obtain the development of the other half hardly needs any explanation, it is so simple, being the same as already obtained.

To prove the accuracy of this problem I would refer the reader to Fig. 2, also to Euclid's proposition 21, book 3, where he says "The angles in the same segment of a circle are equal to one another." Therefore the angles 1, 2, 3, Fig. 2, are all equal.



LAYOUT OF THE FRUSTUM OF A RIGHT CONE.

Abuse of Plate in Boiler Shops.

There was a very exhaustive discussion several years ago about the danger of flanging or working on steel when it was at the brittle temperature, and so much was said and written on the subject at the time, together with the notice taken by the Railway Master Mechanics' Association, that it was supposed all railroad boiler makers had stopped the practice. Repeated observations since that time, however, convince us that foreman boiler makers are not even aware that there is any particular danger in working steel at its brittle temperature, or even that there exists a brittle temperature.

While it is not expected that working boiler makers should know the science of their business, the foreman certainly ought to know that hammering a sheet when it is at a brittle temperature is sure to produce bad effects and ought not to be permitted. This also recalls the fact that hand flanging of boiler sheets is not by any means obsolete. More than one road now prominently in mind is absolutely devoid of a flanging press, and doing practically all of its heavy boiler repair work without outside assistance. There is not much room for dispute in the assertion that when this work is done in a hydraulic press the operations are so quickly performed that the sheet is in no danger of falling below the proper temperature. If a railroad company cannot afford to purchase a suitable press, those in charge should have their flanging done in a shop equipped with modern boiler-making appliances.

It at times occurs to us that master mechanics and general foremen might watch the rough practices of the boiler shop to rather more advantage than they do. One of the immediate resultant effects would be a decreased number of boilers with cracked sheets. The fact is, however, that the demand for hurried output of work is responsible for a great deal of the inferior boiler-making practices which cause so much trouble and annoyance to the men handling and caring for locomotives.—*American Engineer and Railroad Journal.*

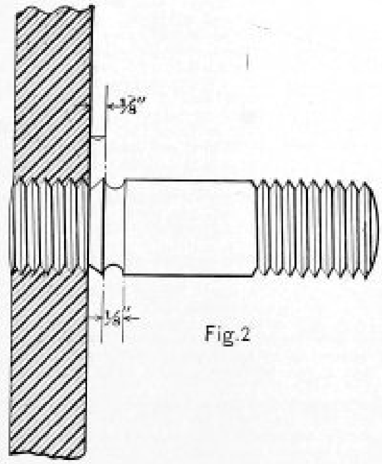
STANDARD PRACTICES.

BY C. E. LESTER.

It is expected at all times in boiler shop work, as well as in every other line of work, that a foreman has good judgment and will exercise it, but the terms, "It was good practice, in my opinion," and "I thought I used good judgment," have made all sorts of standards, or, rather, no standard method of doing work at many plants.

Men of action have ideas and will exercise them where there are no authorized standards to follow. Recognizing this very human characteristic, the general mechanical officers of railroads, as well as industrial plant officials, have adopted standards to eliminate a variety of practices to the greatest extent possible.

These standards are, of course, not adopted without a full consideration of all the good or objectionable features involved. The railroad company with which I am connected is adopting standard practices in the mechanical department wherever feasible, and before any practice is made standard sample practice cards are made up in the office of the mechanical engineer and submitted to the different department heads for comments and criticisms. After all replies are in



DIAMETER AT GROOVE	
25-64 for	1-2" Stud
31-64 for	5-8" Stud
19-32 for	3-4" Stud
21-32 for	7-8" Stud
25-32 for	1" Stud
59-64 for	1 1-8" Stud
1 1-32 for	1 1-4" Stud

STUDS.

they are carefully scrutinized, and the new standard practice is made up to embody the greatest number of good points and eliminate, if possible, all of the objectionable ones. When these practices are put into effect there is no excuse for a foreman or a workman to do work according to his own ideas and in conflict with adopted standards.

The following are a few standard practices adopted: Previous to their adoption every shop on the system had their own standards, and there was a considerable variety, and at some points practices recognized as an almost absolute necessity were never in force.

BOILERS CLEANED.

No. 1. All boilers must be thoroughly scaled and washed before applying flues.
When boilers are placed in shop for new fire-box or other heavy repairs, necessitating the removal of the lagging, it is required that they be thoroughly cleaned and given a coat of Freight Car Paint No. 5 on the outside after work is completed.

This practice will be recognized as a good one to retard deterioration of the exterior of the boilers, and to keep the physical and thermal efficiency of the boiler normal by scaling and locating possible defects underneath the scale.

STANDARD PRACTICE: FIREBOX STUDS.

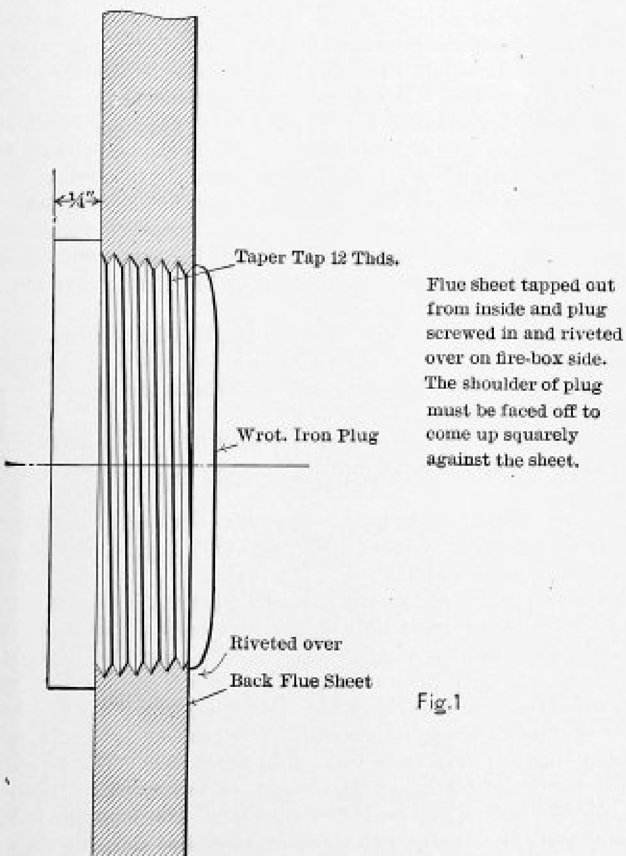
No. 2. When locomotives pass through the shop for T. B. M. F. repairs, all studs inside of fire-boxes, screwing through sheets into the water space, must be renewed.
Studs screwed into locomotive boiler plates, including fire-box studs mentioned above, must be provided with weakening grooves, located ⅛ in. distant from exterior surface of boiler shell. (Fig. 2.)

The necessity of using studs in fireboxes is deplored, but their use in many boilers is made necessary by the design. Studs are made with a weakening groove to cause a stud to break in preference to pulling out of the sheet.

STANDARD PRACTICE: PLUGS.

No. 3. No plugs shall be applied to any fire-box sheets larger than ¾-in. diameter unless applied in accordance with standard print. No boiler will be accepted having a plug, or plugs, in fire-box sheets not in accordance with above. (Fig. 1.)

It is common practice on some roads to plug flue holes from the fire side, and to apply plugs of all kinds and sizes to other cracks and defects in fireboxes, seemingly without a thought of efficiency and resultant liability to loss of life and other damage should the plugs blow out. The above practice is, in my opinion, one of the best practices it has ever been my pleasure of assisting to enforce.



FIREBOX PLUGS.

STANDARD PRACTICE: PUNCHING BOILER AND FIREBOX PLATES.

No. 4. All holes punched in boiler and fire-box plates should be punched 1-16-in. small and reamed to size after sheets are properly bolted together.

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

TESTING ALL RESERVOIRS ON LOCOMOTIVES IN CONNECTION WITH AIR BRAKE EQUIPMENT.

No. 5. In order to insure the impossibility of air reservoirs exploding in service, they must all be removed whenever the locomotives pass through the shops for T. B. M. F. repairs and subjected to a hydraulic test, to a pressure 25 per cent. greater than each will carry in service.

A main reservoir, on a locomotive equipped with high-speed brakes, is subjected to a pressure of 130 lbs. per square inch, and should be given a test pressure of 163 lbs. per square inch. Main reservoirs on freight engines carry 110 lbs. per square inch and should be given a test of 138 lbs. per square inch.

Main reservoirs on passenger and freight engines that carry 100 lbs. per square inch should be given a test of 125 lbs. per square inch.

Main reservoirs carrying 90 lbs. per square inch should be given a test of 113 lbs. per square inch.

Auxiliary reservoirs on engines equipped with high-speed brakes carry 110 lbs. and should be given a test of 138 lbs. per square inch.

Auxiliary reservoirs carrying 70 lbs. per square inch should be given a test of 88 lbs. per square inch.

Equalizing reservoirs on high-speed brake engines should be given a test of 138 lbs. per square inch.

Reservoirs in connection with the Economy Steam Heat Apparatus must be given a test of 100 lbs. per square inch.

Each reservoir shall be stenciled with the pressure at which it is tested and shop at which test was made. Stenciling shall be done with white lead, the figures and letters to be 1 in. high. All stenciling shall be placed in such position that it can be readily read when reservoir is on the engine.

After hydraulic test has been applied make a hammer test as follows: Use a standard machinist's ball pein hammer, paying particular attention to the bottom, where the moisture naturally collects, and if tests develop any indentation drill a 19/32-in. hole, in order that the thickness of sheet may be ascertained. If it is found to be less than 5/32 in. at any point reservoir must be taken from service. In event of reservoirs being suitable for service hole should be tapped and 3/8-in. pipe plug applied.

Those who consider this practice from an impartial viewpoint will recognize its necessity for the proper protection of employees and the traveling public.

BOILER MOUNTINGS AND FITTINGS.

BY JOHN CREEN.*

It is very necessary for the efficient working and operation of steam boilers that their mountings and fittings, as, for instance, the smoke-box, up-takes, funnel, safety valves, feed pipes and valves, steam and water gages, scum blow-off cocks, etc., etc., should be properly fixed, fitted and proportioned to the duties they have to perform.

The smoke-box is that part of a boiler which is fitted to conduct the products of combustion as they emerge from the tubes through the "up-takes" into the funnel. In the old box-form of boiler it was built inside, and formed an integral part of the boiler; but with the modern cylindrical boiler it is a separate structure, secured to the boiler front by studs. It is constructed of iron or steel plates and angles, and made "smoke-tight"; it should, however, be calked if necessary to prevent air being drawn to the inside. In front of the tubes are a number of doors hung on hinges, and so arranged that every tube may be swept or removed in case of necessity. The doors should be of such a size as to be easily handled, and when the nests of tubes are so large as to cause the door to be too ponderous if made in one, two may be fitted. These doors may be arranged to open on a vertical or horizontal axis, but the former is preferable when possible, as they are then more easily handled. The bottom of the smoke-box should be at least 12 inches wides, measured in direction of the length of the boiler, and when possible as much as 16 inches. If too narrow it is soon filled with soot and ashes, covering the ends of and rendering useless the bottom rows of tubes, as well as the baffle-plates on the inside of the doors. The bottom plate should be at least 2 inches below the bottom row of tubes, and the side plate the same distance from the side tubes, so that the tubes may be drawn clear of the 2-inch angle-iron rim around the doorways. The front of the smoke-box is sloped outwards, so as to be about twice the breadth of the bottom, from the boiler front, above the level of the top row of tubes; above this the smoke-box contracts towards the funnel base, and its configuration must depend on the position of this, and on the consideration that the section transverse to the flow of gases must have an area at least equal to the area through the tubes. The part between the smoke-box and funnel, or "up-take," as it is termed, should have easy bends, and lead as directly as possible to the funnel without recesses or obstacles where the draft may be baffled or checked. The bottom and sides of the smoke-box and up-take should be of 1/4-inch plates for large boilers, but 3/16 will be sufficient for smaller ones, or where weight is a consideration. The smoke-box doors should be of the same thickness, and have baffle-plates 1/8 inch thick on the inside, with air or screen plates of the same thickness outside. These screen plates prevent radiation of the heat, and for the same purpose the sides of the smoke-box and up-take are also so fitted.

To protect the boiler front, which has only steam on its inner surface, the up-take should have a back commencing from just above the level of the top row of tubes. When this cannot be done a good and well-fitting baffle-plate should be fixed to the boiler front. A casing should be fitted around the funnel from its base to the level of the deck casing, to prevent radiation; a corresponding casing is fitted round the funnel above the level of the deck coamings to a convenient height, and over this a "hood" or "bonnet," secured to the funnel, so as to prevent water passing down while allowing the hot air to come out. When there are several boilers discharging into one funnel, each smoke-box should have a separate up-take, so that the smoke from one does not enter the box of another. A damper should be fitted in each of these up-takes to regulate the draft and give a uniform evaporation in all the boilers, and in case of necessity to isolate a particular boiler. The funnel is usually of circular section, but sometimes, to minimize the transverse size of the boiler hatch, it is made an oval section. The best height to look well is four to five diameters above the taffrail; the latter, when there are high bridges or boats, in wake of the funnel. For the same reason, the ring for the shrouds should be nine-tenths the diameter from the top. Funnels are made of ship quality plates, lap-jointed, or butt-jointed, with single straps inside; the latter costs more, but when so made are more durable.

The funnel plates should, for strength, be thicker at the base than at the top, but the top plates wear out faster than those at the bottom. The following may be taken as the approximate thickness of funnel plates:

Top plates = 0.1 inch + 0.025 for each foot of diameter.

Middle plates = 0.125 inch + 0.025 for each foot of diameter.

Bottom plates = 0.15 inch + 0.025 for each foot of diameter.

If the funnel is stiffened with angle or T bars it may be of somewhat thinner plates.

Furnace fronts and doors, although often made of cast iron, are much better made of wrought iron or steel, as they can better withstand the rough usuage to which they are exposed. It is mainly from this cause that most of the improved doors which have been tried have been finally rejected; and because of this rough usage all attempts at refinement in the fittings meet with but indifferent success on board ship. The smaller the doors the better, as when open an excess of air passes into the furnace and lowers its efficiency. On the other hand they must be large enough to stoke, work and clean the fires; a long grate requires a larger door than does a short one. Furnaces above 42 inches diameter should have a pair of doors, to be used alternately; the amount of opening when stoking or cleaning a fire is thereby reduced, and the sides of the grate

* Mr. Creen's article refers to marine boilers, and the United States inspectors are very strict in carrying out our Government laws. Copies of these laws can be had by applying to the Steamboat Inspection Service Washington, D. C.

are better attended to. The doors should be so arranged as to remain open in a seaway. This may be effected by making a projection and a corresponding recess in the hinges. A star damper should also be fitted to the fire-door, so that when open a supply of air is admitted to the fires. The baffle-plate inside the doors should have a number of small perforations to distribute the extra supply of air.

The length of grate should never exceed twice the diameter of the furnace, as the fires cannot be properly worked when this is exceeded. To get the highest efficiency of grate it should not be more than one and one-half times the diameter. The slope of the grate should be 1 inch to the foot, which may be increased in furnaces over 42 inches in diameter to 1½ inches with advantage. If the grate is over 5 feet long there is generally some difficulty in properly stoking the back end, and it is only a good fireman who can properly work the fire on a long grate. The increased slope materially helps to overcome this difficulty, and at the same time the fire is better supplied with air at the back, and is not choked by the products of combustion from the front.

The bridge or brick barrier at the end of the grate should be built to such a height that the area of passage over it is not less than one-eighth nor more than one-sixth the grate area, and when possible the distance from the top of the bridge to the top of the furnace should be sufficient for a man to pass into the combustion chamber. When anthracite or other similar coal is to be burnt on the grate there should be no space between the bars and the sides of the furnace; when the furnaces are corrugated these side bars should be made to fit into the corrugations. The fire-bars are usually in two lengths, but the grate is more efficient when they are in one, as the bearer is avoided, which baffles the free flow of air to the fire above it, and prevents the fireman from "pricking" effectively. Cast iron fire-bars to burn bituminous coal may be 5 feet 6 inches long, but if the coal contains much sulphur they are safer in two lengths. Fire-bars are made from 1 to 1½ inches broad on the face; the former is better when the bars are not very long, and when of wrought iron may be with advantage even ⅞ inch wide; the usual breadth, however, is 1¼ inches in the mercantile marine. The depth of the bar at the middle depends on the length, and should be:

$$= 0.6 \sqrt{\text{length}} \text{ when of cast iron,}$$

$$\text{and } = 0.5 \sqrt{\text{length}} \text{ when of wrought iron.}$$

The thickness at the bottom should be one-third the breadth of the face, and should taper to two-thirds beneath the flange.

For burning bituminous coal there should be a space of ½ inch at least between the bars, and when it cakes quickly there may be as much as three-fourths of an inch, but if good steam coal or anthracite is to be burnt there should never be more than ½-inch spaces, and with narrow bars the space may be advantageously less.

The main stop-valve should be of sufficient size to pass out all the steam the boiler is capable of making with little resistance; loss of pressure in the cylinders is often due to this valve being only partially open; on the other hand, when cylinders are large, and the strokes of the piston comparatively slow, priming may be effectively checked by partially closing the stop valves, so that there is no sudden withdrawal of steam. The diameter of the stop valve is generally settled by considering the size of the main steam pipe at the engines.

Let D be the diameter of the main steam pipe and n the number of boilers (at least two), then diameter of branch pipe

$$\text{to each boiler} = D \sqrt{\frac{4}{3n}}.$$

The area of pipe section to suit a boiler may be found by the following rule:

$$(0.25 \text{ square in per square foot of grate} + 0.01 \text{ square inch per square foot of total heating surface}) \times \sqrt{\frac{100}{\text{pressure}}}.$$

The diameter of the stop valves should be such that the clear area past it is not less than those given by the above rules.

$$\text{The diameter of spindle} = \frac{\text{diam. of valve}}{50} \times \sqrt{\text{pressure}} + \tfrac{1}{8} \text{ inch.}$$

The valve and seat should be of gunmetal or bronze, and should be both hard and strong. The valve should have the boiler pressure always on the side opposite the spindle, so that it helps to open it; the spindle should have a square thread, and when possible the screwed part should be outside, so that in opening or shutting the valve the spindle does not turn round. As the full pressure is on the valve when shut, the bridge, etc., should be strong enough to withstand it; the seat when fitted with wings for the guide to the spindle should be carefully secured and the wings curved, so that when expanding with the heat the seat is not distorted. These seats when fitted into cast iron are very apt to get loose and leak from the permanent set of the metal, induced by the resistance of the cast iron to the expansion of the brass.

The safety valve is for the purpose of providing a safe and self-acting means of relieving the boiler of excessive pressure. A good safety valve should be: (1) Large enough in diameter and have sufficient lift to allow the steam to escape as fast as it is generated, when the pressure is slightly above that to which the valve is loaded; (2) it should be so made that it closes as soon as the pressure has dropped below the load; (3) it should be free to open and shut, so that it may always act efficiently and promptly; (4) it should be so enclosed that it cannot be tampered with or accidentally interfered with by pieces of coal falling into it; (5) for marine purposes it must be so constructed as not to be effected by the motion of the ship. It is unnecessary to deal with weight-loaded valves, as none are now used; the fifth condition being met by means of steel springs for the load. When weights were used the amount of lift given to the valve by the steam pressure was very small, and since the lifting of the valve compresses the spring and increases the load the spring-loaded valve opens less; this being so, area of opening can only be obtained by increasing the diameter of the valve. Many ingenious methods for increasing the lift have been tried, but all those involving the use of special mechanism have given place to those that do without it. The most successful and probably the best-known of the latter is the one generally called Adam's valve.* This valve consists essentially of an ordinary mushroom valve with a secondary outer rim of inverted **U** section, which overlaps the rim of the seat, so that there is a second contracted orifice at the outer edge of this rim. As soon as the valve opens the steam fills the outer rim, and the valve is then virtually of larger area; the load on it is so suddenly increased that the valve lifts wide open immediately, and will continue to vibrate with the spring until the pressure falls. The second condition is best fulfilled when the valve can be made to dance over its seat from the vibration of the spring. The third can only be satisfied by making every movable part a very easy and, in most cases, a very slack fit. To prevent the valve from being injured by accident or design, it should be enclosed in a case, and the authorities require that such cases shall be locked up and the key kept by the captain of the ship.

The size of the safety valve depends on the volume of steam which can be generated by the boiler in a given time, and that

* In the United States this style of valve is known as "Pop Valves," and are made by many manufacturers, among them the Ashton Valve Company, Lunkenheimer Company, Wm. Powell Company, Jos. T. Ryerson & Son, Star Brass Manufacturing Company.

depends upon the weight of fuel it can consume on its efficiency and on the working pressure. In boilers made on the same general design and for the same pressure this volume of steam varies with the grate area. Strictly speaking, any rule for the safety valve should fix the amount of circumference rather than area, and considerable allowance should be made for the load pressure, as for the same weight of steam the volume varies inversely as the pressure. The following are the rules for the size of valve:

1. To satisfy the Board of Trade, when the working pressure is 60 pounds per square inch, there must be valve area equal to half a square inch for each square foot of grate area, except in the case of boilers having less than 14 square feet of grate there must be two valves to each boiler, so that for ordinary boilers diameter of each safety valve

$$= \sqrt{\frac{\text{area of grate}}{452}}.$$

The area of grate is here in square inches, since the diameter is required in square inches.

Lloyds lay down a similar rule, but allow special valves of any size, so long as they are satisfactory when tested. The French government rule is based on the amount of heating surface contained in a boiler, and this perhaps is the truest gage of a boiler's capacity, as it bears a constant relation to the amount of coal consumed; allowance is also made for the steam pressure. The diameter is here given in inches, the heating surface in square feet and the pressure in pounds per square inch. Diameter of valve (if only one)

$$1.23 = \sqrt{\frac{\text{total heating surface}}{\text{pressure} + 9}}.$$

The German government rule also makes allowance for the steam pressure, and is as follows:

To have a clear area of valve, or valves, after deducting for the wings or other obstacles at the rate of so many square "lines" (*N. B.*, 144 lines = 1 square inch) for each square foot of total heating surface, in accordance with the following table:

Working pressure in atmospheres..	0 to 0.5	0.5 to 1	1 to 1.5	1.5 to 2	2 to 2.5
Number of square lines per foot of surface	10	7	5.3	4.3	3.6
Working pressure in atmospheres..	2.5 to 3	3 to 3.5	3.5 to 4	4 to 4.5	4.5 to 5
Number of square lines per foot of surface	3.2	2.8	2.5	2.2	2.0

An improved rule, which is simple and easily used, is: Area of each two valves = 0.05 square inch per square foot of grate + 0.005 square inch per square foot of total heating surface,

$$\times \sqrt{\frac{100}{\text{pressure}}}.$$

The miter on a safety valve seat should not be more than one-sixteenth inch broad, except for very large valves, and the bearing area in any case need not exceed that necessary for a pressure of 1,200 pounds per square inch on it, when there is no steam pressure on the valve, hence breadth of miter = diameter

$$\text{of valve} \times \frac{\text{working pressure}}{4800}.$$

The ordinary rule for the size of steel for the spring is:

$$d = \sqrt{\frac{S \times D}{C}}.$$

S is the total load on the valve; D the diameter of coil, measured from center to center of wire in inches; d is the diameter of round wire and the side of square section wire; C is 8,000 when the coil is made of round section steel, and 11,000 when of square section.

It is a reprehensible practice to have a length of pipe between the boilers and the safety valve; the valve should be placed directly on the shell of the boiler, and the neck, or part between the body and the flange which is bolted on to the boiler, should be as short as possible and be cast in one with the chest. The area of safety valves per square foot of fire-grate surface should not be less than that given in the following tables, opposite the boiler pressure intended, but in no case should the valves be less than 2 inches in diameter. When, however, the valves are of the common description, and are made in accordance with the tables, it will be necessary to fit them with springs having great elasticity, or to provide other means to keep the accumulation within moderate limits; and as boilers with forced draft may require valves considerably larger than those found by the tables, the design of the valves proposed for such boilers, together with the estimated coal consumption per square foot of fire-grate, should be carefully considered. In ascertaining the fire-grate area the length of the grate should be measured from the inner edge of the dead plate to the front of the bridge, and the width from side to side of the furnace on the top of the bars at the middle of their length:

SAFETY VALVE AREAS.

BOILER PRESSURE.	Area of Valve Per Square Foot of Fire-Grate.	BOILER PRESSURE.	Area of Valve Per Square Foot of Fire-Grate.	BOILER PRESSURE.	Area of Valve Per Square Foot of Fire-Grate.
Pounds	Sq. Inches	Pounds	Sq. Inches	Pounds	Sq. Inches
15	1.250	77	.407	139	.243
16	1.209	78	.403	140	.241
17	1.171	79	.398	141	.240
18	1.136	80	.394	142	.238
19	1.102	81	.390	143	.237
20	1.071	82	.386	144	.235
21	1.041	83	.382	145	.234
22	1.013	84	.378	146	.232
23	.986	85	.375	147	.231
24	.961	86	.371	148	.230
25	.937	87	.367	149	.228
26	.914	88	.364	150	.227
27	.892	89	.360	151	.225
28	.872	90	.357	152	.224
29	.852	91	.353	153	.223
30	.833	92	.350	154	.221
31	.815	93	.347	155	.220
32	.797	94	.344	156	.219
33	.781	95	.340	157	.218
34	.765	96	.337	158	.216
35	.750	97	.334	159	.215
36	.735	98	.331	160	.214
37	.721	99	.328	161	.213
38	.707	100	.326	162	.211
39	.694	101	.323	163	.210
40	.681	102	.320	164	.209
41	.669	103	.317	165	.208
42	.657	104	.315	166	.207
43	.646	105	.312	167	.206
44	.635	106	.309	168	.204
45	.625	107	.307	169	.203
46	.614	108	.304	170	.202
47	.604	109	.302	171	.201
48	.595	110	.300	172	.200
49	.585	111	.297	173	.199
50	.576	112	.295	174	.198
51	.568	113	.292	175	.197
52	.559	114	.290	176	.198
53	.551	115	.288	175	.195
54	.543	116	.286	176	.194
55	.535	117	.284	177	.193
56	.528	118	.281	178	.192
57	.520	119	.279	179	.191
58	.513	120	.277	180	.191
59	.506	121	.275	181	.190
60	.500	122	.273	182	.190
61	.493	123	.271	183	.189
62	.487	124	.269	184	.188
63	.480	125	.267	185	.187
64	.474	126	.265	186	.186
65	.468	127	.264	187	.185
66	.462	128	.262	188	.184
67	.457	129	.260	189	.183
68	.451	130	.258	190	.182
69	.446	131	.256	191	.181
70	.441	132	.255	192	.181
71	.436	133	.253	193	.180
72	.431	134	.251	194	.179
73	.426	135	.250	195	.178
74	.421	136	.248	196	.177
75	.416	137	.246	197	.176
76	.412	138	.245	198	.176

The safety valves should also be fitted with lifting or easing gear, so arranged that the two or more valves on any one boiler can at all times be eased together without interfering with the valves or any other boiler. The lifting gear should in all cases be arranged so that it can be worked by hand, either from the engine-room or stokehold. The safety valves should have a lift equal to at least one-fourth their diameter; and the openings for the passage of steam to and from the valves, including the waste steam pipe, should each have an area not less than the area of the valve itself; each valve body should also have a drain pipe fitted to its lowest part. Too much care cannot be devoted to seing that there is proper lift and free means of escape of waste steam, as it is obvious that unless the lift and means of escape of waste steam are ample the effect is the same as reducing the area of the valve or putting on an extra load. The valve seats should be secured by studs and nuts.*

Internal pipes should be fitted from the stop valves to the highest part of the boiler, and be made with holes or slits, whose collective area is equal to twice the area of section of the pipe. The chief object of this pipe is to collect the steam gently from every part of the boiler, so as to avoid setting up a strong current in one particular direction and thereby induce priming. These pipes are usually made of brass, but some engineers prefer copper, and others make them of cast iron, to avoid risk of galvanic action and to reduce the cost. By fitting an internal pipe the stop valve can be placed in a position convenient for working and examination; it should always be so situated as to be easy of access at all times. Arrangements should also be made for opening and shutting it without going into a difficult or dangerous position. This can always be effected by lengthening the spindles or fitting chain gear. In the mercantile marine the stop and safety valve bodies are almost invariably made of cast iron, the valves, seats and spindles being of gunmetal. But in most navies all boiler mountings are required to be made of gunmetal, and cast iron is not allowed to be used.

Each boiler should be fitted with a self-acting non-return or check valve, through which the feed-water is pumped. It should also have a screw spindle, which may be used to regulate the lift or to shut it down when water is not required. There should also be a similar valve through which the donkey pump can discharge water into the boiler; this is termed the auxiliary feed valve.

These valves are generally of mushroom shape and made similar to the ordinary stop valve, except that it is detached from the spindle. It is made wholly of gunmetal, and should be very strong, as at times the pressure upon it may be excessive and the wear and tear is very considerable.

There should be 6 square inches of clear area through the valve and pipe for every hundred pounds of water evaporated, or put in a more convenient form, area through main feed valve in square inches = total heating surface in square feet ÷ 240, and area through donkey feed valve in square inches = total heating surface in square feet ÷ 300. As the feed valves cannot always be placed on that part of the boiler best suited to receive the feed-water, and also in order to distribute that water so as to avoid its affecting the boiler plates, an internal pipe should always be fitted. To avoid the necessity of blowing the boiler down in case of accident to the feed valves, it is a very common practice to fit these valves high up on the boiler, in many cases above the water level. This plan also has the advantage of providing a means of warming the feed-water, and nothing is more essential to the preservation of the boiler. The heating is effected by the passage of the water through a long internal pipe of brass or copper, which leads it to where there is a down current of water, so that the comparatively cold feed-water may not interfere with the circulation. Some engineers prefer to inject the feed-water in the form of spray, either above or a little way beneath the surface of the water in the boiler; this avoids all chance of injury to the boiler plates, as any gaseous matter mechanically mixed with the feed-water is at once given up and mixes with the steam. Great care should be taken in any case that the internal feed pipes "run full"; that is, that they are never filled with steam, but always with water.

The dynamic effect of the steam in the feed-water when mixed inside the pipe is very startling; every stroke of the feed pump produces an explosion, and in a very short time both external and internal pipes are damaged seriously. To avoid this the internal pipe should, when discharging above the water level, be turned upwards at the end, so as to always remain filled with water, and when turned downward to discharge under the water the end should be well below the lowest working level.

An additional means of safety is sometimes afforded by fitting inside the boiler a clack or check valve, so arranged as to close over the end of the internal pipe or on the spigot of the ordinary check valve. When this is provided the latter can be examined when steam is up.

A blow-off cock should be fitted at or near the bottom of the boiler, to answer the double purpose of admitting sea-water before getting up steam and to blow off some of the water when required. This cock should be a very strong one, as it is liable to rough usage, and being out of sight and not easily got at it is very apt to be neglected. For this reason, as well as because a large cock is difficult to open and shut, some engineers prefer a valve to a cock. If a cock is fitted it should be so arranged that the handle or spanner cannot be removed when it is open.

The clear area through a blow-off cock should be = 1 square inch + 0.2 square inch for each ton of water in the boiler. As it is a very reprehensible practice to quickly blow off a marine boiler when at its normal working temperature, a somewhat smaller cock is fitted to the bottom of the boiler, so that when the pressure of the steam is down to about 20 pounds the water may be blown into the sea through the ordinary cock until the level is just above the furnace crowns; it is then allowed to remain and to cool down with the boiler and finally emptied into the bilge through this cock.

A scum cock, having a clear area through it of one-third that of the blow-off cock, should be fitted to the boiler near to the level of the water, and to it is connected a perforated pipe, inside the boiler, not lower than the lowest working level. The object of this pipe is to collect all scum and floating impurities from the water and discharge it overboard. Large quantities of grease and greasy matter are pumped with the feed-water into the boiler (especially if no grease filter is fitted), and this should be got rid of occasionally. Simple oil is not obnoxious, but a particular kind of hard grease is formed in the condensers of engines whose cylinders are lubricated with a certain class of oils. Portions of it are pumped with the feed-water into the boiler in the form of small pellets, which being of superior specific gravity to pure water sink to the bottom and remain there until the density of the water increases sufficiently to cause it to rise and come in contact with the hot surfaces. To this, Mr. W. Parker, late chief engineer surveyor to Lloyd's Register, attributes the cause of some of the apparently mysterious furnace collapses.

The scum cock is used as a means of reducing the quantity of water in the boiler before adding a fresh supply from the sea (or fresh-water tanks, as the case may be); but if the surface is clear of dirt this is better done with the bottom blow-off, especially if it is possible to check evaporation for a few minutes before blowing off.

It is of the first importance that those in charge of a boiler shall know with certainty the position of the water level within

* In the United States the seats are screwed or forced in.

the boiler. The ordinary gage for this purpose consists essentially of a glass tube, whose ends communicate freely with the inside of the boiler, and so situated on the boiler that the plane of the water surface bisects the tube transversely when at its normal working level. It is, however, found necessary in practice to use considerable discretion in the choice of position of this gage. Since the difference of one-tenth of a pound pressure corresponds to 2.7 inches of water, it is quite possible so to place the gage as to give very false readings. The upper end of the gage should not communicate with the boiler near any exit for steam, for the rush of steam past the orifice can easily make a reduction in pressure of one-tenth of a pound on the gage pipe. The lower end should also be clear of any part from which steam is evolved, as steam bubbles might flow into the pipe and tend to raise the water level in the glass. It is usual, especially with large boilers, to fit the gage cocks and test cocks to a brass or cast iron casting, connected by pipes to the bottom and top of the boiler. This is termed a "stand-pipe," and is a necessity when the gage is on the front of the boiler. The test cocks are placed on the stand-pipe at the lowest and highest working levels, for the purpose of checking the glass gage and for use when the latter is broken or out of order. The length of the gage glass visible should be at the rate of 1¼ inches for each foot of diameter of the boiler; the external diameter of the tube is ⅜ inch for small boilers and ⅞ inch for large ones. The glass is usually about ⅛ inch thick. The gage is so placed that the water is just disappearing, or, as it is generally said to be, just in sight when the level is 2 to 4 inches above the top of the combustion chamber. The allowance should be 0.3 inch for each foot of diameter of boiler.

The pipes connecting the stand-pipe to the boiler should be from 1 to 1½ inches in diameter, and of strong copper, so as to be fitted direct to the boiler. Some engineers insist on having a cock on the boiler at the top and bottom; but this, like many other intended extra safeguards, is in itself a real source of danger, for the cocks are apt to be shut by mistake or carelessness, and thus cause the gage to show a false level. That this is no mere fanciful danger has been proved on more than one occasion. All large boilers, and especially those in ships which are often under sail, should have two water gages, placed as far apart as possible in an athwartship vertical plane. The gage and test cocks should always be fitted with a small plug in line with the bore, which, on being removed, allows a wire to be introduced to clean it of deposit and scale.

The steam gage on Bourdon's principle is now nearly universal, and so well known as to need no description. Schoeffer's gage, although less liable to derangement than Bourdon's, is not so accurate, and does not find so much favor. The boiler gage should have a dial, so marked that it may register pressures to at least 25 percent higher than the working pressure of the boiler. These gages should be carefully tested when new, and at frequent intervals after being at work, as it is often found that they require some slight adjustments.

The hydrokineter is used for the purpose of warming the water in the bottom of the boiler when getting up steam. It consists of a series of nozzles, one within the other, each having a grating body in rear when a current is set up by a jet of steam issuing from the center one. The steam is obtained from the auxiliary boiler which has been used to supply the winches. Without this instrument (unless other means are used) the bottom of a large boiler remains cold long after the steam is raised; with it the temperature of the water at the bottom differs very little from that at the top; steam can in this way be safely raised in a shorter time than usual and at no extra cost, and the endurance of the boiler is very considerably increased. There are many other ways of promoting the circulation when steam is up, but none do this so efficiently during the time of raising steam as the hydrokineter. Although it ought here to be mentioned that a very good plan, and one that has proved eminently satisfactory (when a hydrokineter is not fitted), is to connect the donkey feed pump suction with a suitable pipe attached to a valve on the boiler bottom; the pump can then (when required) draw water from the bottom of the boiler and discharge it back again through the auxiliary feed check valves and pipes, thus maintaining a continuous circulation when raising steam.

Steam whistles are of two kinds, known as the bell-whistle and organ-tube whistle. The latter has, to a large extent, superseded the former on account of its simplicity of construction and superior tone. An improved form has a division in the tube, so as to emit two distinct notes, which may be in harmony or discord, and when sounded together they are heard at a great distance. It is important that the whistle sound as soon as the steam is turned on, and to insure this happening great care must be taken to keep the whistle pipe free of water, which is no very easy matter. It may, however, be effected in two ways: first, by leading the pipe from the boiler into the funnel and keeping it inside as far as the level of the whistle; second, by taking steam for the steering engine from the top of the whistle pipe, thereby insuring a constant flow of steam and no accumulation of water.

The separator, although perhaps not a boiler fitting, is so intimately connected with it that it ought to be mentioned, and this also in face of the fact that a separator is not generally fitted in the mercantile marine, although it might be often used with advantage there. All men-of-war are fitted with separators—and they are very necessary, on account of the tendency to prime on the part of their boilers when working at full speed, the consequent danger to the engines when working at a high velocity of piston from water getting into the cylinders. The separator consists of a vertical cylindrical chamber having a division plate exending from the top to about half-way down, and so placed that the steam in going through the separator must pass under this diaphragm. The object is to separate out the water mechanically mixed with the steam by dashing it against the diaphragm and precipitating it to the bottom of the separator, whence it is blown to the hot-well, or sea, whichever is convenient.

The separator should have a diameter twice that of the steam pipe, and be 2½ to 3 diameters long. It is often made with a hemispherical top and flat bottom, and sometimes with both ends hemispherical. The division plate should extend half the diameter of the steam pipe below the level of the bottom of the steam pipe.

The boiler shell should be well coated or covered with some non-conducting material, to prevent loss by radiation from its surface, which may amount in some cases to as much as 10 percent. The material used should, besides being a non-conductor of heat, be incombustible and inorganic. The following materials are those generally used for boiler clothing:

Hair felt is a good non-conductor, but it is very liable to take fire, and if exposed to moisture and heat will soon rot away.

Silicate cotton,* manufactured from slag and having the appearance of cotton, is eminently fitted for boiler clothing. It is a good non-conductor, incombustible and imperishable from chemical action; it is, however, very brittle, and for this reason will not withstand mechanical action, therefore if loosely packed and subject to vibration it soon becomes dust, which is most offensive if it gets into the engine bearings. Asbestos fiber has very much the same nature as silicate cotton, but is more durable.

Cements of various kinds are used, their efficiency depending generally on the amount of vegetable fiber contained in them; they have not, however, so high an efficiency as the foregoing.

Fossil meal, or infusorial earth, is a composition containing

* Known in the United States as mineral wool.

large quanties of minute shells and is a most efficient covering; besides being inexpensive it is also incombustible and durable.

Papier maché is also employed for this purpose, and is a fairly good material, but it is not altogether incombustible and is apt to rot.

The last three materials must be put on when the boiler is hot and be carefully done. This does not help in their favor, as it is an objectionable thing to have steam on the boilers when the ship is being finished.

The felt, silicate cotton and asbestos fiber may be covered with sheet iron to make it more durable. The cements are generally covered with a strong duck cloth and strapped with strong bands, painted or tarred over so as to be waterproof. The parts exposed to wear are generally covered with light sheet iron to protect the clothing.

Concerning the Care of Flues and Fire-Boxes.

BY L. A. BARNEMAN.*

While it has been sometime since I have taken up the flue and fire-box question, I have noted considerable debate in regard to it, and am glad to see some of our master boiler makers have not yet given up all hope of getting more support from their superior officers in regard to improvements in boilers and care of engines at terminals.

A master boiler maker should be a progressive man and be backed up by his superiors or he is likely to be considered a "dead one.". If he cannot make improvements and be allowed to handle his work properly he cannot be expected to get it out in good time or have it well done. His ideas or suggestions should be given the closest attention, and whenever possible worked out, as he then will become a valuable man for his company; on the other hand, if he is held down he will soon become a "back number."

I wish to congratulate Mr. Kelly on his recent paper, and I believe if we keep hammering at it we can get better results at terminals in the care of engines, provided proper methods are used.

The round-house foreman is the man we should get after, but he should be given space to properly care for the engines under his charge; but it is his work to see every care given them from the time they leave the cinder pit until they are in the house. We should try to educate and instruct the cinder-pit men just how to handle their work, and see to it ourselves that instructions are closely carried out.

The round-house foreman should also be encouraged to take interest in boiler work and get his men interested in what comes under his and their charge.

The boiler maker is the man who has it "up to him" to make the best possible repairs in the time allowed, which we all know is usually far too short to make a lasting job, and a poor job is not always his fault.

In my experience the beading tool and flue roller are the most damaging tools that are used on flues; should the beader not be placed at the proper angle, it more or less cuts the sheet and forms a burr between the flue and sheet, thus damaging it for future service. There is no way to get rid of the burr unless the flue is taken out and the reamer applied. I would recommend to overcome this trouble throwing away the beading tool and locking up the roller, with the result of a longer life of the flues and sheet, and this means fewer flue failures.

The sectional expanders, or rollers, we have in use at all our terminals are so made that when they are placed in the tube they cover the bead, as does a beading tool in order to keep the bead from rising up when the flue is forced back against the sheet.

We have considerable trouble with crown sheets sagging when tee bars are placed just back of the tube sheet on our Pacific and Atlantic type engines; in fact, with all wide-type fire-boxes. The reason for this is that the design of these locomotives is not good; there should have been six braces applied to the tee bars instead of four; but the way tee bars are fitted to wagon-top sheets six bars cannot be used.

A remedy is to remove the tee bars and use flexible radial stays. In so doing you are also applying a remedy for troubles with top flanges and knuckle of the tube sheet. I have made a practice of leaving out, at the top, several flues to overcome cracking as much as possible.

*F. B. M. C. St. Paul & O. Ry.

THE FLOW OF HEAT THROUGH FURNACE WALLS.

BY WALTER T. RAY AND HENRY KREISINGER.*

The furnace used in the tests forms part of the fuel-testing plant at Pittsburg, Pa., and was done under the direction of the Geological Survey.

Although the main object of the researches made with the furnace was to examine critically the production of *sensible* heat by combustion along the path of the gases rising from the fuel, an interesting as well as important side problem developed in the study of the simultaneous *disspiation* of the heat through the walls and roof of the furnace. Thus data were collected on the temperature gradient through the walls at several places. These temperature data (together with the heat conductivity of the material of the walls) formed the basis for calculating the heat dissipated through the walls.

The object of the report is to present these temperature data, and particularly concerns the air-space type of wall construction as compared with the solid brick wall or walls type, in which the air space is filled with some solid material of low heat conductivity. The conclusion will surprise some readers, as, so far as loss of heat is concerned, a solid wall of brick or any ordinary material is preferable to a hollow wall of the same total thickness, especially if the air space in the hollow wall is near the furnace side.

There is a general belief that since air is a poor conductor of heat, air spaces built into the walls of a furnace will prevent or reduce heat dissipation through the walls. Although there may be instances of furnace walls in which such construction reduces the rate of heat flow through them, yet as a rule the effect of the air space is just the opposite. While the heat does travel very slowly through the air by conduction, it leaps over the air space readily by radiation. Although this latter mode of heat propagation is common in nature, the laws governing it are not generally known, and are seldom taken into consideration when furnace walls are being desiged.

It may be stated here that the quantity of heat passing through a portion of a solid wall by conduction depends on the difference between the temperatures of the two planes limiting the portion of the wall. The quantity of heat that passes across the air space in the wall depends on the difference of the fourth powers of the absolute temperatures of the surfaces inclosing the air space. It follows that, in case the heat passes by conduction through the solid portion of the wall, the loss remains approximately the same so long as the temperature of the two limiting planes remains constant, no matter what may be the temperature of the two planes. On the other hand, the heat passing across the air space by radiation increases rapidly with the temperatures of the inclosing surfaces, although the difference between these temperatures may remain constant. The important point is that the air space, which is advantageous in the walls of a refrigerator because the temperatures are low, is objectionable in a furnace wall because the temperatures are high.

*United States Bureau of Mines.

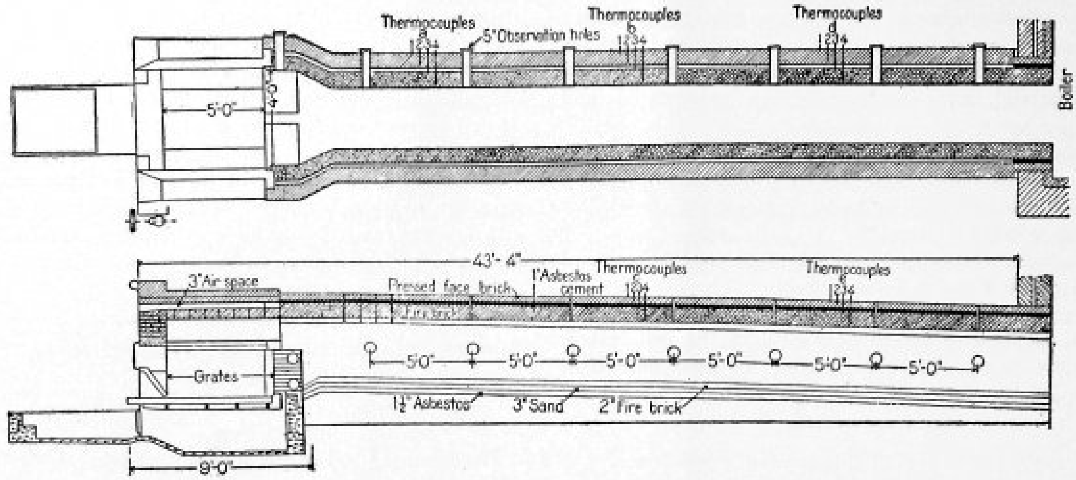


FIG. 1.—PLAN AND ELEVATION OF THE SPECIAL FURNACE.

It is customary to put air spaces in furnace walls between the firebrick linings and the common brick. Usually the firebrick lining is only half a brick thick, which construction brings the air space too close to the furnace. The result is that the temperatures of the surfaces inclosing the air spaces are too high, and in consequence too much heat is radiated across the spaces. The heat passing through such walls would be much reduced if the air spaces were filled with brick, or, better, with some cheap non-conducting materials, such as ash, sand, mineral wool, etc. Even where the firebrick lining is one brick thick (9 inches), the temperature in the furnace may be high enough to raise the temperatures of the air-space surfaces so much that the heat radiated across the space will amount to more than would the heat conducted through a filling, were the filling only common brick. This last statement is amply justified by the data obtained.

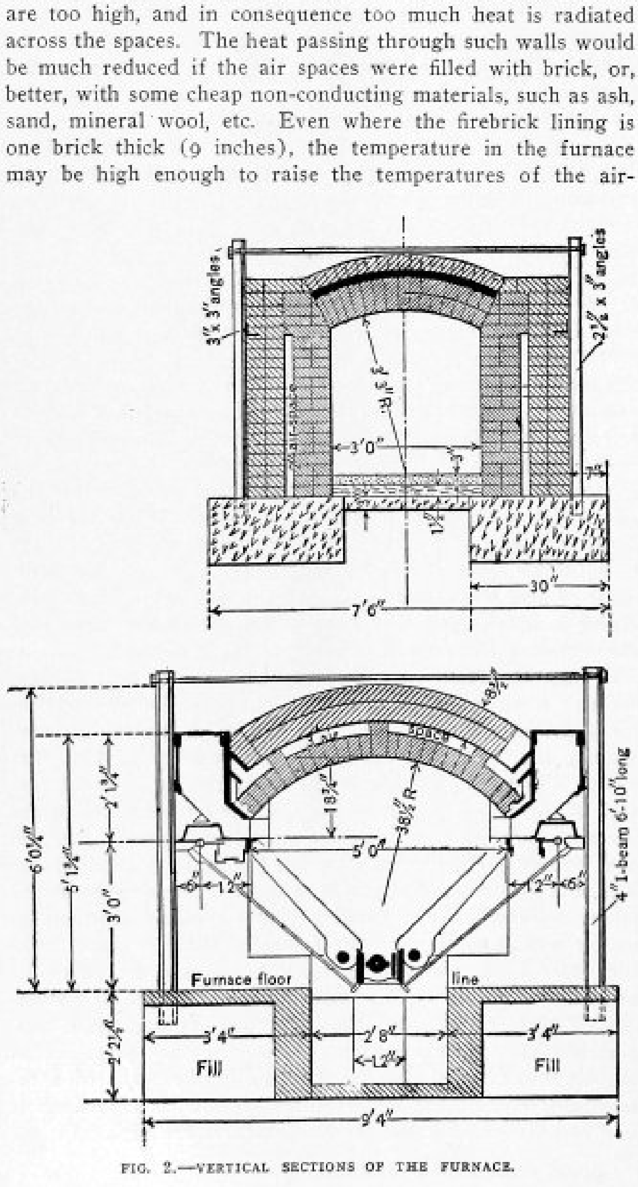


FIG. 2.—VERTICAL SECTIONS OF THE FURNACE.

CONSTRUCTION OF FURNACE.

The specially constructed furnace is about 43 feet long over all. At one end is a mechanical stoker; at the other the gases from the combustion chamber discharge into a watertube boiler. The combustion chamber is a tunnel 3 feet wide, 3 feet 3 inches high, and about 35 feet 6 inches long, with double walls and arch roof. The inner walls and the inner arch are 9 inches thick, and are of best quality firebrick. The outer walls, 8 inches thick, are of common and pressed brick. The outer arch, 4 inches thick, is of repressed brick. In the sides a 2-inch air space separates the two walls; in the roof a 1-inch layer of flake asbestos separates the two arches. Air leakage through the walls and roof is minimized by using blowing and exhaust fans to keep the interior of the chamber as nearly as possible at atmospheric pressure.

POSITION OF THERMOCOUPLES.

The data presented consist of three sets of measurements of temperatures at four different depths in a side wall of the furnace, and also of two sets of measurements in the roof. The material of the outer wall and arch is, for convenience, designated common brick in the discussion of the data.

Fig. 1 presents the elevation and the plan of the special furnace as it was at the time of getting the data given in this report. Fig. 2 gives vertical sections of the furnace. Fig. 3 shows the positions of the thermocouples in the side wall at places denoted in Fig. 1 by *a*, *b* and *d*. Fig. 4 gives the construction of the arch or roof of the furnace and the location of thermocouples at places *c* and *e*. No couples were inserted in the roof corresponding to location *a* in the side wall, because it was feared that the lower side of the lining had been melted away considerably.

The thermocouples were placed in ⅜-inch holes, which were drilled in the wall and the roof after the furnace was built. The holes were intended to extend within 1 inch of the outer and inner surfaces of the wall and the roof, as indicated in Fig. 1. The depths of the holes for couples 1 and 3 could be measured accurately, and therefore these couples were put at known depths, as represented in the figures. The distances of the ends of the holes for couples 2 and 4 from the inner surfaces could not be accurately measured, so that the distance given in the figures are only approximate. Each couple was placed in such a way that the fused junction touched the bottom of the hole. Near the outer surface of the wall the annular spaces around the wires of the couples were filled with asbestos packing as deeply as possible, in order to prevent radiation of heat from the couples and from the bottom of the holes, and also to stop the cooling of the couples by any current of cold air that might be drawn around the couples into the furnace. This precaution was more effective with thermocouples 1 and 2 than with thermocouples 3 and 4, because the packing could not be put around the couples in the inner firebrick wall. Consequently, the indications of these couples, and particularly of thermocouple 4, are not exact and should always be considered as approximate.

CONSTRUCTION OF THERMOCOUPLES.

The thermocouples were made of wires about 1.5 mm. (1/16 inch) square, and proved durable and dependable up to 1,400 degrees C. (2,552 degrees F.).

READINGS.

Inasmuch as all readings were relative, no attempt was made to get the temperature closer than 2 or 3 degrees.

The temperature readings of the thermocouples embedded in the wall and roof were taken on a number of tests. The test was run until the wall temperatures reached equilibrium; that is, until they ceased to increase.

EQUILIBRIUM OF FURNACE-WALL TEMPERATURES.

The nearly true assumption is made that there is no cooling effect due to leakage currents of air through the brickwork or into, out of or along the air space.

During the equilibrium the quantity of heat passing through an inner part of the wall is exactly equal to the heat going through another part farther out. For example, the quantity of heat which is conducted through the inner firebrick wall is exactly equal to the heat which passes across the air space, and is exactly equal to the heat which is conducted through the outer common brick wall, and also equal to the heat radiated or taken in any other way from the outside surface. If this equality of heats did not exist the equilibrium would be impossible. For example, let it be assumed that more heat passed through the inner than through the outer wall and over the air space; then the heat would accumulate near the surface next to the air space, and the temperatures shown by thermocouples 3 would be rising, a circumstance opposed to equilibrium. Again, let it be assumed that more heat passed through the outer wall than through the inner one and through the air space; in that case the heat in the outer wall near the surface next to the air space would diminish and the temperatures shown by thermocouples 2 would drop, an event that would be contrary to the equilibrium conditions. The statement that during equilibrium of the wall temperatures in any cross-section of the wall the quantity of heat passing through one part of the section is exactly equal to the quantity passing through any other part is therefore justified.

TEMPERATURE DROPS IN FURNACE WALLS.

The quantity of heat flowing by conduction from one plane to another through any portion of the furnace wall depends upon the difference of temperature between these two planes and upon the resistance to the heat flow. With the same temperature difference, if the resistance is high, a small quantity of heat flows through; if the resistance is low, a large quantity flows through. Or, if the quantity of heat is to remain constant the temperature difference must be large if the resistance to the heat flow is high, and small if the resistance is low.

So, in the case of the furnace wall, where the quantity of heat passing between any two planes which are parallel to the surfaces of the walls is the same, the temperature difference between any two planes indicates the resistance which the material or space between the two planes offers to the flow of heat. For example, if the temperature difference between the faces of the firebrick wall is high it may be said that the resistance to the heat flow of the firebrick wall is high; or if the temperature difference between the two surfaces on each side of the air space is low, it may be inferred that the resistance to the heat passage across the air space is low. Thus it is possible to rely on the temperature difference as being a true indicator of high or low resistance to heat flow between any two planes which are parallel to the surface of the wall.

CONCLUSIONS.

The results of the investigation justify the following conclusions:

In furnace construction a solid wall is a better heat insulator than a wall of the same total thickness containing an air space. This statement is particularly true if the air space is close to the furnace side of the wall, and if the furnace is operated at high temperatures. If it is desirable in furnace construction to build the walls in two parts, so as to prevent cracks being formed by the expansion of the brickwork on the furnace side of the walls, it is preferable to fill the space between the two walls with some "solid" (not firm, but loose) insulating material. Any such easily obtainable materials as ash, crushed brick or sand offer higher resistance to heat flow through the walls than an air space. Furthermore, any such loose material by its plasticity reduces air leakage, which is an important feature deserving consideration.

INCRUSTATION AND CORROSION IN BOILERS.

BY G. NEWTON HOLT.*

Deposits of solid matter in steam boilers are due to the presence in the feed-water of different substances, some organic and some inorganic. Some of them, such as clay and vegetable matter, are carried in suspension and settle out of the water when they come to settle themselves. Some are precipitated as the water is evaporated. The most common of these are carbonate and sulphate of lime and magnesia. The solid matters appear in different forms, such as scum, which is on top of the water and can be removed by opening the surface blow-off by using a skimmer. Another form is mud, which can be removed by opening the bottom blow-off, or washed out with a hose when the boiler is open for cleaning. There is another form, such as the solid scale, varying from little chalk-like substances to layers so hard that it is impossible sometimes to remove it with a hammer and chisel.

Scum and mud, if allowed to settle for any great length of time, tend to combine with scale-forming salts and increase the total amount of scale and the troubles incident to its presence. Sulphates and carbonates of lime and magnesia settle upon the heating surfaces of boilers, especially over night when the plant is shut down, and later they become baked upon these surfaces. The amount of scale accumulating in the boiler depends upon the amount of scale-forming salts carried in the feed-water, and this varies greatly in different places. The kind of scale also varies with different waters. Every gallon of water does not carry a large amount of scale-forming matter in solution, yet there may be large accumulations in a boiler owing to the large amount of water which must be evaporated. It requires 34½ pounds of water each hour for one boiler horsepower. Water carrying 15 grains of dry solid impurities in a gallon will deposit in a 100-horsepowee boiler about 300 pounds of scale in thirty days, working ten hours a day.

Oil in steam boilers is found in plants where the cylinder oil in the condensed exhaust steam is returned to the boilers.

* In *Southern Engineer.*

While it is possible to separate all the cylinder oil from the exhaust steam either before or after condensation, yet in a few plants they have no means of entirely removing it. Where the returns from heating systems and other condensed exhaust steam are used for boiler feed without removing the oil the greasy deposits upon the tubes and shell will be very noticeable, and the results both dangerous and expensive.

A thin layer of scale, and especially grease, on the heating surfaces greatly reduces the evaporation and increases the coal consumption in proportion. Authorities state that a layer of scale ⅛ inch thick causes about 20 percent increase in the coal consumption, a layer ¼ inch thick an increase of about 40 percent, and a layer 1 inch thick an increase of about 60 percent. Porous scale that allows the water to penetrate it to the shell may not seriously affect the econmy of the boiler, yet it is a very expensive habit to cover all surfaces with scale and grease which keep the furnace heat out of a boiler. Steam plant owners invest many thousands of dollars in feed-water heaters, economizers and mechanical stokers to reduce the coal bill, and if they would spend a few cents a day for the removal of scale and impurities from the boiler it would be found much cheaper and better economy secured.

When the economy of the boiler is poor, because of the effect of scale, even when the plant is running under light loads, it sometimes is impossible to burn the required amount of coal to enable the boiler to generate its full capacity. In many cases additional boilers have to be bought, because the original boilers do not make the required amount of steam. The capacity of a boiler affects its ability to furnish a sudden demand for steam, especially when used in street railway plants and central stations. If the ordinary load represents the capacity, they cannot do the work, and the system will be partially crippled at times. At 200 pounds pressure the temperature of the steam and water is 387 degrees. We can all see that it pays to have the boiler plates thoroughly clean and the water in direct contact with the metal. The tensile strength of steel decreases when heated above 720 degrees; thus at 1,200 degrees nearly 75 percent of its tensile strength is lost. The table shows the tensile strength of steel at different temperatures:

	Pounds.
At 570 degrees the tensile strength is.....	66,500
At 720 degrees the tensile strength is.....	55,000
At 1,050 degrees the tensile strength is....	32,000
At 1,240 degrees the tensile strength is....	22,000
At 1,317 degrees the tensile strength is....	9,000

A thoroughly clean plate covered with water cannot become overheated, but if the surface is rubbed over with a thin layer of mineral oil, the temperature rapidly exceeds 720 degrees even at a fair rate of evaporation, and the effect practically is the same as though the water in the boiler were getting low. Perhaps this explains the cause of many so-called mysterious explosions, and it is known to be the cause of many collapsed tubes and bagged sheets. If a very thin coating of oil will allow the temperature of the metal to be raised beyond the safe limit, it is certain that a somewhat thicker layer of scale or mud will keep the water away from the plates and result in overheating.

If any one believes scale is a good conductor of heat let him clean off the cale from one side of an ordinary iron teakettle, fill it with water and put it over a hot fire, then note where the water begins to boil first, and how long it takes the water over the scale to begin to boil. The removal of scale at the right time from all heating surfaces of boilers is of great importance if the safety of the plant is taken into consideration. In most watertube boilers scale can be entirely removed, but not so with horizontal tubular boilers. At best only a part of the scale can be removed with the use of a hammer between the tubes and when scraping it off the sheets.

One plan for the preventing of boiler scale is to treat the feed-water; another is to allow the scale to form and to remove it periodically. With the latter treatment the boilers are clean and safe only a small part of the time and must be cut out of service occasionally for cleaning. Where the right kind of compound is used the boilers will be clean, efficient and safe from overheating. When a new tube is put into a watertube boiler it represents a new section or unit, but when a fire sheet of a horizontal tubular boiler is repaired it must remain a damaged sheet. This, together with cracks at riveted joints, is doubtless responsible for loss of life and millions of dollars' worth of damaged property due to boiler explosions.

Safeguard in Chipping.

One of the most frequent minor accidents in the shop is the injury to the eye when a barbed splinter of steel or of cast iron flies into its soft tissues. The pneumatic tools in particular, due to the sudden and powerful character of the blow, will throw the chips with high velocity and to a considerable distance. The operator himself may be struck, but this is less likely than that an innocent passerby should become the victim.

A form of portable screen made of burlap stretched upon a light wood frame, which can be set up in the line of flight of the chips from the work. By using a textile surface, the chip will not rebound as from a metallic or hard surface, and, further, its impact is deadened, and it falls or adheres until brushed off. The screen can be put at any angle or height on the upright. This form of screen of textile material cannot, of course, be used when the impact is to be from incandescent sparks. In certain forms of grinding, and in electric welding operations or some sort of hammer work the burlap must be replaced by a fine wire mesh of brass cloth. This lets light and vision through, but any metallic particle small enough to pass is effectively cooled before it can do any harm, or its energy so exhausted that it works no injury.

The ordinary procedure when a chip flies into the eye is to secure its removal by a toothpick or a knife blade, or in better cases to use a magnet to which the iron or steel may adhere. The delicate tissues, however, are very susceptible to infection by the germs adhering to unsterilized surfaces; and such rough and ready surgery is not always effective in any case. Many of the better and more highly advanced of the industrial establishments have a room set apart with necessary equipment for effective sterilization of any instrument used upon wounds or lacerations, and to this home hospital or infirmary all cases of chip-wounds will be sent for treatment. Where 3,000 people were employed the number of treatments given in 1910 amounted to 14,000. This implies that every employee was in the hospital nearly five times in the twelve months, or that almost five persons came in every hour of the 3,000 hours of the working year. Such a room plainly has justified itself.—*Journal of Industrial Safety.*

A Pressure Recording Indicator for Punching Machinery.

At the spring meeting of the American Society of Mechanical Engineers, which was held at Pittsburg from May 30 to June 2, a paper was presented by Prof. G. C. Anthony, which described the application of the steam-engine indicator to the punch, in order to obtain diagrams showing the variation of pressure during the stroke, the maximum pressure for which punches should be designed, the point of maximum stress in the punching of plates, the advantage to be derived from the use of shearing punches, the effect of clearance between punch and die, etc. The indicator is applied by resting the lower die upon a piston, the pressure of which is communicated to that of the indicator hydraulically.

THE DESIGN OF A BOILER COMPENSATING PLATE.

BY JOHN GRAY.

The proper design of a compensating plate calls for a little attention by boiler designers, more so than I think is given at present. The average compensating plate is usually a standard one, and generally does duty for any size of boiler within certain pressures. There are two designs generally used, one with the plate flanged and the other simply a square plate with the hole cut out. Obviously, the best arrangement of compensating plate is one which will have the least size of hole in the shell of boiler. The greater the hole the greater the size of compensating plate, and this is where the objection to the flanged plate comes in. One can see that strong as this type of plate undoubtedly is it cannot be an ideal compensation, as the size of hole on shell must necessarily be as large as the size over the heel of flange. Now, any plate that can

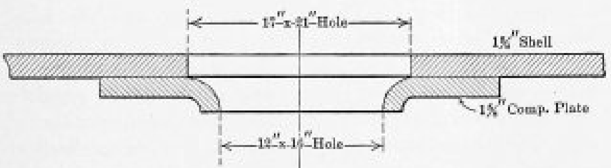


FIG. 1.

give us a less size of hole with equal conditions will suit us better. Then there are other points that come in for consideration, namely: the moment you flange the plate you must reduce the tensile strength. If you have your shell tensile at, say, 30 to 34 tons, the compensation plate, if flanged, will not be more than 27 to 30 tons. The strength of the plate therefore must be reduced in the ratio of 27 to 30, thereby increasing the weight unnecessarily as well as increasing the cost. Then, again, the difference in tensile strength of the shell plate and compensating plate cannot be a good point, as under pressure the plates will not stretch equally. The compensating plate will accommodate itself more readily to expansion than the shell, and due to this unequal expansion a shearing stress is set up in the rivets which causes an extra strain on the

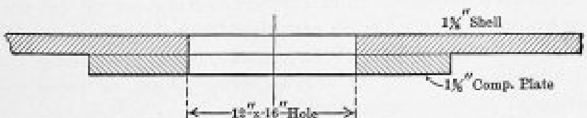


FIG. 2.

material. Everything points, then, to a plate that is not worked in the fire, one that has an equal tenacity with the shell and butt-straps. With a compensating plate not flanged we can have the plate square up to the edge of the hole on the shell. If we compare the strengths of the two we see also the favor is on the side of the not flanged plate. Suppose the hole in our compensating plate is 16 inches by 12 inches, the hole in the shell would be about 21 inches by 17 inches with the flanged type. See Fig. 1. Therefore the amount we require to compensate would be 17-inch by 1⅝-inch thick shell, equal to 27.625 square inches. In considering the breadth of the plate, and taking the depth of flange for calculating purposes at 1 inch, we would have $B \times 1\frac{5}{8}$ inches $= 27.625$, or B equal to 17 inches. Now this 17 inches must be increased as the difference in tensile strength of shell and compensating plate, therefore the breadth for this type of plate, neglecting rivet holes, would be $\frac{17 \times 30}{27} = 18.88$ inches broad.

Considering the type of plate not flanged, see Fig. 2, we have the size of hole on shell the same as the compensating plate $=$ 16 inches by 12 inches, therefore amount to compensate would be 12 inches by 1⅝ inches shell equal to 19.5 square inches, and breadth of plate $= B$ by 1⅝ inches $= 19.5$, or B equal to 12 inches, neglecting rivet holes, and as this plate is not worked in the fire there is no reduction due to difference in tensile strength, so we have a direct saving of practically 7 inches in breadth of plate, which in a few boilers means a good weight and a good deal of money.

NOTES ON THE CORROSION OF COPPER AND BRASS

The following article by Lieutenant-Commander W. B. Tardy, U. S. N., is based on a paper read before the Institute of Metals by Mr. E. L. Rhead, F. I. C., and the discussion which followed. The object has been to condense the matter so that the various theories may be published in a convenient form, with the hope that those who have non-ferrous corrosion troubles and the opportunity of making tests may try out one or more with a view to our accumulated practical knowledge, finally enabling us to arrive at a solution of the problem both as to cause and remedy.

In the above-mentioned papers the discussion and recorded experiments tend to establish the following facts, that corrosion of copper and brass is due—

1. "To methods of manufacture."
2. "To selective chemical action."
3. "Corrosion resulting from chemical action set up or promoted by the electrical conditions resulting from the presence, side by side, in the alloy, of different components containing the constituents of the alloy in varying proportions, or from the presence of included impurities."
4. "The effect of vagrant electric currents escaping from the electrical equipment."

Without going into the details of the various experiments made, or into the highly technical reasoning, we will discuss in a popular way the above theories, in the order given.

It is conclusively shown that with copper of a fixed purity that part which is hardest, either from processes of manufacture or from operations in working it into shape, is more readily attacked and suffers more rapid deterioration. The evident remedy is uniform annealing, using copper or brass of the softest quality compatible with the service required of it. In this connection it was admitted in the discussion that copper corrosion troubles in serious form date from 1899, it being stated that this corresponds to the time when the first electrically-produced copper, manufactured in 1898, was put on the market. It is difficult to see how this method of producing copper would make it more susceptible to attack, provided, of course, that it is remelted afterwards. It would not differ from ordinary smelted copper, except that it might be somewhat purer. This immediately raises the question whether electrically-deposited copper has not had certain beneficial minute impurities removed. This question might, it seems to us, be very readily answered in a general practical manner by having two similar pipes installed close together in a ship to do the same duty, making all conditions identical except having one of the pipes made of electrolytic copper and the other copper purified to the same degree by smelting processes.

In regard to causes 2 and 3 it is stated that it does not seem possible for cause 2 to operate unless affected by 3, but that the electromotive force resulting from the contact of copper with zinc alloys containing copper in large amounts is very feeble, never exceeding 0.08 volt when immersed in sea-water. A long series of experiments was made, immersing hard and soft copper and various copper alloys in different saline solutions, from which it is shown that the harder the metal the more susceptible it is to corrosion or to solution, that the relative order of the solution tensions of metals varies with the liquid in which the metal is placed; but that in every case the corrosive action is increased by the presence of carbonic acid gas. In this connection the discussion brought forth descriptions of the rapid failure of condenser tubes, due to lodgment of particles of cinder, ash and coal or other forms of carbon in the tubes. The obvious manner of avoiding troubles due to lodgment of gas-producing solids is to so locate suctions that they are well clear of ash discharges, have pipes, condenser tubes, etc., as straight and with as few pockets as possible, then increase the velocity of flow to the point where all silt or solid matter will be scoured out and swept through pipes or tubes.

The small electromotive force difference above referred to (0.08 volt) is the only force tending to produce electrolysis between elements of different composition, however slight, within the same pipe or tube, due to differences of metal, method of manufacture or working, or to slight local differences of alloy composition, if we except the effect of vagrant electric currents due to grounds on the ship.

If we accept the electrolytic theory of corrosion we must, to account for the rapid deterioration of copper pipes and copper alloys aboard ship, show a more powerful force setting up electrolytic decomposition and deposition than the insignificant potential difference (0.08 volt, maximum) existing between a small copper element and an alloy element in the walls of a copper pipe. In general discussions, such as occur in wardrooms, it is sometimes held that if grounds in the ship caused electrolytic action, the steel, being electro-positive, would be attacked, and the copper pipes would be immune or possibly have iron plated out on them. This is valid reasoning if one is justified in the assumption that each metal, the steel plating on the one hand and the copper pipe on the other, is so pure that all other possible electrolytic couples are thereby eliminated. A glance at Dr. Cushman's specimen of commercially homogeneous iron or steel embedded in a culture rich in phenolthalien as an indicator, which shows by color reaction what is taking place, due to electro-chemical differences in the purest obtainable steel, shows that the above assumption is untenable.

It is shown in the discussion by the members of the Institute of Metals that the tubes of a condenser were protected and their life materially lengthened by making electric contact from the main injection pipe to the overboard discharge pipe with a large capacity cable, thus electrically short circuiting the condenser. This was the main condenser of an electric power plant in which there were known to be serious grounds.

From the above case, from our own experience and observation, and the experience of a large number of officers in the service, we offer the opinion that theory No. 4, vagrant electric currents escaping from the electric plant of the ship, furnish both the cause and the electromotive force that produces by far the greater part of the rapid destructive copper, copper-alloy corrosion that occurs on board our ships. It is admitted at the outset that the fact that the ship is purposely made the ground for the wireless has no direct bearing or effect; since its electromotive force, and consequently its current, is alternating, there can be no injurious effect other than the possibility of this alternating effect assisting a direct-current current to flow where otherwise the resistance was too great for it to be established or maintained by the small direct electromotive force due to leaks from the plant.

It is a mater of common experience and observation that copper pipes most frequently fail at or near bends; one side or other, sometimes both sides, of flanges. It occurs so frequently next to flange at outboard end of line where suction pipe connects to stool pipe as to give rise among certain officers to the belief that the corrosion is, or may be, due to thermo-electric effects.

The location of the most destructive corrosion is where one would expect it, reasoning from the first three theories. The greatest differences in character of metal, due to working, are formed at bends and flanges. The greatest differences in composition are found near flanges, due to brazing material, and the most active liberation of corrosive gases would naturally be at or near bends. Therefore, postulate No. 4 is needed only to account for the rapidity of corrosion. The theory is that vagrant currents will take naturally the easiest path, that the copper pipe, where it is straight and continuous, offers this path, that at a flange the resistance is enormously increased, due to discontinuity of pipe and interposition of gasket, so that the current finds its easiest path through the salt water by the joint. It leaves the pipe just short of one flange and re-enters metal of pipe just beyond the joint, the point of leaving becoming the positive pole, the metal there going into solution and plating out further along the pipe or being swept out altogether. It is believed that some such action takes place at bends. So far as we know, nothing practical has ever been done to test this theory. The theory is given and the hope expressed that some engineering officer on a ship in commission will do something that will tend to prove or disprove it. With two similar or exact pipes doing as nearly as possible the same duty, one might have an uninsulated copper conductor of large capacity laid parallel, with one end in close mechanical contact with the pipe outboard of outboard flange and other end connected to pump or whatever pipe is attached to; or copper sleeve might be slipped over each joint, making electric contact with the pipe each side of flange, while no such precautions were taken with the similar pipe; long observation ought to give an indirect proof or determination.

With a Siemens-Halske thermocouple galvanometer and proper leads and contacts it ought to be possible to determine any potential differences from point to point in the body of a pipe, also the direction of current—at least such difference as would be produced by grounds—and from these determinations see whether corrosion does always, or usually, occur on the positive side of an interposed resistance.

SUMMARY.

Copper and brass corrosions are due probably to—

1. Methods of manufacture.
2. Selective chemical action.
3. Corrosion resulting from chemical action set up or promoted by electrical conditions resulting from the presence, side by side, in the alloy, of different components, containing the constituents of the alloy in varying proportions, or from the presence of included impurities.
4. The effect of vagrant electric currents escaping from the electrical equipment.

TO PREVENT OR LIMIT CORROSION.

1. Uniformity, physical and chemical, in copper and copper alloys is necessary.
2. Prevent entrance of sewage, carbonic acid gas, ashes or coal; if latter cannot be prevented, make pipes and tubes as straight and free of pockets as possible, and increase velocity of water so that they will be scoured out.
3. Eliminate or minimize grounds if the theory of vagrant currents be accepted.

If this be not accepted, make tests on board ship to prove or disprove its validity; those suggested above, as well as others that will suggest themselves to the practical investigator.—Abstracted from the *Journal of the American Society of Naval Engineers.*

Mr. Frank Bradshaw, who has been acting master mechanic at the Santiago shops of the National Railways of Mexico, has been appointed master mechanic, with headquarters at the City of Mexico. Mr. Bradshaw was for a long time general foreman boiler maker for the above company.

CRACKED FURNACES.

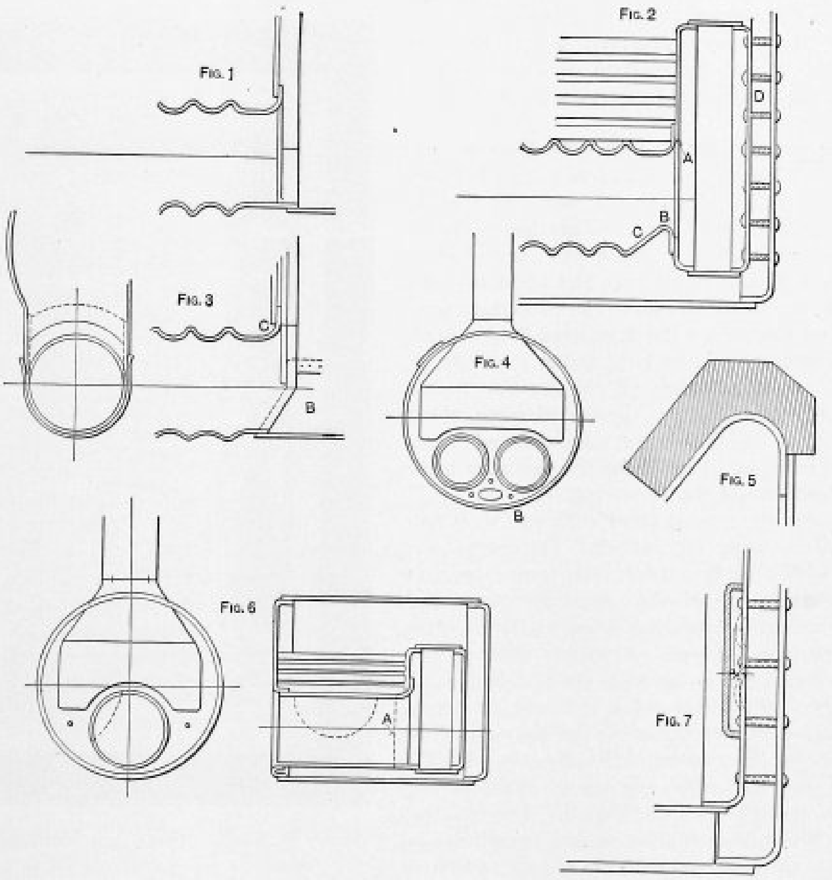
BY D. KOOIJMAN.

When steam pressures were increased it became necessary to use ribbed furnaces in boilers, as the thickness required for the higher steam pressure of plain furnaces had to be such that the resistance offered to the transmission of heat by the plate was too great. Ribbed furnaces, or, as they are sometimes called, corrugated furnaces, are much stronger than the plain; but even with this additional strength the collapsing of furnaces occurs to-day. Oil or grease lodging on the heated plates makes them a very bad conductor, and therefore they become easily overheated under these conditions and collapse. The thickness of the plate is not of so much importance in preventing the heat traveling through them as is even a very thin volume of oil.

Attention is drawn here to the investigation of Mr. Stromeyer, who found that the thickness of 10-inch boiler steel is put to a severe test, which poor material, of course, would not stand. They are first rolled up from the plain plate and welded, and then are rolled on groove rolls to produce the corrugations, and any steel that can stand this treatment must be of excellent quality. It is found in manufacturing these ribbed furnaces that they are flattened a little on the top. The cause of this is that they become hotter on the top than on the bottom, so that the expansion is more in one place than in another.

All furnaces are subjected to severe stresses, due to unequal heat; as when the fire-door is opened they cool off and when closed heats up again, thus continually changing the temperature from time to time.

In referring to the flatting of the furnace above noted, if not more than ¾ inch little attention need be paid to it; but it is not well to have these flattened surfaces any more than the above amount. It seldom occurs that an overheated furnace bursts notwithstanding that the strength of the steel



LOCATION OF CRACKS IN MARINE FURNACES.

a one-tenth of an inch scale, and an oil film of one-hundredth inch thick offer the same resistance to heat conduction. It is therefore quite evident that it is of great importance to keep oil and grease out of boilers.

Some ships have been fitted with what are known as oil separators between the low-pressure cylinder and the condensers. This is good, as the oil does not work into the condenser, impairing its efficiency, and then be passed on over into the boiler, doing the damage above referred to. But these separators take up considerable space, and they are not always perfectly satisfactory, therefore they are not fitted as often as they should be.

Referring again to ribbed furnaces, one thing which makes them better is the fact that in their construction the material is much diminished by a high temperature. The Purvis furnace, as it is known, when first made used to often crack when overheated; this was due to the fact that it was too stiff. and this no doubt is the reason why this style of furnace is now seldom applied.

When a furnace collapses it does not always crack, and it is quite safe to use it for a time to reach harbor, as in collapsing the surface, which has generally been coated with oil or grease, becomes free from same by burning away.

In ribbed furnaces the connection to the back tube plate is made as shown in Fig. 1. It is a difficult job to take out the old furnace and put in a new one. Half of the boiler practically has to be bent in, which takes considerable time, and is very expensive. It is, therefore, better to have the ribbed furnaces made with "Courley" end, as shown in Fig. 2. With this furnace the flames may impinge on the seams *A*, and so injure the plate as to make the seam leak, and many engineers, therefore, will not use this style of end, but there are many cases where it has proved very satisfactory. These "Courley" ends are in common use in England, but very seldom used in Germany. It is the opinion of the latter Nation's engineers that in the arrangement shown in Fig. 2 the flange is not sufficiently water-cooled, and may, therefore, crack between the rivet holes. They hold that many such furnaces crack at the point *B*, Fig. 2, and this may be accounted for, as it is evident that at *B* the plate has been most strained in manufacture. A better arrangement is shown in Fig. 3. In this the disadvantage noted is removed by the use of the plate *B*.

An attempt has been made to find out what would be the deformation of the part *C*, Fig. 2, when the boiler was under hydraulic test, and the testers were considerably astonished that weakness was apparent, and it was judged necessary to stay this part, yet the writer made a templet, shown in Fig. 5, which fitted exactly to the surface, and with a pressure of one and one-half times the working pressure, which was 192 pounds, he could detect no deformation whatever. This boiler had two Morison suspension furnaces with three stay-bolts on the under side.

The two boilers of the steamer *S*, each with Morison suspension furnaces with "Courley" ends, had two stays between the furnaces. After four years' service it was seen that all these furnaces were cracked at *B*, Fig. 2. They had to be removed. If only one had cracked it might have been laid to the inferiority of the wall, but as all four had to be replaced it was evident that it was in the design. The conditions were that while this boat was in service the fires were drawn every evening, the boilers, of course, being hot; during the night, of course, the cold air circulated through the furnace to the funnel and cooling the entire boiler. In the morning, about an hour before starting, the fires were relighted and steam gotten up as soon as possible. This treatment evidently over-strained the boiler, and caused the above repairs.

In the tug *H* a boiler was placed fitted with one plain furnace, the steam pressure being 135 pounds. The engine was used in connection with a surface condenser, feed-water was taken from the discharge pipe of the circulating pump, and the temperature of the water thus taken being higher than the condensed steam from the hot well. This was done to prevent oil being forced into the boiler with the feed-water. A new engineer of this ship did not think this was necessary, and was very much given to heavily oiling the engine, and he neglected, most unwisely, to use the blow-off cock. After a few months it was seen that when towing the furnaces collapsed, as shown in the dotted lines, Fig. 6. The fire was immediately drawn, which in such cases is very dangerous, as it, of course, increases the heat momentarily far above that in ordinary service. The boiler was then blown off and the tug towed to the works. It, of course, required a new furnace, but times were very hard and such repairs would be extremely expensive. Therefore, the owner proposed another plan. This was to cross-cut the furnace at *A*, and put in another straight tube, as this would be far less expensive and could be riveted up in place and could be quickly done. On inspection the surface of this furnace showed where so much oil had gone to.

The boiler of the steamer *A* showed leaks at the fire-box in the stay-bolts, Fig. 7. As the engineers could not get them steam tight a boiler maker was called in, and this man at once saw what was the real trouble. A plate had bulged and the oil had lodged on these bulges, which soon became overheated and gave way. The stay-bolts were riveted over and then calked, and a cast iron plate was attached, as indicated, to protect the injured places from the flames. It was considered that the oil had been burned off by the overheating, but for the sake of security an extra plate was placed as shown. Not long after the engineer took down this plate and no leakage or bulging was to be seen. All this tends to show most clearly that it is well to keep grease and oil out of the boilers.

Testimonial to Colonel E. D. Meier.

At the summer meeting of the American Society of Mechanical Engineers, held in Pittsburg, May 30 to June 2, a very handsome testimonial was presented to Col. E. D. Meier, president of the society. Herewith is a picture of the testimonial. The text is as follows:

TO COLONEL EDWARD DANIEL MEIER.

The undersigned committee of your fellow members of the American Society of Mechanical Engineers, on behalf of those associated with them, tender to you their cordial regards in

TESTIMONIAL GIVEN TO COL. E. D. MEIER, ON HIS SEVENTIETH BIRTHDAY.

commemoration of your seventieth birthday in appreciation of your distinguished career in military service and in engineering, to which you have made many notable contributions, and in which you have established an honorable name.

M. L. HOLMAN, Chairman.

DAVID F. CRAWFORD.	WILLIAM BENSON MAYO.
CHARLES J. DAVIDSON.	R. S. MOORE.
ARTHUR J. FRITH.	HENRY G. MORRIS.
LEONARD L. GRIFFITHS.	E. GYBBON SPILSBURY.
ANDREW M. LOCKETT.	THOMAS B. STEARNS.
CHARLES H. MANNING.	MAX TOLTZ.

C. J. H. WOODBURY, Secretary.

May 30, 1911.

The testimonial was handsomely illuminated by Tiffany & Company. Accompanying the testimonial is a folio containing the names of the many hundreds of members of the society who contributed.

Announcement was also made that an artist has been engaged to paint a portrait of Colonel Meier as soon as a sitting can be arranged for.

BAD BOILER PRACTICE.

It is the common practice, after all of the seams of a boiler are riveted and calked, and before it is placed on board, to test it with water pressure. Frequently this water pressure is about one and one-half times the working pressure of the boiler. For the lower steam pressures, say less than 150 pounds per square inch, a test pressure is the working pressure plus 75 pounds. Lloyd's Register requires twice the steam pressure, and this is by many engineers judged to be too much, as on this test pressure the limit of elasticity of the material of the shell and stays is often nearly reached.

Let us take, for example, a boiler of 10 feet diameter, with the steam pressure 192 pounds per square inch, the least percentage of strength of the longitudinal seam 85, then the thickness of the shell plate will be according to Lloyd's rules (the longitudinal seams having double butt-straps of equal width, and the breaking strength of the material being 27 tons per square inch):

$$T = \frac{192.120}{21.85} + 2 = 15/16 \text{ inches.}$$

Under ordinary steam pressure the tensile stress to which this shell plate is subjected in its weakest point (between the rivet holes of the outer row) is found by the following formula:

Diameter $\times$ steam pressure $=$ 2 $\times$ thickness of plate $\times$ % $\times$ stress of material, or $120 \times 193 = 2 \times 15/16 \times 0.85 \times S$.

$$S = \frac{120 \times 192}{2 \times 15/16 \times 0.85} = 12{,}700 \text{ pounds per square inch.}$$

The tensile strength being 27 tons $=$ 60,500 pounds per square inch the factor of safety $= \frac{60{,}500}{12{,}700} = 4.75$.

But when tested by a water pressure of 384 pounds per square inch the stress of the shell plate will become 25,400 pounds per square inch.

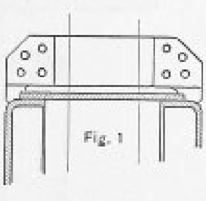
The limit of elasticity of the material having a tensile strength of 27 tons per square inch will be about 28,500 pounds per square inch, so that the limit is nearly reached.

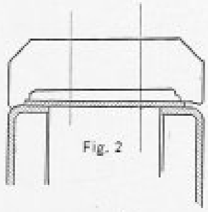
This is the reason why many engineers add to the thicknesses of plates and stays over and above Lloyd's rules in order to sustain with safety the high boiler pressures.

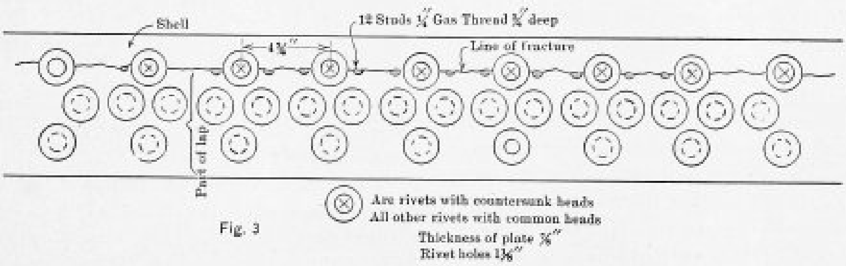
Sometimes it occurs that when under the water pressure one or more stay-bolts break.

In the writer's presence, when testing a boiler with a water pressure of one and one-half times the boiler pressure, which was 192 pounds per square inch, a very heavy knock was heard, and it was thought that one or more stay-bolts had given away, but not the slightest leaking or bulging of the plates showed itself, and therefore the boiler was emptied and carefully inspected. It was then seen what was the cause. The girders for supporting the combustion chamber tops were made up of two plates with a cast iron piece at each end, riveted between the two side plates, as indicated in Fig. 1.

The fitting of one of these stays had not been well done; not resting on the tube plate corner, but only on the edge of the top plate (Fig. 2). When under the heavy test load the edge of the cast iron gave way, and the girder came down heavily on the tube plate corner.







SOME DEFECTS IN MARINE BOILER DESIGN.

In a boiler shop it is necessary that all work should be inspected by the foreman, so that bad work of this kind is not passed. Again, the foreman should be especially careful in a boiler shop as to alteration in the pitch of the rivets in longitudinal seams, which may, if made as indicated in the drawing, diminish the percentage of strength in the joint, so that the intended maximum steam pressure cannot safely be carried. An example of such lack of care with very serious results was experienced in repairing the boiler of the tug *D*.

The shell of this boiler consisted of three plates, the joints of which were treble-riveted lap joints, as shown in Fig. 3. One of these joints started leaking along its entire length, and when thoroughly inspected very small cracks were seen between the rivet holes of the inner row, close to the rivets, which were partly made with countersunk heads, as indicated in Fig. 3. To prevent these cracks spreading, small holes were drilled and tapped with ¼-inch gas pipe taps and plugged. But in so doing a great deal of the material between the rivet holes, which had, of course, to stand the pressure, was drilled away, so that the strain was greater than the tensile strength. The boiler was filled, the fires lighted. and the next morning the first two soon started leaking, and after some hours the seam gave way and all the men of the tug were killed.

D. K.

Periodical Reduction of Boiler Pressure.

In this country alone, within the last twenty years, more than ten thousand boilers have been blown to pieces, resulting in the death of more than ten thousand persons, the injury of more than twenty thousand others, and almost inestimable property loss. Boiler insurance, necessitating inspection at stated intervals, and the efforts of State or city inspectors have been effective in reducing the number of explosions. But even with the improvements in design and better methods of operation required by inspectors, boiler explosions are more numerous than there is reason for.

To accuse inspectors of carelessness, wanton neglect, or of susceptibility to bribery, would not be fair or just to a class of men who are thoroughly competent and adhere strictly to duty. Any visible defect, such as corrosion, a cracked plate or a broken stay, is almost invariably detected and the boiler put out of commission, or operated at a lower working pressure, until repairs are made. Evidently it is not the visible defects to which boiler explosions can be attributed; rather, the invisible imperfections, such as faulty riveting, granulation of the metal and deterioration incident to long service.

That it is good practice to have a large factor of safety for new boilers in order to allow for wear and tear and possible defects of material or construction, is considered of the utmost importance. Is it not just as important, or even of greater importance, to maintain this factor of safety in a boiler through its years of service? It is hardly probable that the material in a boiler is as strong after continued service for a number of years as in the beginning. Deterioration is more than likely to occur, and to what extent depends largely on the service and the care the boiler has had.

To judge the degree of impairment in a boiler at the end of any given time is difficult, and especially so when the impairment is caused by the gradual and indeterminate changes due to successive strains and the action of heat in the structure of the metal itself. It is here that the inspector is liable to err in judgment. There is no set rule to guide him, and unless there is unquestionable evidence as to the extent of the impairment, reduction in pressure may be made sparingly. It is not uncommon to find boilers that have been in service from fifteen to twenty years still operating under the pressure for which they were originally designed. In such a case there is considerable uncertainty as to whether a fair factor of safety has been maintained.

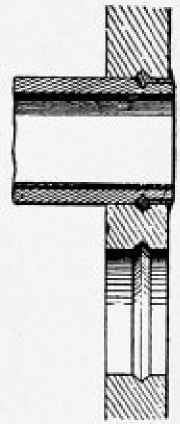
To eliminate this uncertainty it has been suggested that a periodic reduction of pressure be fixed by law and perhaps varied to conform with the service to be imposed upon the boiler. It would, of course, be difficult to determine just what reduction should be made. Even if the boilers were in the same sort of service the amount of reduction selected would be too great in some cases and too little in others because the experience of the firemen, the grade of the metal, and the care given the boilers are all determining factors. It is argued, however, that such a step would be in the right direction, and, although unjust to some, would have a tendency to reduce the number of boiler explosions, which, of course, is the end sought.

Viewing the matter impartially, it would appear that the factor of safety of four to five, usually adopted in construction, is small enough for security at any time, and that the difference between working and bursting pressures should be as great, or even greater, in an old boiler as in a new one. One way to maintain this margin is to adopt a uniform scale of pressure reduction, graduated according to the age of the boiler. Another way—and the one which is almost universally followed—is to leave it to the judgment of the inspector.—*Power.*

Trying to Make Flues Tight.

With regard to flue failures, I will say that flue failures will not be stopped until they weld or braze them in. This can be done now with the oxy-acetylene process. I believe they can and will be put in this way just as sure as they are using air pumps and injectors on engines to-day. It was said for years that air pumps and injectors could not be used, so it has been said that flues could not be welded or brazed in. There is no reason why it will not work if the weld can be made, and this welding is now being done. The flue can be reamed out and the spout will be just as good or better than new.

One great cause of flue failures now is that they are not only about half expanded or rolled when put in, as I have seen flues leak when engines came out of the shop, after having new ones put in.



HINE'S METHOD FOR FLUES.

One cause of cracked bridges is that they are cracked when trying to expand the flues, when it has become loose after being used a while. If you weld or braze flues in, they can use a thicker flue, which will make them last longer where treated water is used.

Having had over thirty-five years' experience on a locomotive in different parts of the country, and used almost all kinds of bad water, as well as good, and for thirty years have made a study of leaky flues, I will say that the only way to stop flue failures will be to weld or braze them in. Expansion and contraction has very little, if anything, to do with making flues leak. After having watched leaky flues for over thirty years I might be able to tell or say something about them. It is a great study and problem.

It is a stand off now between inferior iron and cheap work in putting flues in. The extra cost of failures would more than pay for good iron and having them put in properly.—*D. B. Hines, in the Railway and Locomotive Engineering.*

The Mechanical Stoker Up to Date.

Railway sentiment in favor of the introduction of mechanical stokers seems to make very small progress, but trains continue to be loaded heavier and the fireman's labor of handling the required supply to coal to the fire-box is getting nearer and nearer to the limit of human ability and endurance. For some time after mechanical stokers were first tried on locomotives there was a strong spirit of opposition to the invention manifested among firemen, but that feeling has now almost entirely vanished. A mistaken impression prevails concerning the purpose of a mechanical stoker. It was looked upon by many as a contrivance that would dispense with the

skillful fireman and permit the employing of an ignorant laborer in his place. We were at that time in a position to find out the inside views of railroad officials concerning mechanical stokers and it certainly was that the mechanical stoker would lighten the labor of the fireman and enable him to do his work more skillfully and with less effort.

Ingenious people readily receive the impression that devising a practical mechanical stoker for a locomotive would call for small inventive ability; but very many inventors have found out that the designing of such a stoker is one of the most difficult inventive problems ever undertaken. At first inventors thought that a device which would inject the coal over the fire-box from a hopper loaded by the fireman would be satisfactory, and several patented stokers were made in that manner and gave satisfaction as far as their work went. But familiarity with that type of stoker aroused the question why should it not have a conveyor that would bring the coal from the tender to the hopper? There is where the problem of this invention now rests. There are several mechanical stokers that perform their functions satisfactorily after the coal has been placed in the hopper; but there has been no combination of carrier and stoker brought out that receives an unmitigated verdict of approval.—*Railway and Locomotive Engineering.*

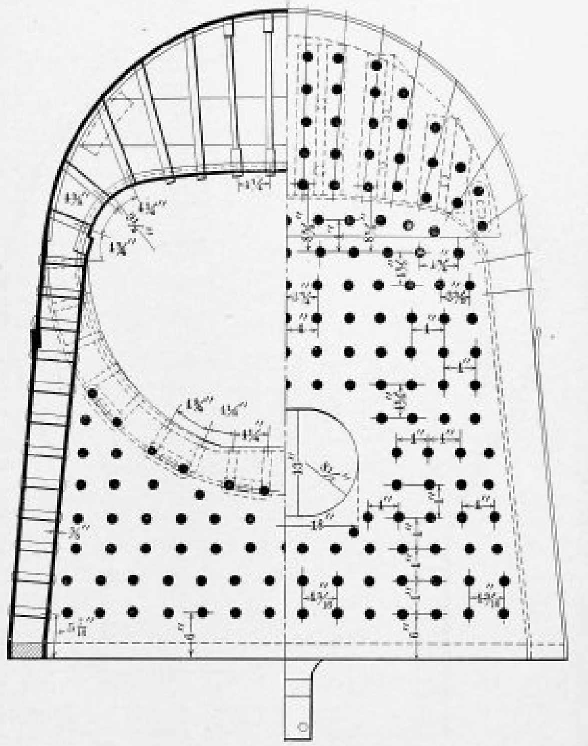
FIREBOX REPAIRS.*

While there are over fifty different types of locomotives running on the world's railways, their boilers have nearly all the same general features. The chief variations are in the form and structure of the fire-box. This box is the heart from whence the power-giving movement of the locomotive comes. Its form may be flat or round-topped, narrow or wide-based, but the general principle is the same.

Coming to the problem of the careful use and repairs to locomotive fire-boxes it may be truthfully said that while no part of the locomotive gives so much trouble as the boiler, by far the largest amount of these troubles are due to the fire-box. The avoiding of these troubles or overcoming them demands more time and attention than any other part of the machine does. This is not to be wondered at when we consider the forces that are operating towards the destruction of the fire-box when in use, taking a first-class passenger locomotive as an illustration. If the heating surface of the fire-box amounts to 200 square feet with a steam pressure of 200 pounds per square inch, there is less than 2,880 tons pressure upon the sides and top of the fire-box. If to this we add the variations in temperature tending to alter the crystallization of the metal, the difference in the expansion of the outer and inner sheets of the boiler, the impurities inseparable from all kinds of water, the destructive action of the intense heat on rivet heads and the projecting ends of flues, the sand-blast action of the fine particles of coal, and the tendency of stay-bolts to fracture by reason of the unequal expansion of the boiler sheets, it will be seen that the causes of much trouble and rapid decay are not far to seek.

With regard to holding the sheets of the fire-box in place, the sides and back of the box are secured to the outer plates by stay-bolts, the front sheet is secured by the flues riveted to the smoke-box sheet, and also to the sheet in the front end or smoke-box. In supporting the top or crown sheet of the fire-box there are three methods in use. The first, and generally admitted to be the best, is by screwed stays attaching the crown sheet of the fire-box directly to the outer shell of the boiler; the other methods are by having girders or bars placed on the top of the crown sheet of the fire-box, the bars being secured to the crown sheet by screwed bolts. The ends of the crown bars rest on the edges of the two side sheets. From these girders, slings are attached that reach suitable attachments on the outer roof plate.

The Belpaire system of bracing, so called from its inventor, Mr. Belpaire, a Belgian engineer, is an adaptation of the radial stayed type, skillfully contrived to meet the changing stresses and insure a larger degree of rigidity of the parts. The main objection that has been raised against the system is that it has been found difficult to keep the crown stays tight in the spaces



RADIAL STAYED CROWN SHEET.

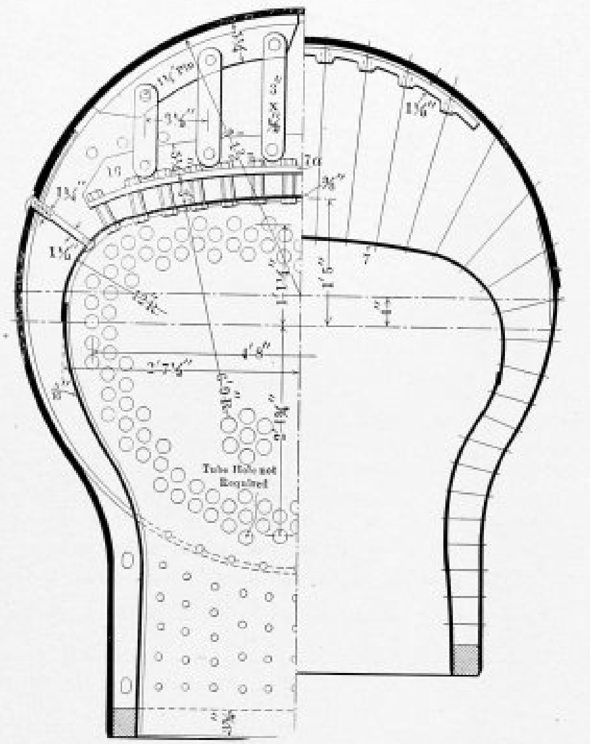
near the ends of the braces running from the back head to the top of the fire-box shell. The trouble is generally conceded to be that the rigid system of bracing does not allow the flue sheet sufficient room to expand vertically. Various modifications of this type have been successfully installed, and when fitted with staybolts of a flexible type the results have been that the breakage of stay-bolts have greatly diminished. In testing flexible stay-bolts the caps should be removed, as hammering on the caps will speedily affect the threads. Careful experiments have shown that flexible stay-bolts are very reliable and need not be subjected to inspection oftener than once in a year, the period having recently been extended by the government commission to sixteen months.

From this brief outline of the structure and causes of failure of the fire-box it will readily occur to those engaged in the running repairs of locomotives that an avoidance of rapid changes of temperature is a natural and important safeguard against some of the troubles to which we have referred. With the important improvements that have been made in recent years in boiler-washing appliances, with the refilling of the boiler by hot water, a valuable advance has been made in the saving of fire-boxes, but where such apparatus is not in use it is well, however limited the appliances may be, to constantly guard against a sudden change of temperature.

It should also be borne in mind that the washing of the boiler may readily become a mere perfunctory performance unless accompanied by a thorough and systematic inspection of the boiler. To this end it will frequently be noticed that there

* *Railway and Locomotive Engineering.*

are parts of nearly all kinds of boilers that are difficult of inspection and, of course, difficult to keep perfectly clean. This is especially the case in boilers where the crown sheets are equipped with crown bars, crow's feet, or other attachments. In such boilers it is the proper province of those having charge of repairs to instal plugs of sufficient size not only to admit of a thorough inspection of the sheets, but also for the admission and operation of such tools as may be necessary in completely removing the scale that accumulates very rapidly on the crown sheets of fire-boxes



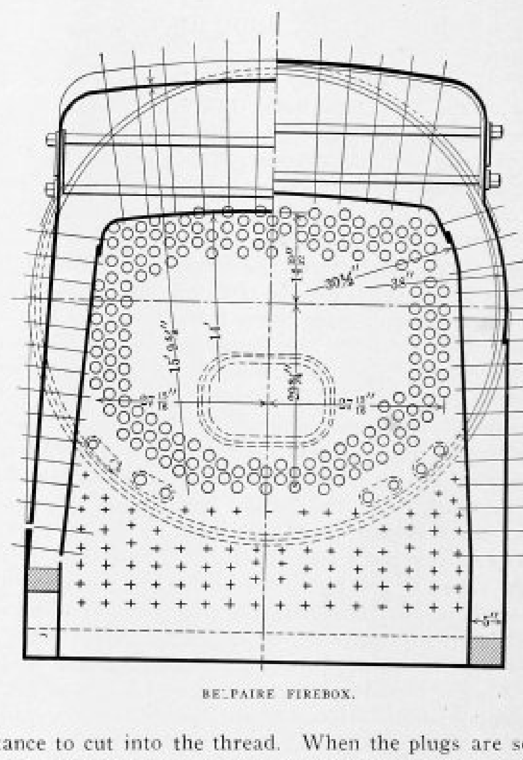
FIREBOX WITH CROWN-BARS.

so constructed. The hardening of scale on the crown sheet makes its presence known by the appearance of lime around the rivet heads, and also by particles of coal adhering to the sheet. With such evidences of internal incrustation, if it is not practicable to have holes cut for inspection plugs, it is advisable to have the dome cap and throttle pipe removed to reach and clean the crown sheet thoroughly. It is frequently noted that the same appearances are observed over the fire-box door, showing an accumulation of scale in that part of the inner chamber of the boiler. In this case the insertion of a plug over the fire-box door is a matter of easy attainment, and that part of the boiler may be readily cleaned. In the matter of plugs it should be noted that the threads are subject to injury, and plugs should be made sufficiently long and with sufficient taper to submit to having the threads rechased and the holes retapped. In putting back plugs after a washout it is advisable to coat the plug with graphite grease.

The common method of testing stay-bolts is, when the boiler is emptied of water, to hold a sledge on one end of each bolt, in rotation, and tap the other end with a hand hammer. A broken stay-bolt that has its broken ends separated can be very readily found, but where the broken ends are pressing hard against each other the break cannot be so readily detected. Where compressed air is available a pressure of 40 pounds per square inch in the boiler while the testing of the stay-bolts is going on is of assistance in detecting broken staybolts, as the pressure has the effect of slightly separating the fractured parts from each other.

In view of the fact that sound tests are not altogether reliable, an excellent method of detecting broken stay-bolts was established when the practice of drilling holes 1 inch deep in their outer ends came into use. The stay-bolts almost invariably break near the outer sheet of the boiler, and hence the hole need not be more than 1 inch in depth. The period between inspection is different in different localities, the time varying from one month to six months, and even longer. The extra work in removing lagging should not be permitted to interfere with the proper and systematic examination of so important a part of the locomotive as the fire-box.

One of the first indications of the pernicious influence of the formation of scale around the stay-bolts will be the appearance of cracks in the sheets running from the stay-bolt holes in the lower part of the fire-box. If such cracks are attended to in time they may be remedied by removing the stay-bolt, and drilling a hole near the stay-bolt hole, leaving about one-eighth of an inch of metal between the stay-bolt hole and the new hole. The center of the new hole should be located in the crack and need not exceed ¾ inches in diameter. The hole should be tapped with a fine thread tap and a suitable plug inserted. If the crack extends further than the space covered by the plug, another hole should be drilled and the center of this hole should also be located in the crack, and the drill should be allowed to cut into the first plug a sufficient



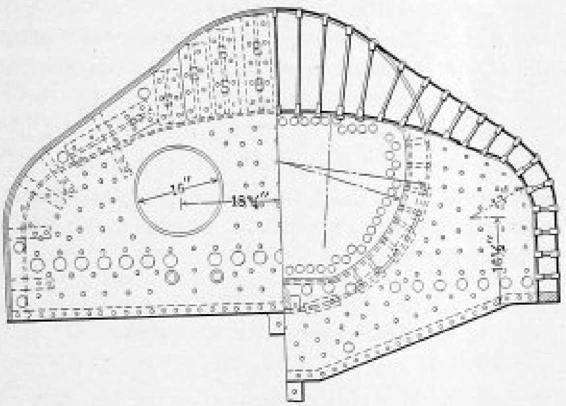
BELPAIRE FIREBOX.

distance to cut into the thread. When the plugs are securely in place, a projection of two threads of the plugs should be allowed for riveting over. The stay-bolt hole should then be retapped and a new bolt fitted and riveted in the enlarged opening.

It is hardly necessary to state that when a considerable number of cracks manifest themselves, and especially if more than one crack is observed as running from the same bolt hole, the sheet may be set down as nearly past remedy, and new fire-box sheets alone will place the boiler in safe condition.

It is sometimes observed that defects will be confined to a limited area, in which case the weakening part may be cut out and a patch put on. The patch should overlap the opening 1½ inches, and holes to admit ¾-inch tap bolts should be drilled around its outer edge 1¾ inches apart, or as nearly so as the space will admit. The holes in the patch should be countersunk and the tap bolts carefully fitted to match the angle of the countersink. The holes in the sheet to receive the tap bolts should be tapped with a 12-thread taper tap. The patch should be annealed and fitted as closely as possible to the sheet. When the tap bolts are tightly screwed into place the patch should be hammered around the bolts and the tap bolts again tightened and finally hammered over, securely closing the countersink. The outer edge of the patch should be caulked as the last part of the operation.

Plugs and patches may prolong the life of the side sheets of the fire-box, but in five or six years it will be necessary to



WOOTTEN FIREBOX.

remove the lower part of the side sheets on the fire-box as well as the flue sheet. Indeed if the fire-box is of the shallow kind, it is more advantageous to cut out the entire sheets, as in the case of half sheets it is often found that the seam where the new and old metal is found is very apt to develop cracks in the old part, just as patching an old garment will develop new rents in the vicinity of the new material.

As a rule, crown sheets outlast several sets of side sheets, from the fact that they are not subject to the extreme changes in the temperature. The formation of the fire-box has also much effect on the durability of the sheets. In the Wootten type of furnace, the part that fails first is generally that portion of the sides that approach the vertical. It will also be noted that the door sheets of fire-boxes that slope forward do not last as long as those that are vertical. This is readily accounted for by reason of the wiping action of fire and water circulation on sloping sheets. On the other hand, it is noticeable that fire-box sheets that slope outwards are more durable. Whether the sloping sheets induce circulation and greater steaming qualities which may overcome the increased cost of maintenance is a question with which running repairs may be closely associated, but into the merits of which we need not enter at present. Suffice it to say that in whatever form the fire-box of a locomotive appears it requires constant watchfulness, skill in repair, and thoroughness in cleaning. On its stability largely depends the generation of the energy that creates and sustains the power of the steam engine.

High Steam Pressure in Locomotive Service.

A report by Professor Goss on the use of high-steam pressure in locomotive service has recently been issued by the University of Illinois. It was only a short time ago that high-pressure steam was advocated for a remarkable increase in the economy of a locomotive. Steam pressures were increased from 150 to 185, then to over 200 pounds and finally to 240 pounds per square inch. The reports from tests of locomotives using such high-pressures presented some startling figures as to the increased economy and efficiency, and there was a general rush to the use of high-pressure steam in new locomotives. The report from Professor Goss brings out further figures which are more nearly the truth in regard to the use of high-pressure steam. The difference in coal consumption per indicated horsepower-hour from Professor Goss' report amounts to only .69 pound between 120 and 240 pounds pressure, a drop from 4 to 3.31 pounds of coal. If the steam pressure is above 160 pounds there is a small gain in fuel, but the use of high steam pressure involves a high cost of maintenance. The comparatively small increase in economy and efficiency, therefore, is offset by the increase in cost of maintenance. The more sensible method of obtaining better results is to use a boiler of larger capacity with a moderate steam pressure. A boiler of this type probably will not weigh more than a smaller high-pressure boiler, and the cost of maintenance will certainly be reduced.

Boiler Shop Tool-Room Practice.*

BY L. M. STEWART AND R. B. VAN WORMER.

A systematic and satisfactory method of handling and maintaining the small tools in the boiler shop is in effect at the Waycross, Ga., shop of the Atlantic Coast Line. Each boiler maker and boiler maker apprentice has a number for checking in and out. When first employed he gives his name and check number to the tool room keeper, who makes a record of it, and furnishes him with six tool checks and a small iron tool box with a number on it corresponding to the check number. The tool room man sees that each tool box is at all times equipped with three flat chisels, three cape chisels, two round-nose chisels, one center punch, one 12-inch monkey wrench, one standard alligator wrench, one hand hammer, one electric light extension cord and lamp, three drift pins and two hand calking tools. The tool boxes of men assigned to certain classes of special work are also temporarily supplied with the tools that may be required. The tool boxes are returned to the tool room every Saturday night; they are checked over, and all broken or badly-worn tools are replaced with repaired or new tools.

All other tools required by a boiler maker, including pneumatic tools, are checked out under the tool check system. The number of checks furnished to one man is limited to six in order to prevent any one workman having more tools than actually required, and at the possible expense of other work. If he should require additional tools he can exchange with some of the six tools already checked against him. This reduces the number of tools required to a minimum, and their time in actual service to maximum. No boiler maker or apprentice is allowed to keep any tools in his clothes locker or private box, as such practice keeps a large number of tools out of service, which cannot be easily located. The boiler maker has his helper carry the six checks, which are secured to a ⅛-inch brass wire safety pin that can be fastened to the jacket. The boiler maker sends his helper for the tools and holds him responsible for the checks. The boiler maker is, however, held responsible for both the tools and the checks.

All pneumatic tools must be returned to the tool room every night. The hammers are stored in a tank of oil over night. The air motors are placed on suitable racks and every morning both the air drills and the hammers are thoroughly oiled for service. Every small or portable tool used in the boiler shop is kept in boiler shop tool room. All wedge bars and holding-on bars are stored on a rack adjacent to the tool room and under supervision of the tool room keeper. We have adopted a standard make of air hammer and air motor, and keep a small number of repair parts in stock at the tool room to facilitate rapid repairs to all air tools, including those sent in from outlying points.

We have experienced success in driving stay-bolts with a long-stroke air hammer and find it results in saving of time, as well as giving excellent results in bad water districts.

* From the *Railway Age Gazette*.

The Boiler Maker

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

A Practical Experiment.

Every once in a while some heretofore generally admitted theory or idea receives a shock from the work of careful researchers. We are prone to accept assertions from the lips of those who make experiments, and, while the deductions are correct for certain conditions, they are very often wide of the mark if accepted in general. We attribute this to the fact that much research work has, of necessity, to be done in miniature. In this issue we give extracts from the tests made by the Bureau of Mines on the flow of heat through furnace walls. Some remarkable and certainly highly practical information was obtained with a full-sized boiler under working conditions as regards the flow of heat through boiler settings, and the results quite upset the text-books' assertions and opinions held in the past as to air space in boiler settings. Instead of an air space being advantageous, the experiments clearly show that this is not so, except with low temperatures. Again, the position of the air space is found to be more effective if placed as far as possible away from the furnace, which, of course, would follow, as there lower temperatures would exist, and, as far as we can recall, this is the first time any mention of the position of an air space has been made. It is shown that a space in the boiler setting is advantageously filled with material, if this material is loosely sifted in and not tamped down. The plastic effect of the filling reduces the air leakage, and such material as mineral wool, sand or ashes are recommended. It must be remembered, however, that with low temperatures, say from 600 degrees Fahrenheit down, the air space is more advantageous than solid walls. If it were possible with low temperatures to produce a vacuum in the air space, of course, there would be a very great gain.

The information given in the report should be most carefully remembered by all boiler people, as it means a saving of many dollars and cents for their customers; and, as time goes on, economy in fuel will press more and more for recognition, and, no matter how well a boiler may be designed, if improperly set it may easily prove unsatisfactory in fuel consumption. We should strongly recommend our readers to obtain from the Bureau of Mines, Washington, D. C., a full copy of the tests made by it, and we think the very greatest credit is due to the men who so ably carried out this very important and practical test. We repeat, that here was no laboratory deductions, but conditions were those which would exist in actual every-day practice.

The Apprentice Question.

In our last issue we commented upon the interest shown in the apprentice question at the last meeting of the Master Boiler Makers' Association at Omaha. We wish now to add a few words further on the subject.

There seems to be an unwillingness, most unfortunately, on the part of some of those who have the power to advance the wages of the apprentice when he is out of his time, and this seems to us a most serious mistake. The young man who is worthy of being taught his trade, who works conscientiously, cannot be expected to have the loyalty for his shop, which is of such value to the concern employing him, if he does not feel he is getting fair treatment. It is to be hoped that this reluctance to properly advance the apprentice's pay to that of a journeyman is only occasionally encountered, but we fear this is not the case, as there seems to be considerable dissatisfaction on the point.

We are inclined to think that it is advantageous for a young man just out of his time to take employment in some shop other than the one in which he serves his times, as most shops differ in their equipment, management, and often in their methods, but it is manifestly wise to try to retain the young man finally who is brought up with the shop, as it is clear that his familiarity with his associates, tools and general shop methods will render him of greater value than men with even far greater experience who are new employees; and then, above all, there is that personal interest and pride which can be engendered, and should be engendered, in all apprentices in their shop and in those who have to direct them, and we quite agree with an expression of someone at the meeting which referred to the fact that it is wise for a railroad to develop its own mechanics, and we earnestly hope that the short-sighted policy of holding back just wages is not often the case, as we have been led to believe.

COMMUNICATIONS.

Concave and Flat Boiler Heads.

EDITOR THE BOILER MAKER:

The following question appears in a recent issue of an engineering journal, and the answers that were made furnish food for thought: "Is a concave head of a boiler stronger than a flat or convex head? If so, why?

Four correspondents answered the question. The first said: "A concave boiler head is the strongest, because it braces itself against the shell of the boiler." The second made answer like this: "A concave or convex head is stronger than a flat head of a boiler, as it cannot be bulged owing to its rigidity of form." The third answered thus: "Yes, a concave head is stronger on account of the enormous outward pressure of the steam." The fourth answered in this way: "A convex head is stronger, because a convex head has less pressure against it."

The foregoing answers seem to indicate that the correspondents did not quite understand the main features of bumped heads, as used in steam boilers. Bumped heads may be called "concave" or "convex," according as to how they are placed in the boiler. The hollow, rounding side of a bumped head is called the concave side, and the swelling, rounded form opposite the concave side is called the convex side. Sometimes the convex side is placed outward, thus leaving the hollow or concave side to confine the pressure in the boiler; and then, again, the concave side is on the outside and the pressure is restrained by the convex surface. Bumped heads are stronger than flat heads of the same diameter and thickness. This is true whether the concave or convex side of the head be placed to resist the pressure within the boiler. Of course, the comparison is made on the assumption that the flat head is not supported by braces. When the pressure acts against the concave side of a bumped head it is at its best, because it is already in the form that the pressure would naturally tend to make it. It is for that reason that bumped heads do not require to be braced, as required in flat heads. When the convex side of a bumped head is placed inside the boiler its resisting power is not as great as when the concave side meets the pressure, for the reason before given. But it is stronger than an unstayed flat head of the same diameter and thickness. It is important that we make clear our meaning when referring to concave and convex heads, so that no doubt will exist in the minds of those to whom we are addressing either a written statement or a verbal message. It seems to me that the way the rules (which I am about to give) are worded makes clear beyond a doubt as to which is which, as between concave and convex heads. Here they are: To find the safe working pressure per square inch for convex heads, that is, heads which present the concave side to the pressure, and when single-riveted to the shell, this rule is employed: $\frac{t \times T}{r}$ = safe pressure. In which t = thickness of the head in inches; T = one-sixth of the tensile strength of the material of which the head is made, expressed in pounds per square inch section, and r = one-half the radius to which the head is bumped, also expressed in inches.

When heads are double riveted to the shell this rule should be used: $\frac{1.2 \times t \times T}{r}$ = safe pressure per square inch. But if the convex side of a head is placed inside the boiler to resist the pressure, then the respective results obtained from the rules given must be multiplied by the value 0.6. Suppose, for example, that by using the first rule given the safe working pressure obtained is 250 pounds per square inch when the pressure acts against the concave side of the head; if the head were reversed so that the convex side received the pressure, then the safe working pressure would be $.6 \times 250 =$ 150.0 pounds per square inch.

A few words about the radius to which the head is bumped. This is a poser to some, if we may judge by the number of inquiries concerning the matter. Lack of knowledge of geometrical drawing is responsible, I think, for the difficulty that some readers have in understanding what is meant by "the radius to which a head is bumped." Here is a way that is sometimes used: To find the radius to which a head is bumped, square one-half the diameter of the head, expressed in inches, and divide the product by the height of the bump, also taken in inches. To the quotient so found add the height of the bump in inches, and finally divide the sum by 2.

In view of the foregoing rules and explanations, which are current practice in the United States at least, what could have been the understanding of the persons who answered the question alluded to at the beginning of this communication?

Scranton, Pa. CHARLES J. MASON.

Once More from Old Mexico.

EDITOR THE BOILER MAKER:

In your January issue I wrote about how I try to prevent fractured flue sheets at top flange and what kind of a patch I put on that gives no trouble when the flange has a fracture.

I am now going to write concerning the kind of a patch I put on a fractured side sheet, how I treat all fractures and what I think about stay-bolts; also, how I try to have a set of rules adhered to, to prevent leaky flues and stay-bolts.

When side sheets fracture at stay-bolts I take out the bolt as soon as possible and put in a larger bolt, using the old thread in wrapper sheet; therefore I must make a large and small end to my bolt, but I save the outside wrapper sheet, so when putting in a new fire-box we can put in the original-sized stay-bolt. When the fracture shows a second time I plug it with copper. I find copper gives better satisfaction than iron, as it is not apt to come loose, as does an iron plug. When fractures extend between two stay-bolts I put on a patch, as follows:

I space the stay-bolts 4 inches center to center, and put on a patch 5½ inches wide; that is, if the fracture to be patched is only between two stay-bolts and in a straight line. I use ⅜-inch fire-box steel annealed, as I believe it is better, as it gives the patch bolt more bearing in the countersink, and is not so apt to fracture from patch bolt to calking edge. I space my hole in patch 1¾ inches and use 13/16-inch patch bolts. I also use a copper gasket, 1/32 inch, back of my patch. When calking I use a heavy fuller. I then chip the lap as bevel as I can without cutting the patch-bolt head, and cut away all the fuller mark down to 1/32 of the edge of patch. My patch bolts are finished flush with patch; by doing this the fire has no chance to act on the patch or patch bolts. I never use a tool called the "Frenchman" on a patch, stay-bolt or rivet, but only a round, flat-hand tool. I have put patches on every way I could possibly think of, and the above application of a patch gives me excellent results. When these big, wide fire-box engines came here they had a button-head radial. As soon as they began to give trouble I put in a taper bolt, using a tap tapered 2 inches to the foot. Radials do not give any trouble after applying these taper bolts. Stay-bolts on side sheets which have ragged edges in fire-box side will leak very badly until the rags are cut off and the head of the bolt cut down to feather edge with a round flat-hand tool. I now have less leaky stay-bolts. Some of these stay-bolts had a head on them and were threaded three and four threads in the plate. I believe this is too much, so I cut them down to two full threads. The more you calk the bolt the looser it gets and edges curl out; to prevent this I cut them down to two threads.

When applying stay-bolts in this bad-water district I make a good, snug fit in the fire-box, no matter how loose they are outside, and I always get good results.

After closely watching results of ⅞, 15/16, 1, 1 1/16-inch stay-bolts in side sheets, I find ⅞-inch stay-bolts give me the best service, in not fracturing so frequently. But I believe, and I wish I could try it, that 11/16-inch stay-bolts, spaced 3½ inches from center to center, would give better results. The stay-bolt would have as much strength being spaced closer than the longer ones if spaced 4 inches from center to center. The stay-bolt head in the fire side would be smaller, and therefore the fire would have less effect on them. I wish some one would express himself on this point, or suggest something better. If any one has tried it I would like to have him speak up. The breaking of stay-bolts is a subject much talked about, and will continue to be talked about until we quit using them. I average about twenty broken stay-bolts on my wide fire-box engine in six months. I always test my engines with washout plugs out and boiler warm, and also place these washout plugs in a position so I can see if there are any fractured stay-bolts which I cannot find with the hammer; also, washout plugs are placed so I can remove scale with ease.

I have indifferent success, but when everything is done as I wish it to be done I need no boiler maker for days. When I have indifferent success I have to work engines every time they enter house. I have wood-burners, coal-burners and oil-burners to take care of.

Montery, Mexico. D. L. AKERS, F. B. M., T. N. DE M.

Our Friend the Kicker.

EDITOR THE BOILER MAKER:

My position in the world is that of a "kicker." I have always been that way. I had only a fair education, and some of those men who taught me seemed to think that my brains were in my trousers, and the application of the toe of their boot would impart more knowledge to me than could be got into my head.

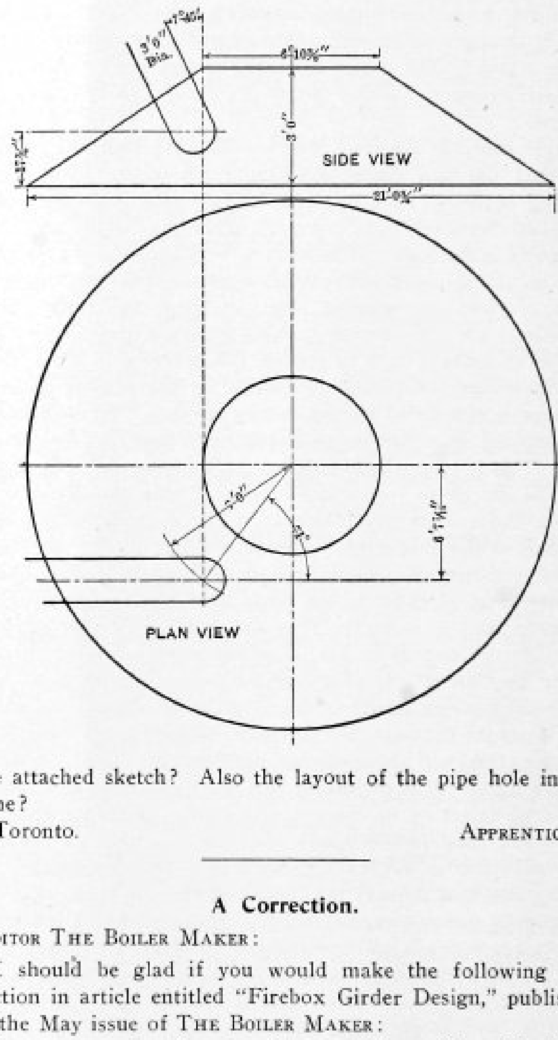
Now, Mr. Editor, I have just read a book, and I saw charts and curves and no end of words, and when I got through I could dimly see that the fellow who wrote it was paid to make it show that what he was writing about was a good thing—to sell. I don't kick so much on this, but for us poor "numskulls" I insist that he should have wound up something this way: "Buy Blank's machine or you will be very sorry." Now, we could have all understood that, but he started out to show that certain conditions give certain results, and for the life of me I could not "dope it" out when I got all through whether these results were good or bad. What he wrote put me in mind of a rhyme I used to hear when I was a kid: "The last that came foremost were troopers behind." One thing got me "woosey" was that he said "to become skilled in the use of this machine requires very little time for an ordinary workman." I do not believe that is true. Nothing that is fair to call "skill" can be obtained in a little time by an ordinary man, or even a good one. Let us assume that the author of the work was talking about riveted joints or welds. All right, go ahead and chin about the analysis and the charts, and a lot of things I do not understand; but what I kick at is, why can't he wind up about this way: "In order that the lazy lunkheads can understand what all this is about, I say, 'a riveted joint is only about half as strong as a solid piece, or a welded joint is five-eighths as strong as a solid piece' "—if either of these is true. I could then have felt that I had learned something and knew something more than when I started in to read, and I could have at least had the pleasure of pointing to my authority when I made either of the above statements. What I want is, Mr. Editor, a "lunkhead windup" to much that appears in print.

Chicago. "KICKER."

Layout of a Pipe Connection to a Cone Wanted.

EDITOR THE BOILER MAKER:

Will you be so kind as to ask your readers if any one can give the layout of the pipe connection to a cone, as shown in



the attached sketch? Also the layout of the pipe hole in the cone?

Toronto. APPRENTICE.

A Correction.

EDITOR THE BOILER MAKER:

I should be glad if you would make the following correction in article entitled "Firebox Girder Design," published in the May issue of THE BOILER MAKER:

On page 124, the formula given as $p\ (L - P) = W$ should read $p\ (L - P)\ D = W$.

On page 125, $I = \dfrac{rd^3}{12}$ should read $I = \dfrac{td^3}{12}$.

It should also be noticed that t and d are both interchangeable symbols for the thickness. F. A. GARRETT.

Lincoln, England.

Laying Out Spiral Pipe.

EDITOR THE BOILER MAKER:

I would like to know, through your valuable paper, the correct and simplest method of laying out a spiral pipe. Can it be laid out by triangulation? I hope some of your readers will get interested in this subject, as it seems so simple, but is not an easy task to undertake if a person does not know the first principles. INQUIRER.

Oklahoma City.

EDITOR'S NOTE.—In our January issue, 1909, will be found an article on "Laying Out Spiral Pipe," and also in our October issue of 1910 the question of "Strength of Spiral Riveted Pipe" is remarked upon. We should be very glad if some of our readers can suggest another way of laying out spiral pipe, and we hope to hear from them.

A Gage Glass Question.

EDITOR THE BOILER MAKER:

Standing in the boiler room one day I watched the fireman cutting a watch gage glass to length. After he did this he took a piece of waste and dipped it in a little gasoline and rammed it into the hole so as to get the dirt out. Looking about him for something to push the waste through with, he took up a round file that the machinist had brought in for some job and used that. The owner of the place was with me, and he went over to the fireman and said: "You must not use that glass, as it will break because you use a metal in cleaning it out." Of course, the fireman would do as he was told, but he looked as if he did not believe the boss, and the boss saw that, so he said to him: "Lie the glass upon that shelf and you will see in a few days that it will crack," and it did. I told this story to several and it is not generally believed.

Have any readers of THE BOILER MAKER had a like experience, or can they throw any light on the subject?

LAP JOINT.

TECHNICAL PUBLICATIONS.

Engineering Descriptive Geometry. By F. M. Bartlett, Commander, U. S. N., and Theodore W. Johnson, A. B. M. E., Professor of Mechanical Drawing, United States Naval Academy. Size, 6 by 9 inches. Pages, 159. Illustrations, 137. United States Naval Academy. Price, $1.50.

This work of Commander Bartlett and Professor Johnson seems to us to be ideal in its simplicity and clearness. It is so difficult for most minds to think in more than two planes, and probably the student is more embarrassed by trying to understand descriptive geometry than by any other branch of mathematics.

The few errors in the first edition have been corrected and some of the drawings have been modified. We have tried to write something which would give an idea of the true value of this book, but we find we cannot do better than copy from the preface of this work, and we compliment most heartily the authors. It says:

The aim of this work is to make Descriptive Geometry an integral part of a course in Mechanical or Engineering Drawing.

The older books on Descriptive Geometry are *geometrical* rather than *descriptive*. Their authors were interested in the subject as a branch of mathematics, not as a branch of drawing.

Technical schools should aim to produce engineers rather than mathematicians, and the subject is here presented with the idea that it may fit naturally in a general course in Mechanical Drawing. It should follow that portion of Mechanical Drawing called *Line Drawing*, whose aim is to teach the handling of the drawing instruments, and should precede courses specializing in the various branches of Drawing, such as Mechanical, Structural, Architectural and Topographical Drawing, or the "Laying Off" of ship lines.

The various branches of drawing used in the different industries may be regarded as dialects of a common language. A drawing is but a written page, conveying by the use of lines a mass of information about the geometrical shapes of objects impossible to describe in words without tedium and ambiguity. In a broad sense, all these branches come under the general term Descriptive Geometry. It is more usual, however, to speak of them as branches of Engineering Drawing, and that term may well be used as the broad label.

The term Descriptive Geometry will be restricted, therefore, to the common geometrical basis or ground work on which the various industrial branches rest. This ground work of mathematical laws is unchanging and permanent.

The branches of Engineering Drawing have each their own abbreviations and special methods adapting them to their own particular fields, and these conventional methods change from time to time, keeping pace with changing industrial methods.

Descriptive Geometry, though unchanged in its principles, has recently undergone a complete change in point of view. In changing its purpose from a *mathematical* one to a *descriptive* one, from being a training for the geometrical powers of a mathematician to being a foundation on which to build up a knowledge of some branch of Engineering Drawing, the number and position of the planes of projection commonly used are altered. The object is now placed behind the planes of projection instead of in front of them, a change often spoken of as a change from the "1st quadrant" to the "3d quadrant," or from the French to the American method. We make this change, regarding the 3d quadrant method as the only natural method for American engineers. All the principles of Descriptive Geometry are as true for one method as for the other, and the industrial branches, as Mechanical Drawing, Structural Drawing, etc., as practiced in this country, all demand this method.

In addition, the older geometries made practically no use of a third plane of projection, and we take in this book the further step of regarding the use of three planes of projection as the rule, not the exception. To meet the common practice in industrial branches, we use as our most prominent method of treatment, or tool, the use of an auxiliary plane of projection, a device which is almost the draftsman's pet method, and which in books is very little noticed.

As the work is intended for students who are but just taking up geometry of three dimensions, in order to inculcate by degrees a power of visualizing in space, we begin the subject, not with the mathematical point in space but with a solid tangible object shown by a perspective drawing. No exact construction is based on the perspective drawings which are freely used to make a realistic appearance. As soon as the student has grasped the idea of what orthographic projection is, knowledge of how to make the projection is taught by the constructive process, beginning with the point and passing through the line to the plane. To make the subject as tangible as possible, the finite straight line and the finite portion of a plane take precedence over the infinite line and plane. These latter require higher powers of space imagination, and are therefore postponed until the student has had time to acquire such powers from the more naturally understood branches of the subject

F. W. B.
T. W. J.

The Slide Rule—A Practical Manual. By Charles N. Pickworth. Size, 5 by 7½ inches. Pages, 118. Illustrations, 34. New York: D. Van Nostrand & Company. Price, $1.00.

The value of this little book on the slide rule is largely proved by the fact that it has passed through eleven editions, and in the present issue it has been revised and extended. There is not much to be said on the subject that is new. The significance of various gage points is commented upon, and some new styles of slide rules are described. It seems from our observation that a person once started on the study of the slide rule very soon "gets the habit," and its practical use is really endless, and to the busy engineer or draftsman it is of the very greatest help, and we strongly recommend that this little book be purchased, knowing it will prove valuable.

Self-Taught Mechanical Drawing in Elementary Machine Design. By F. L. Sylvester, M. E. Size, 5¼ by 7¼ inches. Pages, 325. Illustrations, 218. The Norman W. Henley Publishing Company, New York.

All through this work the author has stuck closely to the highly practical. The mathematics needn't frighten anyone. They are extremely simple, clear and can be understood by anybody that can multiply, divide and subtract. It is much more than a book just on learning to draw and design, as it goes into the fundamentals of physics clearly and concisely. It gives excellent examples of various accepted styles of mechanical contrivances, and it would seem to us that the apprentice should welcome the book most heartily. The only thing that we criticise is the author's idea of making self-study easy. We are not of the opinion that anything that is easily obtained sticks well. A little hard digging is good. The ambitious boy that wants to know something can learn, but there is a never-ending lot who are mentally ambitious and thoroughly lazy. This class want their study in capsules to swallow at a single gulp, and we hardly think that the class is worthy of consideration, but any determined young man in the mechanical trade can read Mr. Sylvester's book with advantage.

Steam Turbines. By Joseph Wickham Roe, M. E. Size, 62 by 9½ inches. Pages, 137. Illustrations, 77. Numerous tables. New York-London: McGraw-Hill Book Company. Price, $2.

Professor Roe offers this work on steam turbines to the student, whether at a school of engineering or in the engine room. It is concise, but the information given can be supplemented, as the Professor has adopted the excellent method of giving references, which are generally available. At the end of each chapter details of construction of various makes of turbines are shown. It is, of course, supposed that the student is somewhat versed in mathematics, but if he is not, he will not regret buying the work, as there is much explained therein which requires no mathematics whatever.

Gas Engines. By W. J. Marshall and Capt. H. R. Sankey, R. E. Size, 6 by 8½ inches. Pages, 278. Illustrations, 127. Price, $2.00.

We hardly believed it possible that there was room for another book on gas engines, but after reading the results of the labor of Messrs. Marshall and Sankey we feel that a very valuable addition has been made to the literature concerning what is at times a very provoking prime mover, and to those who study this work many of the provoking actions of a gas engine will become things of the past. "Mysterious action" is only a very easy name for pure ignorance, and there seems to be a determined resentment to thoroughly understand gas engines, and one would believe there is some more satisfaction in guessing at what is the trouble than understanding its cause. The illustrations in the book are most admirably clear, and we recommend it with confidence to all who have anything to do with internal-combustion motors.

Power. By Charles E. Lucke, Ph. D. Size, 5½ by 8 inches. Pages, 304. Illustrations, 223. New York, 1911: Lemcke & Buechner. Price, $2.00.

Professor Lucke's book is an admirable one for every student to read at the very outset of his engineering studies. In a most pleasing manner the reader is carried from the past into the present concerning prime movers, and the way is paved for more minute and exact study of the various power producers. If the student could understand everything which is written by the Professor he would have lost his right to the name and have become an engineer, but where the work seems especially valuable in our eyes is in the admirable way in which it awakens in the reader a desire for further knowledge, and certainly such a sentiment is the desire of every instructor, and we are glad to know that such a book is obtainable, and we advise even those who are not engineers, but interested in the subject, to read it, as they will be thoroughly well repaid.

LEGAL DECISIONS OF INTEREST TO BOILER MAKERS

Erroneous Exclusion of Evidence as to Time and Result of Examination of Boiler.

In a railroad engineer's action for injuries by the explosion of the firebox and boiler of a locomotive it was held to be an error to exclude the positive testimony of a witness as to the exact time he examined the boiler and his statement that it was in first-class condition, and that it was his duty to make the examination. This error was not harmless, though his testimony as to an examination without fixing the exact time and his statement that the materials were good, so far as he remembered, were received in evidence.—*Houston & T. C. R. C. v. Haberlin, Texas Court of Civil Appeals.*

Patent for Steam Blower Held Not Infringed.

The Circuit Court of Appeals has held that the Parsons patent, No. 573,480, for a steam-blower, which requires the superheater to be located in an enclosed brick-encased chamber arranged above the grate of the furnace and adjacent to the side wall of the furnace, is not infringed by a superheater which is not enclosed in a brick-encased chamber, is not above the grate of the furnace, and is not adjacent to the side wall of the furnace.

The Parsons specifications say: "The nozzle-frame B is connected with a steam supply pipe C, which is again connected with a suitable superheater D that is arranged in a brick-encased chamber D^1 arranged along the side wall of the furnace and the grate E, as shown clearly in Figs. 1 and 5. The steam is supplied to the superheater D by a pipe D^2 from the steam dome of the boiler and superheated by the heated bricks which form the chamber D^1, so that the steam is supplied in dry and superheated condition to the nozzles of the blower."—*Parsons Mfg. Co. v. Coe.*

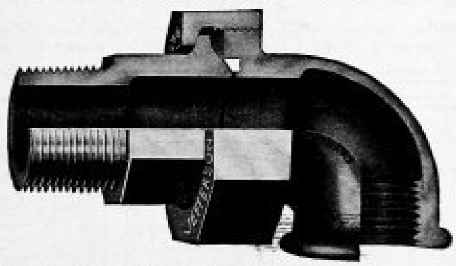
Boilers Sold Conditionally and Installed on Premises of Third Party with Notice Remain Personalty.

Certain boilers were sold under a conditional bill of sale to a construction company for a lighting company. They were erected on the plant of the lighting company, but were not fully paid for, and the sellers of the boilers, in an action to recover possession of them, rested its right to possession under the agreement with the construction company, providing that the title should not pass until the purchase money was paid. At the time the boilers were erected the lighting company's plant was subject to a mortgage held by a trust company, which was afterward foreclosed and the plant sold. At the time of the action the boilers were in the possession of a purchaser which claimed that it was an innocent, subsequent purchaser in good faith and, consequently, not liable to the sellers. About the time of the installation of the boilers notice of the sellers' claim was given to the president of the lighting company. This was *prima facie* notice to the company. Under the terms of the agreement of sale the boiler remained personal property as between the sellers and the water company when installed on the latter's premises with notice to it of the terms of the sale. The trust company did not acquire any title to the boilers by their being placed on the plant, upon which it already held a mortgage. And neither the purchaser nor the mortgagee came within the protection of the New Jersey Conditional Sales Act protecting "creditors of the person contracting to buy." Judgment for the plaintiff was affirmed.—*Oil City Boiler Works v. New Jersey Water & Light Co., New Jersey Court of Errors and Appeals.*

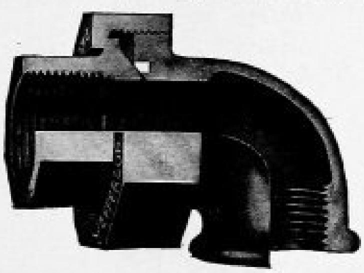
ENGINEERING SPECIALTIES.

Jefferson Union Elbows.

Unions and elbows combined have been put on the market by the Jefferson Union Company, of Lexington, Mass. These new union elbows are made all-female, or male-and-female ends. The all-female elbow takes the place of two pipe joints and three fittings. There are therefore just so many less



chances for leakage. The male-and-female elbow saves three pipe joints. Precise alignment of the fitting and pipe does not have to be made, as they have the Jefferson ground spherical brass-to-iron joint, which cannot corrode, and which makes an unfailingly tight joint without the use of a gasket. In addition, there is a large amount of play between the nut of the union and the swivel end, making the union very easy to apply.



The construction of the nut and its adjustment to the swivel and the brass seat ring are the special features peculiar to Jefferson unions. The brass ring is turned from seamless brass tubing, and sets in a recess away from the runway of the pipe, with an iron wall on each side, and is thus secured against any possible loosening on account of the difference in the expansion and contraction of the iron and brass. The pipe ends are made of malleable iron, and are threaded with Briggs' standard taper pipe threads. The nut threads are coarse enough to allow of rapid adjustment, and are coated with graphite for lubrication and to prevent corrosion. The union may always be easily disconnected after it has been in use.

Valve of the Oldham Long-Stroke Riveter.

Attention is called to the novel valve mechanism located wholly at one end of the cylinder of the Oldham long-stroke riveter, made by George Oldham & Son Company, Frankford, Philadelphia, Pa. It consists of a cup-shaped imperforate valve. This construction allows the use of a heavy valve with large bearing surfaces, which insure strength and good wearing qualities. The cup-shaped valve moves in the same direction as the piston or hammer; valves in most riveters move in the opposite direction from the piston. It is impossible to short-stroke this hammer, for the following reason: The valve itself is moved and held positively in one direction by live air, and in the opposite direction by the momentum of the piston. When the hammer is traveling rearwardly it is impossible, under the working conditions, for the valve to change earlier than it should, as it is held down by its own weight, also a pressure of air on a large area in the rear of the valve. The piston is shot back with sufficient force to overcome this. The valve and piston now move rearwardly, in unison, by reason of the momentum of the piston, to the full extent of the stroke of the valve. The 8-inch riveter used for driving 1-inch rivets weighs 23 pounds, and is 20 inches over all.

The Stereo Pyrometer.

There is being put on the market by Messrs. W. & J. George, Ltd., Nivoc Works, Birmingham, England, a little appliance, as easy to use as an opera glass, by which the temperature of an article varying from 550 C. to 2,000 C. can be seen. It is called a Stereo pyrometer. It consists, as is shown in illustration, essentially of small glass cells contain-

ing dyes, by the absorptive powers of which it is claimed that all the light of whatever color emitted by a hot body is absorbed. If the temperature of the body is raised the cell will not absorb all the light; some will be transmitted and the body appear visible. If it is desired to pour molten metal at a certain temperature, the object is observed through the appropriate cells until it becomes invisible; at that moment it is quenched or poured.

Vanadium.*

Any new material which the commercial world takes up is very apt to be misunderstood as to its true value. This has been the case with the metal vanadium. Most marvelous virtues have been accorded it, consequently there has been some disappointment in its use; yet it is of the very greatest value in making gray iron castings and in combination with various metals.

The American Vanadium Company of Pittsburg, Pa., places squarely before the inquirers the true value of this material. They tell us that at present it costs about $5 per pound. To add one-tenth of a percent of vanadium to cast iron raises its cost about ½ cent per pound, which will naturally increase the selling price about ¾ to 1 cent per pound. The use of vanadium is not to remove oxygen and nitrogen in cast iron but to increase its strength, and it adds from 10 to 25 percent to the initial strength, and this is due to the intensifying effect on the metals. It also exercises a very strong effect on the grain of the iron, causing a more even distribution of the graphite, resulting in fewer hard or spongy spots.

The wearing properties of the iron are also increased. In

* Extract from *American Vanadium Facts.*

fact, it practically doubles its lasting qualities under certain conditions. For instance, a pair of locomotive cylinders are said to give twice the mileage when made of vanadium cast iron when compared with ordinary cast iron cylinders. This is quite sufficient to show its value, and, again, in a foundry the loss in bad castings when making cylinders for the above purpose was brought very low, no less than 183 of such cylinders being cast perfectly. For other purposes the advantage of vanadium adds greatly to the value of the iron, as in bottle molds, here a very considerable gain is obtained.

A test of vanadium cast iron shows the following:

A test piece, 1 inch square, placed on 12-inch centers, the test bar being machined all over close to size, showed the following:

Plain cast iron, 2,130 lbs. transverse.........24,225 lbs. tensile
Vanadium cast iron, 2,318 lbs. transverse.....28,728 lbs. tensile

In a hydraulic test the ¾-inch section stood 750 pounds pressure. The usual amount added to cast iron is 1/10 percent of cupola-melted iron, equal to 5 ounces of ferro-vanadium to the 100 pounds. Some foundries advocate as high a rate as 15 percent, but as little as .05 percent will show results. The effect of vanadium in carbon steel casting is to increase its elastic limit about 30 percent.

The vanadium casting should never be used without annealing; unannealed they are more brittle than carbon steel castings. They have also to be annealed at a higher heat than ordinary steel castings—say at a temperature of at least 1,500 air, or, better, 1,560; .25 percent, or 2½ pounds to the thousand pounds, is found satisfactory, and the amount of vanadium remaining in the cast is .18 to .20 percent. In bearing metals the addition of .05 percent shows very good results.

Twentieth Century Automatic Loose Pulley Oil Cup.

The Twentieth Century Automatic Loose Pulley Oil Cup is made of thin pressed steel and is so light that counterbalancing is not necessary. It is, however, amply strong, as there are no moving or wearing parts. It is manufactured by the American Specialty Company, Chicago. The illustrations show the

FIG. 1.

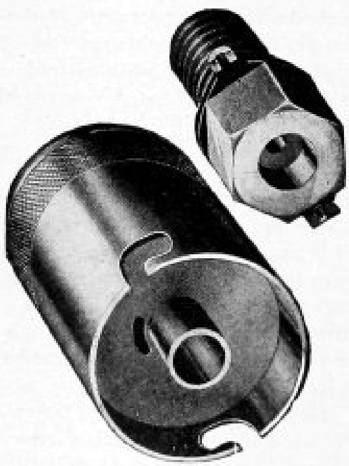


FIG. 2.

manner in which the principles of centrifugal force is used to automatically oil loose pulleys. The cup will run from one to three weeks per filling according to the number of starts and stops, speed, etc. All oil put into the cup goes to the bearing, and the nuisance of having oil flung and spattered over floor, workman, machines and belts is entirely done away with and a decided saving in oil and time effected. Fig. 1 shows the cup ready to screw into the hub of the pulley. When the pulley is brought into operation the centrifugal force throws the oil to the top of the cup and fills the feeding tube. When the pulley starts next time a portion of the oil in the tube is fed to the bearing and the tube again fills itself.

Fig. 2 shows the cup detached from the nipple for filling. This can be done easily with the hand, no wrenches being required. The cup can be removed, filled and replaced with the pulley in any position, thus doing away with the necessity of shifting belts, turning shafting, etc., to bring the oil hole on top.

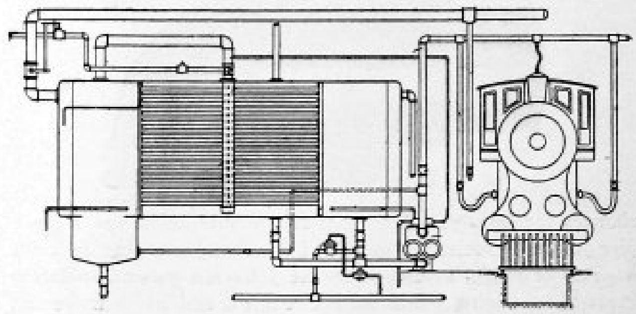
SELECTED BOILER PATENTS.

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

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

992,834. SYSTEM OF AND APPARATUS FOR WASHING AND REFILLING LOCOMOTIVE BOILERS. ELA BERT WHITE OF LONDON, ENGLAND, ASSIGNOR TO NATIONAL BOILER WASHING COMPANY OF CHICAGO, ILL., A CORPORATION OF MAINE.

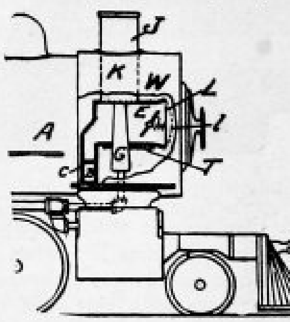
A locomotive boiler washing and filling system comprising a tank, means for storing a body of fresh water therein, means for heating the



said water by directly mingling therein a portion of the blown off contents of the locomotive and by indirectly conveying to said water the heat units from the remaining blown off contents of the locomotive.

992,123. MEANS FOR CONTROLLING THE DRAFT OF LOCOMOTIVE FURNACES. JOHN FOURNIA OF ALBANY, N. Y., ASSIGNOR OF ONE-HALF TO FREDERICK R. GREENE OF ALBANY, N. Y.

A locomotive provided with a steam boiler; a smoke box; a smoke stack connected with said smoke box; an exhaust nozzle in said smoke box; a box placed in said smoke box having an opening toward the front



of the locomotive centrally disposed with reference to the end of the boiler, said exhaust nozzle projecting into said box; a means for conducting the exhaust from said nozzle and the contents of said smoke box to said smoke stack; a spark flue connected with said box and having an opening a short distance above the floor of the smoke box.

992,198. FURNACE. WILLIAM H. HURST OF CHICAGO, ILL.

In a furnace, the combination of a chamber, a grate in said chamber and dividing it into upper and lower compartments, an outlet for products of combustion, a set of flues extending from said lower compartment, a second set of flues adapted for communication with said upper compartment, and damper mechanism adapted in one position to effect communication of said second set of flues with said upper compartment and to shut off connection of said first set of flues with said outlet, and said damper mechanism adapted in another position to disconnect the second set of flues from the upper compartment and to allow both sets of flues to be serially interposed between said lower compartment and said outlet.

990,992. FEED-WATER DE-AERATOR. ERNST KUEHNE OF BREMEN, GERMANY.

A feed-water de-aerator, comprising a vessel, water inlet and outlet to said vessel, a rising pipe upon said water inlet, a plurality of helical plates around said rising pipe, said helical plates affording a plurality of helical passages for the descent of water, said helical plates affording, at their upper ends, entrances to said helical passages, and a casing, said casing enveloping said plates and having openings for the escape of air from said helical passages.

THE BOILER MAKER

AUGUST, 1911

PROCEEDINGS OF THE TWENTY-THIRD ANNUAL CONVENTION OF THE AMERICAN BOILER MANUFACTURERS' ASSOCIATION.

The twenty-third annual convention of the American Boiler Manufacturers' Association of the United States and Canada was held at the Brunswick Hotel, Boston, Mass., on July 10 to 13, 1911, under the presidency of Col. E. D. Meier, New York City.

MONDAY MORNING SESSION.

Owing to the absence of President Meier the session was called to order by Secretary Farasey, and Second Vice-President J. Don Smith took the chair. The Rev. Dr. Bateman offered prayer. Acting Mayor Walter L. Collins welcomed the association to Boston most graciously in the absence of His Honor the Mayor. M. K. Stewart responded for the association to Mr. Collins' address.

D. D. Russell, chairman of local committee on entertainments, next told of the good times that were in store for the association's members and friends. W. H. S. Bateman, secretary of the Supplymen's Association, made some happy remarks and bid all welcome to a banquet which was to wind up the meeting. As the printed programmes were not ready a brief resumé of what the entertainments would be was read by Mr. Bateman, and it was voted to adjourn until 2 o'clock in the afternoon.

The convention met at 2 o'clock P. M., but owing to the non-arrival of President Meier the meeting was adjourned until 10:30 A. M. Tuesday.

TUESDAY MORNING SESSION.

The convention met July 11 at 10:30 A. M., President E. D. Meier in the chair.

President Meier: Gentlemen, please take off your coats and come to order. The chair wishes to apologize for missing the meeting yesterday afternoon. I started in time, but the railroad went back on me.

The secretary then announced the following committees: Nominating committee, Messrs. D. D. Russell, Kehoe & Tudor; committee on uniform specifications, E. D. Meier, George N. Riley, R. E. Ashley, Richard Hammond and M. H. Broderick; auditing committee, Messrs. J. Don Smith and George N. Riley; committee on place of next meeting, Messrs. George N. Riley, James C. Stewart and M. H. Broderick.

Secretary Farasey: The committee on uniform specifications is to meet this afternoon at 2 o'clock. I have a letter here from George Uhler, supervising inspector, stating that it would be impossible for him to be here.

MEMBERS AND FRIENDS PRESENT AT THE TWENTY-THIRD ANNUAL CONVENTION OF THE AMERICAN BOILER MANUFACTURERS' ASSOCIATION.

A committee has been appointed to frame resolutions relative to the death of our first vice-president, Mr. James Lappan, consisting of Col. Meier, Mr. Hammond and Mr. Riley, to report to-morrow morning on these resolutions.

I am in receipt of a card from Mr. Lappan's family which states that Mr. Lappan's family gratefully acknowledge our kind expressions of sympathy.

I also have a letter from the Robb Engineering Company, stating that they were very anxious to have this convention visit their works. They most kindly offered to furnish an electric car to convey any party from Boston to South Framingham.

President Meier: The intention this morning is to discuss in general the rules of the State of Massachusetts regarding the manufacture and inspection of boilers, but Mr. James Stewart is not here, so I will put that off, and take up some topical questions covering some experiences on which we would like to have light. Mr. Smith will you read your report on topical subjects?

Mr. J. Don Smith: As chairman of the committee on topical subjects I beg leave to submit the following report:

1. (*A*) Should the hydraulic pressure applied to drive a rivet 1⅛ inches diameter (.994 square inch) ever equal 100 tons? or (*a*) on a 1-inch rivet 80 tons? (*b*) on a ⅞-inch rivet 75 tons? (*c*) on a ¾-inch rivet 70 tons?

(*B*) Would it make better and tighter work to apply 25 percent less pressure three times to each and every rivet at intervals, and during such intervals drive a number of rivets to be treated the same?

2. (*A*) Will the present type of butt and strap joint fail frequently in the future as the lap seam has in the past?

(*B*) Can the butt and strap joint be inspected more thoroughly and with reliance upon conditions found?

(*C*) Does the expansion and contraction of the excess metal and rivets required to make a butt and strap joint conduce to greater, or less, efficiency of the joint?

3. What should be the ratio of thickness between a convex and concave head based on the same radius, tensile strength and working pressure?

4. Are the working pressures of steam, where turbine engines are used, increasing or diminishing?

5. Is it good practice to put turnbuckles in stay rods?

6. In building heavy marine boilers, which is the better practice, to put holes in plates before or after bending?

7. (*A*) Has the passing of laws and formulation of rules regarding steam boilers reduced the number of explosions or the disastrous results?

(*B*) If the steam boiler or any product is considered dangerous to use or operate, but is allowed under regulations of law, should the government be held responsible in case of disaster?

President Meier: Gentlemen, what will you do with the report of Mr. Smith? I am sorry Mr. Smith is discouraged, because he has done such excellent work, both on this and former occasions. Mr. Smith has always been able to bring us some very interesting subjects for discussion, and the most interesting work is done right in the convention in discussions. Our uniform boiler specifications grew out of topical discussion. Mr. Smith is entitled to a vote of thanks for what he has done.

Mr. George N. Riley: I move that we extend a vote of thanks to Mr. Smith and that his resignation be not accepted.

Mr. J. Don Smith: I feel that someone else ought to take up the work. Not that I do not like to help the thing along, but that someone would do better and the association more good.

President Meier: I will put the question on the vote of thanks to Mr. Smith, disagreeing with his request to be discharged from further work.

The motion was carried by a unanimous vote.

Mr. J. Don Smith: Gentlemen, I appreciate very much your kind expression.

President Meier: We will proceed now to the first topical question, "Should the hydraulic pressure applied to drive a rivet 1⅛ inches diameter (.994 square inch) ever equal 100 tons? or (*a*) on a 1-inch rivet 80 tons? (*b*) on a ⅞-inch rivet 75 tons? (*c*) on a ¾-inch rivet 70 tons? (*B*) Would it be better and tighter work to apply 25 percent less pressure three times to each and every rivet at intervals, and during such intervals drive a number of rivets to be treated the same?"

Mr. Hammond: Mr. Chairman, I have had a little experience with hydraulic riveting. As far as putting pressure on the rivet two or three times I do not think that is a good plan. Pressures given here are about 25 percent too high for the different-sized rivets. My practice is to allow the rivet to cool under a pressure anywhere from 10 to 30 seconds, according to the size of rivets, by a stream of water running on the dies on both sides, the rivet to be inserted from the inside of the shoulder instead of from the outside, the ram working on the point of the rivet instead of on the head.

Mr. J. Don Smith: What pressure do you put on a ⅞ rivet?

Mr. Hammond: Between 50 and 60 tons, allowing the rivet to cool under pressure. You will find that to be the best practice for heavy plate work. It is better practice to allow the rivets to cool under pressure. If there is a good, fair hold the rivets very seldom leak.

Mr. J. Don Smith: I suppose, Mr. Hammond, the heavier pressure would have a tendency to squash up the bolt?

Mr. Hammond: A pressure of 100 tons will upset a bar of ⅜ inch in diameter for a length of 8 inches; that is, a hot bar the same temperature as the rivet.

Mr. Thomas McNeill: I have had experience with the hydraulic rivets; there was a time when some engineers had ideas of their own. I remember I was doing a large job of pipe, and I had a pressure of about 65 tons on 1⅞-inch material, and the inspecting engineers claimed that I ought to have water running on the rivets, but I objected. I thought it had a tendency to crystalize the rivets and make them hard, so I riveted up one pipe each way. I tested the pipes under hydrostatic pressure, and my pipe won out. The one I drove hot was the better. I tested it to 150 pounds.

President Meier: Is it possible to rivet an entire seam and have it perfectly tight?

Mr. McNeill: Utterly impossible; you can't do it.

Mr. Hammond: Were the holes drilled?

Mr. McNeill: No; punched.

President Meier: Did you ever drive a whole seam without having to calk some rivets?

Mr. Hammond: We drive whole seams without calking; how did the gentleman heat his rivets?

President Meier: In heating rivets we tried oil. We couldn't make it go. How did you heat the rivets?

Mr. McNeill: With coal.

Mr. Hammond: Some succeed in heating with oil but I couldn't make it go.

President Meier: Some people can make it go and some can't. This is quite an important subject. I have never been able to drive a seam yet where we did not have to calk some rivets. Mr. Hammond perhaps has in mind marine boilers, which run up to an inch or inch and a quarter, when he speaks of cooling the rivet under pressure.

Mr. Hammond: Yes, and tested to 300 pounds.

President Meier: You couldn't have any metal as thick as half inch healed up as hot as the rivet. I see the idea of having the plate metal quite near the temperature of the rivets, so that everything cools together. But you can't do that in a heavy plate, so you ought to do the next best thing and cool the rivet heads.

Mr. J. Don Smith: We cool our rivets with a stream of water, and it is very rarely we have to calk a rivet.

President Meier: What thickness of plate do you handle generally?

Mr. J. Don Smith: We can handle anything over half an inch.

President Meier: In regard to question *B*—whether it will make better and tighter work to apply 25 percent less pressure three times to each and every rivet at intervals. That would go against the warning of Mr. Champion, an expert on riveting. If you let your rivets cool and then put pressure on again, you might very easily get them just in the blue heat.

Mr. McNeill: Mr. President, this blue heat—what is your understanding of that?

President Meier: It is this: When the metal has been red-hot, and it comes down until it begins to show blue; it is brittle just at that temperature.

Mr. Goodwin: I am very much interested in this subject. My experience has been strictly on locomotive boiler work, and is that running water is much preferable.

Mr. Hammond: What pressure do you put on?

Mr. McNeill: I put on a little higher pressure than you claimed this morning had been your custom; with a three-quarters rivet I run up to 75 tons, and on an inch and an eighth rivet as high as 125.

President Meier: You might get so much pressure on the rivet as to disrupt the sheet itself. When you have either a strap joint or butt and strap joint it is very important to have surfaces conform to the shell exactly, and it is very important to have a rule in regard to the pressure. If there is nothing further we will pass on to the next question, No. 2: "(*A*) Will the present type of butt and strap joints fail frequently in the future as the lap seam has in the past? (*B*) Can the butt and strap joint be inspected more thoroughly and with reliance upon conditions found? (*C*) Does the expansion and contraction of the excess metal and rivets required to make a butt and strap joint conduce to greater or less efficiency of the joint?" I think those questions are particularly pat. We have had several cases brought up in the past as to the failure of lap joints, but that was at a time when the almost universal practice for boilers of moderate size, say 48 inches to 66 inches in diameter, was to have lap joints. Now we have come to higher pressures and to the use of butt and strap joints, and the question has arisen whether they will fail.

As to the third heading, regarding the expansion and contraction of the excess metal and rivets, I have always held that when you get down below a certain diameter it is very doubtful whether a double butt strap joint is of any value unless you have an exceedingly heavy metal. I built some shells for Boston in 1888 to carry a working pressure of 500 pounds, tested to 900 pounds. Here it was necessary to come to the double butt strap joint. The trouble with them is that on such a small shell the length of the joint, or width of it, more properly speaking, makes such a large proportion of the whole circumference of the shell that it does not expand like a cylinder. When you come to larger diameters—60 inches, 68 inches, 72 inches—that is not so apparent, because the joint does not increase so much with the diameter of the shell. But, to my mind, there are two points to be considered in joints of this kind—and fundamental points. One is you must have a steel that you can absolutely rely on. The other is that you must have your curves exactly alike. The joint must be such as to take part in the general expansion of the shell under pressure without much change in the position. If I found a crack anywhere in a boiler I would have several drillings made along the crack and send them to a competent chemist, and the next thing would be to see whether the curvature of the butt joint had been made to conform to the curvature of the boiler.

These are very serious points to settle on account of higher pressures. I can remember when I came East with my boilers about twenty-five years ago people thought 125 pounds was a horribly high pressure. We are now asked to furnish boilers for 225 pounds pressure. That points out the reason why we are so particular to adhere to our specification in regard to steel.

Mr. Hammond: If I remember right you had some experience with tests made with overlap joints and butt strap joints on a testing machine some years ago?

President Meier: There were some made here in Boston in 1894.

Mr. Scannel: Up at the State House there is a double-riveted joint that comes out on the outside somewhat. I should say the rivets were 6½ inches apart. And if any of you gentlemen are interested you can go up there and see that joint.

President Meier: Was there any test made of the material?

Mr. Scannel: Oh, yes; it was good metal. It was Central Iron & Steel metal. I think the plate was seven-sixteenths thick; about seven-eighths rivets.

President Meier: Was the curvature right?

Mr. Scannel: They claim it wasn't perfect, while it was practically as good as the average.

Mr. McNeill: I would like to ask what holds the seam of a shell of a boiler? Don't the strain come on the shearing strain of the rivets when you put the pressure on? Isn't that all that holds it? What shearing strain have you got on the rivets? Does it make any difference if you put the same kind of strains on a lap joint as you would on a butt joint?

President Meier: You do not get as direct a pull in a lap joint as you do in a butt joint.

Mr. McNeill: You are liable to get it more around.

President Meier: Yes, you get it more gradually. That was one of the interesting things brought out in those tests in Chicago in 1893. There was developed an action which Mr. Robinson, the father of our Mr. Robertson here, very cleverly designated as the "claw-hammer" action. You take a claw-hammer and pull a nail; this is the lap joint action, instead of sheering it was just like a claw-hammer drawing a nail. The way the seams failed was by pulling the rivets. Generally these drums were 6 feet long, 42 inches in diameter. When we tried to prove them the whole drum swelled out like a barrel stave, because at the ends the surface seams held. The three middle rivets acted like a claw-hammer.

Mr. McNeill: I saw a test on a shell of 900 pounds. The seams did not cut and the heads did not cut, but the center of the head bulged right up.

President Meier: Another interesting fact showed up in the tests. The lap joint seams, which were made with punched holes, no rimming, set better than those that were drilled. They had one shell entirely drilled that did not stand as well as the punched one, for this reason: when this claw-hammer action took place those rivets could move easier than when they were riveted into a rough punched hole.

Mr. Hammond: Those were all over-lapped seams?

President Meier: All over-lapped. I believe there was one butt strap joint. We didn't press that point. One drum failed in a peculiar manner. It had a manhole; instead of having it in the head they had it in the top of the shell; it gave way first. We didn't get to the point of breaking the joint at all, because the manhole gave. Another peculiar thing was that one man, who did not believe in the convex head, put four big stay rods from one convex head to the other. It gave way first. The heads were going to take the natural form they would under pressure; as they couldn't, on account of these stay-bolts, the stay-bolts pulled out. There are some very good lessons in that.

Mr. McCabe: I would like to make a suggestion here about the stress in the butt joints. I recall reading some time ago about tests made in England as to the transmission of heat through the plate. My recollections of the results of the tests are that they found that the belt had a temperature of about 50 degrees in excess of the contents of the boiler, and the boiler was reported as being clean. Now, in such a case the location of the joint would be perhaps 45 or 90 degrees from the vertical—from that up perhaps 60 degrees, and you would have the lower two-thirds of the boiler subject to the temperature of the furnace. This portion of your boiler would have that excess temperature of 60 degrees over from the temperature due to the steam.

You will find by calculation a 60-inch boiler the diameter increases about an eighth of an inch, due to the heat of the steam. Now, that being true, assuming that you start your boiler up with a normal temperature of 80 degrees, your boiler will increase in diameter about an eighth of an inch. In this case you have the lower part of your boiler 50 degrees hotter than the upper part of the boiler, consequently there will be a tendency to opening at the seam. In my opinion you will find less flaws in the butt-jointed boiler, but you will find them quite frequently when the plates are somewhat hard. You will have the bending action then.

Now, if the butt straps are properly fitted, of course they will change with the body of the boiler; they will take the larger radius of the boiler, but on the lower part of the boiler your belt is trying to take a larger diameter, consequently you must have a corresponding bending on this point. My recollection is it was about 50 percent increase.

President Meier: The change in the flexure would be due to the increase of the temperature of the lower part of the boiler.

Mr. McCabe: Yes.

President Meier: The difference between 305 and 310 isn't very much.

Mr. McCabe: It would give a tendency to increase the lower part of the shell.

President Meier: You have a heavy joint effect, stiffer than the rest of the shell; the flexure due to the increased pressure would be less on that than on the metal.

Mr. McCabe: The pressure would come on the lower side of the joint; most of the increase in temperature would be in the lower half of the shell.

President Meier: You spoke of the necessity of having the metal very flexible.

Mr. McCabe: I say it is desirable.

President Meier: Have you, in any case where you investigated a failure of that kind, had the metal tested?

Mr. McCabe: No; I have not.

President Meier: I think this is a matter that should be called to the attention of everyone who has to do with the investigation of a failure of any kind. It is very important to determine the chemical composition of the metal. If that is not known we are in the dark.

Mr. Ashley: Mr. Chairman, is it not true that in the majority of failures the chemical and physical tests of the metal have shown the metal to be all right? Does it not resolve itself practically into the workmanship and the joints?

President Meier: That is hardly true. As a rule, when a boiler failure occurs, at least until recently, there have been no records found of the chemical tests or of the physical tests of the plates. A great many people in the past have relied absolutely on the contractors for the quality of their steel. A man would say, "Oh, well, I have always had my plates tested." Unless he has a test of that particular plate and can refer to it, it is worthless. I think we will come to it that every plate will have to be registered that goes into a boiler. Then you have data. Unless there is an inspector's report, which is signed, that the curves are all right and conformed to the general curves of the boiler, you have not got that as a fact; it is simply hearsay evidence.

Mr. Hammond: What do we understand from the gentleman when he says they found the material was all right after the failure?

Mr. Ashley: In reading the reports of various failures, as they come to me, it seems that where the tests have been made of the plates after an accident that the steel has been found to be good metal. The failures do not seem to be due to some evident imperfection of the material itself.

President Meier: We will turn to the third question: "What should be the ratio of thickness between a convex and concave head based on the same radius, tensile strength and working pressure?" It strikes me at once, in connection with the pressure from the inside, that tensile strength has nothing to do with it. It is a question of the compressive strength. It is one of those questions where the difference between a theoretical calculation and a practical test comes in, and shows the necessity of having a practical test. The tensile strength had nothing to do with it on that concave head. The tendency is to flatten out; the tensile strength of the material resists that. Now, what happens at the seam? It is a question of the shearing strength of the rivets. But, then, remember that the sheet is tied on the outside of that, and that on the inside, where the curve approximates to the cylinder, you haven't got any joint, the water collects in there; secondly, you get the claw-hammer action to push it apart, just like a solid weight acting on the sheer to press that apart. Instead of getting only the shearing strength on the rivets you get a tensile strength on the rivets.

Mr. Hammond: What is your practice?

President Meier: Always with the convex head.

Mr. Hammond: What relation to the shell?

President Meier: I make that generally a little heavier; but that is done mainly because we have to cut more holes in the shell. I believe that that question could best be answered by practical tests on full-sized specimens to determine the matter.

A Member: I believe the tensile strength does have something to do with the strength of the head.

President Meier: What I meant was the compressive strength of the material comes in frequently there. The compressive strength is always much greater than the tensile strength; therefore, you are right that the tensile strength had something to do with it.

The next question is: "Are the working pressures of steam, where turbine engines are used, increasing or diminishing?" This is a question of experience. I should suppose that you are being asked for higher pressures in your boilers since the steam turbines have come in.

Mr. Hammond: We have not been asked for any higher pressure.

President Meier: What are your pressures?

Mr. Hammond: 210 or 215 pounds for marine boilers.

Mr. Stevens: A word in regard to the steam pressures. The guarantees are generally 1 percent better for each increase of 10 pounds pressure; that is, if you have a guarantee based on 200, 250 pounds would give you 5 percent better guarantees.

President Meier: Do you find they are asking for pressures higher than 200 or 215 pounds?

Mr. Stevens: No, not as far as my experience goes. Where a plant is already built when the steam pressure is

150 pounds, we don't try to convert the plant to the higher pressure, as the gain would be so slight it would not pay to rebuild.

President Meier: The next question is: "Is it good practice to put turnbuckles in stay rods?" That is a question for you, Mr. Hammond. You never do it, do you?

Mr. Hammond: Yes, we have. Sometimes we get specifications that require turnbuckles. Of course, we conform to the specifications, although we do not like to do it.

President Meier: "In building heavy marine boilers, which is the better practice, to put holes in plates before or after mending?

Mr. J. Don Smith: We roll the sheet and then drill the holes in a great many cases, and then in some cases we punch the holes in the plate, allowing material to ream.

President Meier: Mr. Hammond, can you get satisfaction by putting the holes in first and then bending?

Mr. Hammond: Our practice is to drill the outside plates first on the flat; that is, the edge courses, except where the butt straps come. We put a few holes in to bolt up with smaller than the intended size. Then the plates are rolled up, and when the inner course, the small course, as it is called, and the heads are put in, the butt straps inside and outside are put on, then the holes are all drilled in place. The plates are taken apart and the burrs all removed for riveting. We do not punch holes in our marine boilers.

President Meier: "(*A*) Has the passing of laws and formulation of rules regarding steam boilers reduced the number of explosions or the disastrous results?"

"(*B*) If the steam boiler or any product is considered dangerous to use or operate, but is allowed under regulations of law, should the government be held responsible in case of disaster?"

The first part of the question is answered by the records of the Board of Supervising Inspectors of Steam Boilers. I found that not only the number but the extent of the disasters had been most astonishingly reduced during several decades; further improvements must therefore be a small percentage, because the first ten years and the second ten years had shown such large gains. I think there is no question as to the advantage gained by the steam boiler inspection laws. I figured out at that time that the large cities where there were regulation laws were about twenty times as safe as the country districts where there were no regulations. So, to my mind, there cannot be any question on that subject. Mr. Stevens, I want to ask you to enlighten the convention on this last question; that is, whether the passing of laws and formulas or rules regarding steam boilers reduces the number of explosions or the disastrous results? Massachusetts was the first State to have a State regulation. Your board and your rules have been in use now some three years. Could you tell, approximately at least, what the effect has been on the number of disastrous results of the explosions?

Mr. Stevens: Mr. McNeill can answer that question better than I.

Mr. McNeill: As I understand it, the question is if regulations governing the construction, installation, maintenance and operation of steam boilers tend to reduce the number of boiler explosions and the disastrous effects from such explosions? We can say without hesitation that such legislation does positively reduce the number of explosions, and not only does it reduce the number of explosions directly but it discontinues from service numbers of boilers that may not be positively dangerous to operate but are in such condition that the element of uncertainty fully warrants their being discontinued. That is to say, we make notes of defects that if allowed to continue would result, in all probability, in explosion. Massachusetts, of course, has been looked to on account of the prominent part it has taken in this work. Last winter, in December, 1910, a very disastrous boiler explosion occurred in the State. The explosion was caused by the pressure being increased from 70 pounds, allowed by an inspector, to not less than 225 pounds, the safety valve being screwed down by a licensed engineer. The engineer, without question, did not realize that there was any danger. He was fully convinced that the screwing down of the adjusting nut of the safety valve was not increasing the pressure above that allowed by the inspector; the fact was that the steam gage showed between 35 and 40 pounds pressure a few moments prior to the explosion, and this incorrect reading was caused by a partial stoppage between the boiler and the steam gage. The only solution of any such condition in the future would be to have a safety valve that would be impossible to increase the tension of the spring-in unless the boiler was put out of commission. With that exception we haven't had any explosion since the passage of the Revised Boiler Inspection Law in the year 1907.

President Meier: No explosion whatever in this State?

Mr. McNeill: No, sir; not a boiler explosion, with the exception, I believe, of a cast iron boiler. We have had a number of mishaps of small account. A boiler exploded that had been used in this State and was removed to the State of New Hampshire, and the pressure increased and the firebox disrupted.

President Meier: One boiler explosion in four years in a State as large as Massachusetts, with all its manufacturing establishments, is a complete answer to that last question.

Mr. McNeill: We believe it is.

Secretary Farasey: Mr. McNeill, what is the average pressure carried in the State?

Mr. McNeill: That is a difficult question to answer, the tendency is upwards; that is, we find manufacturing plants installing boilers 125 pounds working pressure where ten years ago 100 pounds was as high as was demanded. On the Massachusetts standard boilers, with very few exceptions, 100 pounds is the pressure for which they are constructed. A large number are also constructed for 180, 200 or 250 pounds.

Secretary Farasey: You have some going up to 250 now?

Mr. McNeill: Yes; but they are rather the exception.

Secretary Farasey: Are those tubular boilers?

Mr. McNeill: No, sir. On external-fire boilers pressures are run up to 150 pounds. From May 1, 1908, to June 12, 1908, inclusive, 4,431 Massachusetts standard boilers were constructed; and on that date there were eighty-six boiler manufacturers who were authorized by the law to construct Massachusetts standard boilers. Twenty inspectors, including the chief inspector in the State department, and eighty-one inspectors employed by the insurance companies, eighty-one inspectors holding certificates of competency as inspectors of steam boilers and employed by the insurance companies, were authorized to inspect and insure steam boilers in Massachusetts.

Mr. Hammond: How many boilers are there now in operation in the State of Massachusetts?

Mr. McNeill: There are 24,000 boilers that come under the provisions of the Boiler Inspection Law; that estimate is based on the fact that during the early part of this year there was legislation presented to increase the number of inspectors in the State Department. I obtained an estimate of the boilers in each district in the State. The State is divided into seventeen districts; and the result of that estimate and the actual information we had of the boilers insured by the insurance companies fully warrant us in stating that the number of boilers is 24,000. The Governor signed a bill the last day of June to add five additional inspectors to the Massachusetts State Boiler Inspection Department, showing that he fully believes that this work should be carried on.

President Meier: Will Mr. McNeill answer the question we had up before in regard to ruptures of belts, for instance, in seams or near the seams; whether, as a rule, it was possible to get accurate information in regard to the chemical constituents and tensile strength, elastic limit, and so forth, of plate in boilers that were built before there were rules. Didn't you find it difficult to get at exact facts?

Mr. McNeill: We have found that on boilers constructed prior to May 1, 1908, there was little or no information available in regard to the physical or chemical properties of the plates; with possibly one or two exceptions we have been unable to find even breaking strength on the plates. We have made extensive tests from specimens of boilers that have exploded, and found a very fair quality of material, considering the fact that the material had been rolled many years ago and without any regulation to govern its physical and chemical composition. In regard to the fractures on longitudinal joints, without exception the fracture on the lap joint begins on the inside of the outside lap and extends gradually outward until it reaches the outside surface of the plate.

I would like to correct my first statement by adding that in New Bedford, in December, 1910, a boiler did explode—a horizontal return-tube boiler, 42 inches in diameter, with a tubular riveted longitudinal lap joint. The boiler had been inspected three weeks prior to the explosion, carefully and thoroughly, we believed, internally and externally; but the plates at the point of fracture showed the amount of metal remaining preceding the explosion, and it was only a few thicknesses of paper. It was on the outside of the lap, immediately beyond the second row of rivet holes. It did not fracture through the rivet holes.

President Meier: How do you account for that?

Mr. McNeill: We fully believe that cylinder was not a true circle. The continual struggle to assume a circle gradually disrupted the plate. We had another case on a vertical tube boiler that didn't show any distress at all; that is, the first distress noticed was a slight leakage around one of the rivets in the longitudinal joint, and we put the boiler under 105 pounds hydrostatic pressure, and it fractured under the lap. It would not have been possible to see the weakness even if we had taken all the tubes out for inspection.

President Meier: When we began this morning I mentioned that the Massachusetts boiler rules would be under discussion to-day as a whole; and I did not see Mr. McNeill or Mr. Stevens, nor did I see any of our Massachusetts friends here except Mr. Scannel, therefore we took up these topical questions first. The explanation given by Mr. McNeill as to the good effect of the boiler rules and inspection under men who have been trained for the work is sufficient in itself to justify the high opinion we have formed of the boiler rules of the Board of Boiler Rules of Massachusetts, and for these reasons in our Detroit convention urged the inspector of the city of Detroit, who came to consult us on the subject, to try to adopt rules as near as possible to those of Massachusetts. I have taken occasion, officially, to write to a number of people in different States that have had this matter under advisement; in doing so I was entirely within line of the settled policy of this association. One of the very first things for which a committee was appointed in 1889 was the establishing of uniform rules for construction and inspection of boilers. We found that the great State of Massachusetts, one of the greatest manufacturing States in the United States, accustomed to give practical, scientific legislation to the whole country, had taken up the question of rule for the construction of boilers. We welcomed the fact with joy. Now, every one of us has had experience, or can have it every day, and there are people who are not quite up to the highest type of manhood who do things which make it necessary to pass laws which very frequently have an irksome and unpleasant effect on those who do not need restraint, so that we must be prepared when a set of laws are established to meet difficulties which are unexpected. This may have been the case with some of our friends in Massachusetts. We would like to hear from any one who thinks there are just criticisms of the rules.

Mr. Scannel: Do you deduct the area of a stay rod when you are figuring the tensile strength, should you also deduct the area of the stay rod?

Mr. McNeill: Under paragraph 34, section 4, part 3 of the rules, is given an example of the maximum level starting pressure computed on stay-bolted flat surface, and to get this maximum level starting pressure the area of the stay-bolt is taken out of the total area supported by the stay-bolt; that is to say, the pitch is stated as 5 by 5, and the area of a seven-eighths stay-bolt as .419; that being deducted, leaves a net area to be supported by a stay-bolt. It is a very simple proposition to apply the same to through and through stay rods above the tubes of a boiler where the nuts of the stay rod pass over the bolt heads. That is to say, the net cross area of the stay rod can be deducted just the same as it is deducted in the book; but when we come to the proposition of screwing the stay rod below the tubes, and angle-bars riveted to the rear head of the boiler, we cannot take out the cross-section of the stay rod.

President Meier: It is getting late, and we have to go to lunch, and we have a very important meeting of the committee on uniform specifications with some of the gentlemen representing the Steel Plate Association at 2 o'clock this afternoon. At 3 o'clock we will have another meeting of the convention as a whole. I will entertain a motion to adjourn till 3 o'clock this afternoon. Adjourned.

TUESDAY AFTERNOON SESSION.

The convention met at 3:30 P. M. President Meier in the chair.

President Meier: Gentlemen, on the question of National and State laws and rules governing the construction of steam boilers, we understood that some of our Massachusetts members wanted a discussion on certain of the boiler rules. Mr. McNeill and Mr. Stevens are here and Mr. McCabe, of Detroit, to assist in the discussion.

Secretary Farasey: There are none of the Boston representatives here now.

President Meier: We expected the discussion to be led by some gentlemen who had some honest criticism, but as long as they are not here we must consider that they have withdrawn their objections.

Secretary Farasey: I talked to Mr. McNeill and Mr. Stevens relative to the fact of these men not being here, and we proposed to postpone the discussion until to-morrow morning, as we want to get them here while this discussion was on. Possibly it would be just as well to postpone matters until to-morrow, provided either Mr. Stevens or Mr. McNeill can be here.

President Meier: We cannot have the discussion if the gentlemen who wanted to prefer the charges are not here, so we will have to drop it.

Mr. Geo. N. Riley: We have a report to make.

Mr. J. Don Smith then submitted the following report: "Your committee appointed to examine the accounts of the secretary audited the same and found them to be correct. (Signed) J. Don Smith and Geo. N. Riley."

President Meier: What is your pleasure in regard to the report of the audit committee?

It was voted that the report of the audit committee be received.

President Meier: I would like some gentleman to move a vote of thanks to the three representatives of the Steel Plate Association for coming here and giving us very interesting information.

Mr. McNeill: I move a vote of thanks to the steel plate men for coming here and giving us valuable information.

President Meier: The committee on place of next meeting, Mr. Geo. N. Riley tells me, is not ready to report. What other committee is there here?

Secretary Farasey: The nominating committee. Mr. D. D. Russell is chairman, Mr. Kehoe and Mr. Tudor. None of the members are here.

President Meier: These committees will be asked to report to-morrow morning at 10:30. As there is nothing official before the meeting we will be glad to hear from any member about anything for the good of the order.

Mr. Stevens: I was very much disappointed that this report of the committee on the National and State laws and rules did not come before the meeting. I think it is a very crucial moment for all of us, since other States and other communities and special corporations are adopting standard rules on boilers. It is of the most vital importance to all of us connected with the business that we should have all the pros and cons. I call attention to the fact that if every State in the Union has a different standard it will make manufacturing a practical impossibility. It seems to me that this matter should be very thoroughly understood. We have the steel men right here with us—all the talkers together—and we are losing a golden opportunity not to get together.

President Meier: Gentlemen, to-morrow morning we have three committee reports at half-past 10; they will probably be brief. The city of Detroit has adopted, practically, the Massachusetts standard, but the State has not yet done so. If the Massachusetts standard is adopted by the city of Detroit, and is worked in the same conscientious manner, it will make such a showing that the State will have to adopt it. Now, the State of Ohio has adopted it practically. The tendency is to adopt a good set of rules that have shown up advantageously to the general public rather than to make changes. We have found within two years after we had adopted steel specifications there were a great many others came in from private and public sources, official engineers of different municipalities giving us credit as a whole. The same thing will happen with the Massachusetts rules. It is simply the duty for you gentlemen who are officially connected with them to so manage your administration of those rules that you will continue to make as good a showing as was reported by Mr. McNeill—less than two one-thousandths of 1 percent of the boilers in use explode. That shows the working of a law well administered. Your law is much better and much more workable than the law under which the Board of Supervising Inspectors are working; yet results have been simply marvelous in the prevention of accidents.

Mr. McNeill: The absolute necessity of having a standard specification is illustrated by this statement: I was called by telephone by a gentleman who represents a concern of contracting engineers in Boston. They received a contract for construction work in the Province of Alberta, Northwest Canada. They sent from Massachusetts their machinery, which included a Massachusetts standard boiler—a vertical firetube boiler—to be used for hoisting the material. When the boiler reached the destination they found that the Massachusetts standard construction conflicted in two details with our regulations, and that the boiler could not be used in the Province of Alberta until those two details had been conformed with. The first is in regard to reinforcing plates where brackets are attached, the other detail was reinforcing rings required around the hand-hole openings.

In looking over these regulations we find very clearly shown that the regulations follow the British Board of Trade in regard to formulas. In conjunction with this boiler 125 pounds was the working pressure; and the authorities in Alberta informed the contractors that the maximum pressure allowed would be 110 pounds. I bring this up to show that it is very advisable for boiler manufacturers, steel manufacturers, designing engineers, operating engineers and boiler owners to work hand in hand to get a uniform standard of boiler design and construction.

Mr. McCabe: In regard to the operation of the rules in Detroit we have had a little trouble there aside from the complaints from the second-hand dealers. They felt real sore about it. Of course, we are powerless to help them any. We have had to reject only three small boilers. We have been rather reasonable in giving the people a chance to get out of the little technicalities. I consulted our corporation counsel, and he has given me some very clear advice. He advised me it was better to use the rule of reason in deciding matters. But, of course, the manufacturers have complied quite reasonably with requirements. We are up against a condition that Brother McNeill has just mentioned. In Michigan we have a new constitution that has been in operation now since 1908. Under the new constitution it gives municipalities the right of home rule in matters pertaining strictly to local affairs, and among those things they place public safety. Our corporation counsel tells me that he has doubt whether or not they can apply a State-wide boiler inspection law in Michigan. He says the State can, by a general law, compel all municipalities to enforce a licensing and inspection and regulation. If the city refuses and neglects to do so the State can send in its officers to do so. The real necessity for steel inspection passed away a number of years ago. I think in 1913 we will be able to frame something that will be of benefit to the boiler manufacturers and people at large, and not to the politicians.

President Meier: Is there anything further before the house? I will entertain a motion to adjourn until 10:30 to-morrow morning.

WEDNESDAY MORNING SESSION.

The convention met at 10:30 A. M., President Meier in the chair.

President Meier: The first report is from the committee on the place of next meeting.

Secretary Farasey: Your committee on the place of next meeting begs to report on the city of New Orleans. M. H. Broderick, Geo. N. Riley and James C. Stewart.

On motion of Mr. Hammond, duly seconded, it was moved that the report of the committee on place of meeting be received, and that New Orleans be selected as the place for the next meeting.

President Meier: Is the committee on nominations ready to report?

Secretary Farasey: Yes, the committee have a report to make. Mr. Tudor wishes me to announce that the committee on nominations recommends the officers remaining the same as last year, with the exception of the fifth vice-president, who has gone out of business, and in whose place they have substituted Mr. M. H. Broderick, of Muncie, Ind. A committee appointed to report relative to the death of our late friend, Mr. James Lappan, our first president, is ready. President Meier will read the report.

In Memoriam.

Boston, July 12, 1911.

As we meet for the twenty-third time in convention there is a note of sadness in the greetings of old friends.

For James Lappan is no more among us.

The sturdy figure, the kind heart, the cheerful spirit, the reliable comrade, are now memories.

But his strong personality persists in the association which he founded and nourished until it has become a power in the industrial life of our country.

We had faith in him, we loved him, and it is our duty to uphold and expand his ideal—the gospel of good boiler making.

Born in that green isle which has given us so many statesmen, soldiers, orators and poets, whose sons alike with brain and brawn were in the van of the peaceful army that conquered this continent, he possessed all the virtues of his race.

The magnificent courage with which he fought his way from rivet boy to manager and owner in a trade which imperatively demands energy, skill, honesty and patience, the warmth of his affection for family and friends, prove the poet's words that

"The bravest are the tenderest."

He was born Feb. 22, 1834. As a boy of ten he landed in Philadelphia, as a youth of twenty he came to Pittsburg.

Three years later he found a wife such as so true a man deserved.

His devotion to her realized the highest ideals of knighthood.

When after more than fifty years of married happiness she "went before," his strong heart would have broken but for his simple, fervent, religious faith.

Only three years more and a sudden virulent illness bade him follow on June 6, 1911, after a heroic operation, which he bore with characteristic, cheerful pluck.

To his three surviving children we express our heartfelt sympathy, and the confident hope that the poignancy of their grief will yield to the balm of time.

And as the mists of sorrow slowly fade away grateful memory will show us in brighter light the living image of the grand old man of the A. B. M. A.

E. M. MEIER,
RICHARD HAMMOND
GEO. N. RILEY,
Committee.

On motion of Mr. W. H. Brunner, seconded by J. T. Corbett, it was voted that the report be received and spread upon the minutes of the proceedings in its entirety, and that an engrossed copy be sent to the family; the vote thereon being unanimous.

President Meier: A clipping from a morning paper reads as follows: "Regarding the question of liability, the consensus of opinion was that the States should be held responsible in case of disaster if a steam boiler or any product considered dangerous to use was allowed by law." There was no such consensus of opinion. It did appear in one of the topical questions; no one rose to discuss it. We request any reporter here to state that this was a mistake.

Mr. Hammond: I would like to offer the name of Mr. H. G. Hartley as an honorary member of the A. B. M. A. Mr. Hartley was one of our charter members.

Mr. W. H. Bateman: I would like to have the pleasure of seconding that.

Mr. George N. Riley: As a charter member I would like to have that privilege. I would suggest that Mr. Bateman and Mr. Brunner be recorded in the minutes as seconding this motion, if that can be done.

President Meier: We can have all three of you seconders. It has been my pleasure to serve, from the very beginning, on important committees with Mr. Hartley, and I have served in various societies and in various places on committees, and I have never met a man who gave such time and such conscientiousness and faithful study to the work on a committee as Mr. Hartley. I am very glad to see this general consensus of opinion in regard to this motion, which I will now put. The motion was then unanimously carried.

Gentlemen, it is proper for the officers whom you have re-elected to extend to you their appreciation of your action. I thank you heartily for your kind recognition of what little I may have done for the society. I will be glad to do the work another year.

Secretary Farasey: Gentlemen, I wish to thank you for renominating me. I would have been pleased to have found a great many more members here, and that there would have been some change made to relieve me. I have said that on many occasions, and I won't make any extended remarks just now on that point. The assistance given by the associate members, particularly Mr. Hare and Mr. Bateman, has been such that it made my duties very light, and I thank you for renominating me. While I have the floor I want to make a report on my going to Omaha as a delegate of this convention, representing the association at the Master Boiler Makers' convention held there two months ago. It has never been my experience in my life to take a pleasanter trip, and I never saw a body of men who did business as business ought to be done better than those men at Omaha last May. There is no difference between the two organizations except that they represent large corporations and railroads. They go there to do business, and they do business, they are attentive to the business. Of course, they are representing large corporations who send them there to exchange views, and they are expected to learn something when they go there, and for that reason they are very attentive. The same is true of this organization, with the exception—and it is a very detrimental exception—that the members that come here will not attend the meetings as they should and transact the amount of business they should, or in the manner that it should be done. Those men in Omaha I found going into their meetings at 9 o'clock, and every man was there at 9 o'clock. Now, of course, the boiler manufacturers, unfortunately, are their own bosses. They come here and expect a fairly good time; but, unfortunately, they allow more for the good time than to the business, and it is a situation that is not creditable to this association. We have talked over the proper method to increase the membership. Now, there is only one resource left, and that is for each member to make it a point to see if he can get one new member. If we could multiply ourselves by two at one meeting, it would be the easiest thing in the world to treble it later. Now, New Orleans is a long ways from here. We have got a great many men who have been coming from the South. I think some effort ought to be made by every member here to take a personal interest and get a man or two to join our organization or go with us to New Orleans. I personally wish that you people would take this under consideration, and try if you cannot obtain members so that we could work with proper numbers in the interests of the association.

Mr. W. H. Bateman: I heard our worthy secretary, Mr. Farasey, refer to New Orleans, which would lead us to believe that you had decided on that city as our next meeting place.

Secretary Farasey: That is the report.

Mr. W. H. Bateman: Vice-President Corbett appointed a committee consisting of Mr. Slocum, Mr. Hare and myself. We took action on the matter, and at the suggestion of the other members as well, unanimously decided upon going to Erie, Pa., for the reason that Erie, Pa., is within a circle inside of a hundred miles radius of some of the largest boiler manufacturing industries in the United States, and knowing that it is the desire of this association to awaken interest in the boiler manufacturers, we decided that we would go into the very soul and center of the boiler manufacturing industry.

President Meier: Mr. Bateman, there certainly is some misunderstanding about this, because I thought the committee had conferred.

Mr. W. H. Bateman: There was no conference.

Secretary Farasey: In answer to Mr. Bateman what he has said is true relative to the manufacturing center of boilers in Erie, Pa. We have no members in Erie.

Mr. W. H. Bateman: If you wish to go to New Orleans we will go there and do all we can to make a success of the meeting.

President Meier: When our committee reported I supposed that the thing was all thoroughly understood and in harmony. Now, allow me to make a suggestion, that our committee and the committee of the supply men get together this afternoon on the boat, and if they then conclude that we should reconsider the matter we will have a short session and take it up to-morrow.

The various re-elected officers and the newly-elected fifth vice-president thanked the convention for the honors conferred upon them.

Mr. James C. Stewart: To illustrate how public opinion has been doctored, I read from the morning paper: "Bay State boiler law held as a model." Now that may be the opinion of one or two. It is not the opinion of the Massachusetts men that had to do with it. I may be called an "old fogey" when I say that this law was entirely unnecessary; that I do not believe in boards of boiler rules and commissions to rule us. There is no other business in the world regulated by it. I feel humiliated that I, a member or a craftsman of a trade, should be held in such bad repute as to be looked upon as a murderer.

Mr. Stewart further contended that without State rules, such as have been laid down by the Board of Boiler Rules and the Massachusetts Boiler Manufacturers' Association, better boilers could be built, and in other States better boilers were built where no such rules existed. He claimed that the labor unions throttled the State Board, and it insulted that body, and that there was no redress from the rules in any way except through the courts, which was practically useless. Many of the rules were faulty, and some of these Mr. Stewart quoted.

The reduction in the boiler explosions was not due to these boiler rules, and he counseled States who had any intention of framing boiler rules to sit down and wait patiently before taking any steps. The rules adopted by Massachusetts had been absolutely detrimental to the oiler business. Regulation of the boiler business by laws he did not believe in; that under the rules there had been one of the most terrible accidents, in which seventeen men were killed.

President Meier: I should like to ask you, as president of the association, to give us a paper on the points which you have made.

Mr. McNeill: Mr. Stewart, would you kindly tell us the rule that the Massachusetts boiler manufacturers wish in regard to the stamping of boilers? The rule that was advocated by your committee was to stamp all boilers "Massachusetts Standard," with a serial number and with the boiler manufacturers' designation.

Mr. Stewart: I always fought against that rule. What I want for one I want for all, and I do not wish to restrict a manufacturer from out of the State of Massachusetts from bringing a boiler in and stamping it "Massachusetts Standard" if he wished.

Mr. McNeill: If we had adopted this rule it certainly would have shown the most unreasonable discrimination against manufacturers outside of the State.

Mr. Stewart: It cannot be said that we adopted it. It was never put through that committee.

Mr. M. H. Broderick: It seems to me as though this question of uniform specification has been brought up at several conventions without gaining very much ground. I think this association should get together and hire a competent man to do the work for them. We are making no headway now. It appeals to me very strongly to get right down to business and hire a man and put him right on this job, and it would be only a short time until we could get just what we wanted and be able to specify a first-class boiler.

President Meier: In 1897 the committee on uniform specification was appointed, and after taking up the discussion from the topical questions for eight years, a certain set of rules—general rules, nothing specific, but general rules—in regard to materials and workmanship were drawn up. These rules were taken up in the St. Louis convention, and adopted after about three days, and there were some changes made in them. They were adopted.

Secretary Farasey: I have in my hand the uniform condensed copy of the specifications. What Mr. Broderick wants to get at can be brought out by getting the information that Col. Meier has asked from Mr. Stewart. These specifications show the quality of plate, the size of rivets, the quality of rivets, and so on, and the workmanship to a great extent. The committee are Mr. Meier, Mr. Hartley, John Moore, of Chicago; James C. Mantell, of Philadelphia; James C. Stewart, James Lappan, George N. Riley and D. Canton. The trouble seems to be, if I understand the situation correctly, not in the quality of steel but the manner of turning, or facing or constructing the boiler hand-holes and stay-bolts; all that information is not here, we have discussed that in the proceedings, but a person would have to go through a great deal of printed matter to get that.

Mr. M. H. Broderick: This appeals to me; we have no uniform boiler specification in the State of Indiana. If this convention has something that was right and approved, it would be the easiest matter on earth to have it adopted at the next session of the General Assembly of the State of Indiana. If the boiler makers don't know what specifications they want, some machinist or a shoemaker is going to step in and get up uniform specification.

President Meier: The committee on uniform specifications is always ready to hear further discussion. If there is anything in the rules which the advance in boiler making or difference in material has made obsolete we are very glad to take it up. I recognize the difficulty of the Board of Boiler Rules and the difficulties that the Board of Supervising Inspectors have. We have met the members of that committee; special committees of the committee on uniform specifications have met with the Board of Supervising Inspectors every year, and we will be very glad to do so again. I asked Mr. Stewart to bring out the rules that have been found to be irksome; I think they will be obviated. I will have them published and sent to all our members who ask for them.

I would like to put in two exhibits in this year's report: "Boiler Explosions During 1910, Reported by the Hartford Steam Boiler Inspection Company."

The total number of boiler explosions in 1910, according to the best information we have been able to obtain, was 533. The number of persons killed by boiler explosions in 1910 was 280, which is almost identically the same as the number in 1908. The number of persons injured (but not killed) was 506 in 1910. The average number of persons killed per explosion in 1910 was .0525; the average number of persons injured (but not killed) per explosion was 0.949, and the average number of persons that were either killed or injured was 1.474 per explosion. A summary of the boiler explosions that we have recorded as occurring in the United States, Canada and Mexico between Oct. 1, 1867, and Jan. 1, 1909, is given in *The Locomotive* for January, 1909, and the total number of persons that were either killed or injured by boiler explosions during this period was 27,953.

In the German Empire last year only fifteen explosions occurred. We have not changed our rules at every shift of the wind. The yield point was brought up a few years ago.

Mr. James C. Stewart: In our last petition to your board you thought we had one good feature, namely, the firebox steel.

Mr. John A. Stevens: I thoroughly agree with you. It should be firebox steel. But in the spirit of not changing the rules every fifteen minutes we have got to go very carefully.

Mr. James C. Stewart: Do you consider to-day that those rules are perfect?

Mr. John A. Stevens: No, sir. There is nothing perfect on earth but mathematics.

Mr. James C. Stewart: We had ten changes to request. Why weren't some of those changed at that time?

Mr. John A. Stevens: With regard to the changes you can readily see that this was a very, very difficult task. We have corresponded with all the authorities in the known world, and we have letters in our file, gentlemen, that mean, in plain English, leave the rules alone.

President Meier: Mr. Stewart is going to give me, as chairman of the uniform specifications committee, the facts as to such changes or modifications as the Massachusetts men here think are advisable. I will have those printed and sent to every member of our association. If it is known to be a general consensus of the boiler manufacturers of the United States that there is too much detail in the rules we can act. Nothing delighted me so much as to hear they were going to cut out the flange steel and put in the firebox steel. There is nothing too good to be put into the boilers.

Adjourned to 10:30 A. M., July 13.

THURSDAY MORNING SESSION.

The convention met at 11 o'clock A. M., President Meier in the chair.

President Meier: Gentlemen, I am sorry that we have such a small attendance. There were several things occurred yesterday which I regret I did not stop at the time, largely owing to the fact that we could not hear very well, owing to the noise, and I did not catch everything that was said, so I take the burden of the blame for not stopping it at the time. It was fully my intention to do so. Our actions have not been an endorsement of every detail of the Massachusetts law, but that we considered that as a whole the bulk of it was good, and was in the direction which we had been working, but we felt always at liberty—not only at liberty but we felt it our duty—to assist our members in any regulation which they deemed necessary. Any objection to the rules I will place before the International Association and our committee on uniform specifications; and we will then work up a paper to be of assistance in this discussion when it comes up properly, according to law, in September.

Mr. James C. Stewart: They have a public hearing in November, but they are not obliged to hold it unless there is a petition.

President Meier: That gives us so much more time. The committee on uniform specifications concluded that it was not wise, in any law, to go into too much detail, and that details are very often matters for local consideration. Now, the general criticism of the Massachusetts law is that it has gone into too much detail.

Mr. James C. Stewart: I would like to say a few words as to why we never needed a boiler commission and why the labor union enters into it so much. You never saw in the State of Massachusetts any opposition to a commission, especially where there is a salary attached—and they are looking for those positions. Now, in this State we have laws for about everything. Why don't we have a commission to regulate the manufacturers of automobiles? Why don't we have a commission to regulate motor boats—the manufacturers of them—to make them safe? And so I could go on and tell you, gentlemen, things without number which could be regulated. I want to impress upon your minds that if there are any of these laws and rules and regulations coming up in your own State, for goodness' sake keep them off as long as you can, or until this national body can get some sort of unanimity and have something that is simple and devoid of all technicalities and useless detail.

President Meier: I will ask Mr. Stewart to give us a paper going more into detail and into the statistics.

Mr. Robinson: Mr. President, our State Board will get you up a set of rules if you want them.

President Meier: A set of rules for care of boilers?

Mr. Robinson: For care of them. They will get you up anything you want.

Mr. James C. Stewart: Our firm has sent out a set of rules for the care and regulation of the boilers. They are under ten heads. Some call them the Ten Commandments.

President Meier: I will send them out, but I have twelve commandments. There ought to be a short set of rules giving some common details sent out with each boiler. I ought to mention right here that while twenty years ago we had intelligent Americans or intelligent foreigners, now we are getting a number of benighted men from Europe; because they will work cheap they are put in as firemen or as water tenders. Those are men who need the instruction. That may be a most potent cause of increased boiler explosions.

Mr. Lynch: I wish to go on record, as representing the Hodge Boiler Works, as endorsing all that Mr. Stewart has said regarding the Massachusetts boiler rules.

President Meier: Anything further, gentlemen? If not we will close the public session and open the executive session.

Secretary Farasey: I rise in behalf of the association to tender a vote of thanks to those who made our stay here so enjoyable—the Acting Mayor, Dr. T. M. Bateman, the local committee, of which Mr. D. D. Russell is the chairman, and we appreciate the efforts of the supplymen who assisted them, also the proprietor of the hotel and the press.

President Meier: We better have a rising vote of thanks to all those who have assisted in making this convention so enjoyable. (Motion carried unanimously.)

President Meier: Mr. Secretary, we have some matters for the executive meeting which is confined to members.

The following attended the convention:

Thos. Aldcorn and wife, Chicago Pneumatic Tool Co., New York, N. Y.

R. E. Ashley, Muskegon Boiler Works, Muskegon, Mich.

E. A. Aplin, Chicago Pneumatic Tool Co., Chicago, Ill.

A. C. Ashton and wife, Ashton Valve Co., Boston, Mass.

W. H. S. Bateman, secretary Supply Men's Association, Philadelphia, Pa.

Wm. Brunner and wife, Tippett & Wood Co., Philipsburg, N. J.

H. A. Beale, Jr., president Parkesburg Iron Co., Parkesburg, Pa.

G. L. Buckman, Ashton Valve Co., Boston, Mass.

Winslow Blanchard and wife, president Boston Branch National Metal Trades Association, Boston, Mass.

Geo. S. Barnum, vice-president The Bigelow Co., New Haven, Conn.

W. W. Beal, The Lunkenheimer Co., Cincinnati, Ohio.

M. J. Broderick and wife, The Broderick Co., Muncie, Ind.

James Broderick, The Broderick Co., Muncie, Ind.

J. F. Corbett, Jos. T. Ryerson & Son, Chicago, Ill.

H. S. Covey, secretary Cleveland Pneumatic Tool Co., Cleveland, Ohio.

D. J. Champion and wife, vice-president Champion Rivet Co., Cleveland, Ohio.
Harry Connelly, Cleveland Pneumatic Tool Co., New York, N. Y.
D. S. Carter, Ingersoll-Rand Co., Boston, Mass.
D. F. S. Clark, secretary Boston Branch National Metal Trades Association, Boston, Mass.
J. V. V. Colwell and wife, Heine Safety Boiler Co., Boston, Mass.
R. S. Cooper, Independent Pneumatic Tool Co., New York, N. Y.
J. J. Cain, wife and family, Bayonne, N. J.
Geo. W. Denyven, The Arthur C. Harvey Co., Boston, Mass.
Columbus Dill and wife, Ashton Valve Co., Boston, Mass.
W. H. Davis, Scully Steel & Iron Co., New York, N. Y.
Chas. Dougherty, Ingersoll-Rand Co., New York, N. Y.
T. S. Eggleston and wife, Chicago Pneumatic Tool Co., Boston, Mass.
J. D. Farasey and wife, secretary A. B. M. A., Prop. Teachout Boiler Works, Cleveland, Ohio.
Miss Marie Farasey, Cleveland, Ohio.
S. A. Fortsen and wife, Lombard Iron Works, Augusta, Ga.
Michael Fogarty, Fogarty Steam Boiler Works, New York, N. Y.
P. H. Fergusen, assistant manager Pittsburg Steel Products Co., New York, N. Y.
Wm. A. Garrett and wife, Monongahela Tube Co., Boston, Mass.
J. T. Goodwin, National Tube Co., Pittsburg, Pa.
P. B. Gaudet, N. E. Boiler Works, Boston, Mass.
H. B. Hare, assistant secretary Otis Steel Co., Ltd., Cleveland, Ohio.
Chas. Humpton, Parkesburg Iron Co., Parkesburg, Pa.
F. G. Hausman, treasurer Star Brass Mfg. Co., Boston, Mass.
Richard Hammond, Lake Erie Boiler Co., Buffalo, N. Y.
Miss Anna Hammond, Buffalo, N. Y.
Wm. L. Hirsch, sales agent American Steel & Wire Co., Pittsburg, Pa.
Chas. Heggie, general manager Scully Steel & Iron Co., Chicago, Ill.
R. R. Harris, general manager of sales Pittsburg Steel Products Co., Pittsburg, Pa.
Robert Joy, superintendent Kingsford Foundry & Machine Co., Oswego, N. Y.
S. F. Jeter, Hartford Steam Boiler & Inspection Co., Hartford, Conn.
W. C. Jones, Hillis & Jones, Wilmington, Del.
Wm. Kehoe, Kehoe's Iron Works, Savannah, Ga.
J. A. Kinkead, Parkesburg Iron Co., New York, N. Y.
Charles F. Koopman, Jr., New England Iron Works, Boston, Mass.
James Lynch, official reporter, Boston, Mass.
John E. Lynch, Hodge Boiler Works, Boston, Mass.
Geo. F. Lawley and wife, Geo. Lawley & Son Corporation, Boston, Mass.
Wilbur Sargent Locke and wife, Carnegie Steel Co., Boston, Mass.
Augustine Lloyd and wife, Rep. Geo. H. Lloyd, Boston, Mass.
H. H. Lynch and wife, Hodge Boiler Works, Boston, Mass.
Walter Long and wife, Walter Long Mfg. Co., Pittsburg, Pa.
Fred R. Lowe, editor *Power*, New York, N. Y.
A. M. Mueller, assistant manager of sales Jos. T. Ryerson & Son, Chicago, Ill.
Alex S. Mitchell, Rep. Champion Rivet Co., New York, N. Y.
Geo. S. Musgrave, Star Brass Mfg. Co., Boston, Mass.
Miss Alice C. Musgrave, Boston, Mass.
Col. E. D. Meier, president Heine Safety Boiler Co., president A. B. M. A., New York, N. Y.
E. J. Mishler and wife, sales manager Reading Iron Co., Reading, Pa.
Thos. McNeil, Pittsburg, Pa.
Jos. H. McNeill, chairman Board of Boiler Rules, Commonwealth of Massachusetts, Boston, Mass.
Jas. A. McKeown, John O'Brien Boiler Works, St. Louis, Mo.
J. McCabe, Chief Boiler Inspector, Detroit, Mich.
F. H. McCabe, Rep. E. McCabe & Co., Lawrence, Mass.
John C. Neale, assistant general manager of sales Carnegie Steel Co., Pittsburg, Pa.
L. F. Nagel, general sales agent Worth Bros. Co., Coatesville, Pa.
Miss Lillian O'Brien, Lowell, Mass.
Harry G. Porch and wife, Lukens Iron & Steel Co., Boston, Mass.
Geo. N. Riley and wife, National Tube Co., Pittsburg, Pa.
Mrs. T. M. Rees, Pittsburg, Pa.
Geo. A. Rees, vice-president Chicago Pneumatic Tool Co., Chicago, Ill.
John Rourke, John Rourke & Son, Savannah, Ga.
Miss Agnes Rourke, Savannah, Ga.
Chas. B. Rowland, vice-president Continental Iron Works, New York, N. Y.
Duncan D. Russell and wife, Jas. Russell Boiler Co., Boston, Mass.
Joseph M. Robinson and wife, Atlantic Works, Boston, Mass.
H. O. Ramsay, National Tube Co., New York, N. Y.
D. W. Robb, Robb Engineering Co., Ltd., So. Framingham, Mass.
Mr. Dan Russell, John Regan, Dan Russell Boiler Works, Boston, Mass.
C. F. W. Rys, metallurgical engineer, Carnegie Steel Co., Pittsburg, Pa.
F. B. Slocum, Continental Iron Works, New York, N. Y.
Mrs. Josephine Schimpf, Philadelphia, Pa.
J. Don Smith and wife, Valk & Murdock Iron Works, Charleston, S. C.
Geo. Slate, advertising manager THE BOILER MAKER, New York, N. Y.
Jas. C. Stewart and wife, Stewart Boiler Works, Worcester, Mass.
Jas. J. Sullivan, Rep. Champion Rivet Co., Boston, Mass.
B. Scannell, Scannell Boiler Co., Lowell, Mass.
Geo. Scannell, Lowell, Mass.
Miss Katharyn Scannell, Lowell, Mass.
Miss Mary Scannell, Lowell, Mass.
J. L. Speirs, Speirs Bros., New London, Conn.
Lewis Sitss, Carnegie Steel Co., New York, N. Y.
John A. Stevens, member Massachusetts Board of Boiler Rules, Lowell, Mass.; F. H. Scantlebury, rep. Hanna Engineering Works, Chicago, Ill.
M. J. Tudor and wife, Tudor Boiler Mfg. Co., Cincinnati, Ohio.
Geo. A. Tibbals, secretary and treasurer Continental Iron Works, New York, N. Y.
Jas. M. Towle and wife, Chicago Pneumatic Tool Co., Boston, Mass.
Geo. Thomas 3d, treasurer Parkesburg Iron Co., Parkesburg, Pa.
John Thrash, Dallas, Tex.
Burton H. Tripp, Chicago Pneumatic Tool Co., Philadelphia, Pa.
C. S. Wayman, Jos. T. Ryerson & Son, New York, N. Y.
Chas. J. Wangler, Jos. Wangler Boiler & Tank Co., St. Louis, Mo.
M. G. Weidner, Walsh & Weidner Boiler Co., Chattanooga, Tenn.
F. Whitney, Apolinaris Agency Co., Boston, Mass.
Quincy W. Wales, Brown-Wales Co., Boston, Mass.
T. P. Wallace, vice-president Hagar Iron Co., St. Louis, Mo.
S. T. Wilson and wife, president Tippet & Wood, Phillipsburg, N. J.
T. V. Wholey and wife, Wholey Boiler Works, Providence, R. I.
Dennis Wholey, Wholey Boiler Works, Providence, R. I.
Samuel Waterworth, N. E. Boiler Works, Boston, Mass.

The officers of the Supply Men's Association for the coming year have been elected as follows:

John Corbett, president.
Thomas Aldcorn, vice-president.
F. B. Slocum, secretary.
H. B. Hare, treasurer.

The testimonial given President E. D. Meier on the celebration of his seventieth birthday pleased him greatly, and while we never could associate the Colonel with age we see that "the snows of life's wintry hours" have fallen around him and whitened his head, but no storm of life can chill in the hearts of his friends their admiration and regard for him.

The re-election of Mr. J. D. Farasey was an acknowledgment of his hard work for the association. His remarks as to the enlarging of membership should be taken to heart by every member, not only for the association's sake but to show a proper appreciation of Mr. Farasey's hard work. The mere vote of thanks for what he has done is but a meager compliment if it is not backed up by following his wise advice, which will redound to the good of the association.

A Book on Boiler Regulations.

The Province of Alberta has issued its Regulations for the "Construction and Inspection of Boilers." In this little book very full details are given, and, if properly studied, the builder or user of boilers in the province will be thoroughly guided, as far as governmental demands are concerned, as to the law. The book is more, however, than just a setting forth of legal requirements. It is generally clear in its rules or formulæ, and it seems to err always on the side of safety, which is most admirable.

We think, however, some of the rules could be more clearly stated for those who have had more to do with the shovel and slicer than the multiplication table, but the book is one which is an advantage to have on the desk of the engineer as well as the drafting board.

As the book is issued by the authority of the Premier of Alberta, the Hon. A. L. Sifton, we presume it can be obtained if applied for.

A Useful Jig.

EDITOR THE BOILER MAKER:

On the inside of the back cover of your issue of July there was shown a six-spindle drill. These are awful nice tools, and are as handy as a pocket in a shirt if you know how to use them. There is one fault with the one which you show, and that is, there are not enough tee slots in the table. I said that these machines were as handy as a pocket in a shirt, but it "takes a little bit of fixing," as they say up East, to get the best out of them.

When you have a whole lot of plates to drill you can afford to make a templet, or, as they call it in the machine shop, a "jig," but when you have only a few this hardly pays.

I once had some plates to drill, and had a drill very much after the order of the one I have referred to, but there were not enough of the plates to warrant making a jig, so this is how I managed:

I put a stop, which was nothing but a piece of machinery steel bolted into the tee slot firmly. I put this 7½ inches from the center of the first spindle. I then made a block 6 inches long, another 3 inches long. If now I brought the sheet up against the stop, I would drill a hole 1½ inches from the edge, and the other five holes would be 9 inches apart. After drilling these six holes, I put the 3-inch piece up against my stay, and pushed my plate up against it, keeping it also up against the spacers, and then drilled. I then took out the 6-inch piece and put in the 3-inch and drilled again. The result was that I had holes pitched 3 inches apart.

It took just two shifts to do all the drilling required, and the plates came out, of course, very accurate.

Now, the advantage of this style of jig is that you can drill holes with it any distance from the edge of the plate from the greater distance down to actually the edge. This is shown by the double dotted lines with the center *A'*, which would bring the center of the hole 1 inch from the edge of the plate

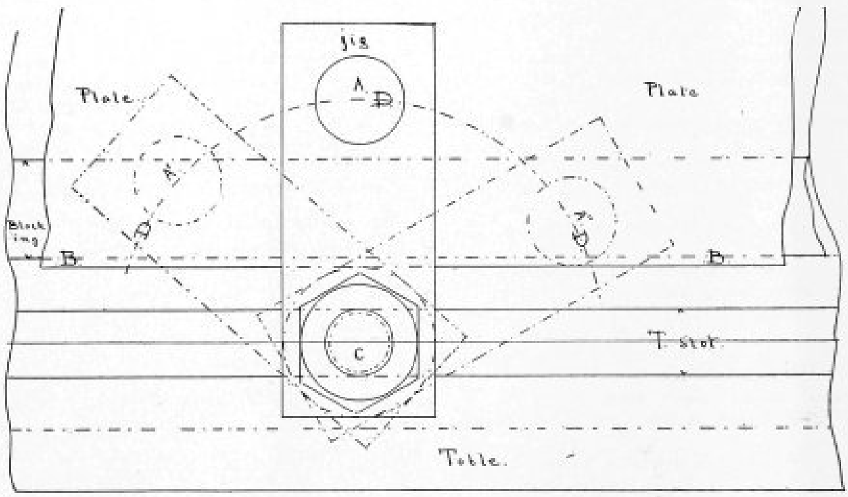


FIG. 1.

I took some cold rolled stuff, which was 1¾ inches wide by ⅞ inch thick, and cut off six pieces 4¾ inches long. As I had to drill inch holes I drilled an inch hole as shown in Fig. 1 at *A*, and 2¼ inches from it I drilled a 13/16-inch hole. I countersunk the tops of the inch holes and case-hardened them and left the other ends soft.

Now, in using a multiple drill the advantage of this type of machine is that you can drill six holes at once; the disadvantage is that you cannot get the heads very near together. The one you show can be pitched 9-inch centers, but I had to have my inch holes pitched 3-inch centers. There was a tee slot at the back of the table, very much in the position which I show in Fig. 2. The center of the holes I had to drill would be 2 inches practically from the edge of the plate. The "spacers," shown in Fig. 2, form stops. I took six bolts, as shown in Fig. 2, slipped the spacers over the bolts and then the jig piece, and then drew down on the nuts. Up against the spacers I put a piece of cold rolled, which was 1¼ inches by ½ inch. I took another piece of this same stock and laid it at the extreme front edge of the table. This blocking was merely to lift the plate up so that the drill would not cut into the table. The next time I use this blocking with a 1-inch drill I shall take a piece of inch stuff, as it gives more chance to get out the chips and for the drill to clear the table.

In this particular case I took the six jig pieces and set them at right angles to the jig slot, directly in line with the drill spindle, and put the plate in position under them. After I had clamped all down good and solid, at the end of the table

if the jig piece was thrown around in the position shown. If it were thrown around, as shown on the right hand, with *A''* as a center, the drill would just cut through the edge of the plate.

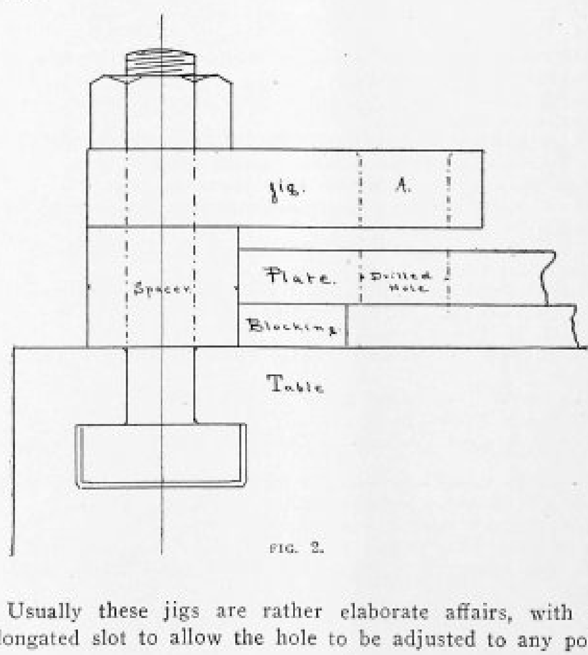


FIG. 2.

Usually these jigs are rather elaborate affairs, with an elongated slot to allow the hole to be adjusted to any position, but I think that what I have attempted to explain will be understood by boiler makers, and I hope it will be handy for some of them. It has been to me.

I like the idea of having two independent drives, shown in the illustration, as often only three drills need be run, so power and oil are saved, and then, sometimes, some of the holes may be larger than others, and two speeds will help matters. I think it would be mighty handy if some system was fitted to the table so a heavy steel could be moved, say 2 inches, or anything under, as it is hard to knock a large plate over and back and to bring a center just under a drill. "Jig."

Pittsburg, Pa.

Another Old Timer.

Editor The Boiler Maker:

I was very glad to read John Cook's experiences. He sure was the Class A No. 1 boiler maker back in the '60's. In speaking of his ability he was very modest. There were very few good men in those days. I worked at Erie, Pa., about '66 and '67, and the company I worked for had some boilers to make for a blast furnace. The engineer wanted the courses made taper, but the foreman said they couldn't be made taper and have the boilers straight. I was very young and foolish those days, and I told the foreman I could make the courses taper and yet have the boilers straight. I had seen such made.* "I suppose that if you can do that class of work you should have a better job—somewhere else." I got through the next Saturday, as I saw that I put my foot in it.

Out in Erie they now turn out boilers about as fast as they do shingles in a lumber camp. If you will send Cook's address I will write him; there are a few of the "old-timers" left. Both he and I, I guess, are in the grandfather class to-day. While speaking about Erie, I will tell of another shop which got a man by the name of Robert Connery, of Philadelphia, as foreman. He was an "A No. Oner," but he put a desk and a chair in a boiler shop and started to use them both; but that didn't suit in those days of boiler work in the city of Erie. What they wanted was a foreman to be the hardest worker in the shop, so Robert left in a very few days. It would take a very long time to tell of the funny things that happened in those Erie shops back in those days, so I will switch off and say something about the Omaha convention.

I was very glad indeed to see such a fine lot of men there, and was sorry to miss some who had gone to the silent majority. Still, I had a handshake from some of them. I could not help but think of the contrast between those old days, when the best pugilist in the shop had to be the foreman. I remember a lot of the other old-timers. Jim Cusick at the Neptune Works, Jack Fanell at Peas & Murphy's, Mike Flannigan at Bunce's in Brooklyn, Charlie Franklin at Allaire's, Jim Stephens at the Novelty Works, Ed. Tankey and Owen Geoghan. I can tell you it took a man strong in the arms to be a foreman in those days, and they did do some tall swearing and a good deal of drinking, and they were first-rate fighters, but they were good men.

One North River captain, who took a lot of them up to the West Point Foundry, said that they swore so hard on the way up that they broke the paddle-box. Bill Roston, I remember, he wanted a raft captain out West to take the news down the river that he had laid out and flanged the first flue sheets in Minnesota, but the captain shook his head, and told him to get that stuff printed; he could not remember it.

I missed an eminent party at the convention. He was a thirty-second degree and past master of the Ananias Society for Dissimulation of Truth. His name was J. H. ———. He was a first-class workman, but if he ever told the truth it was an accident. Mike Flannigan was a master boiler maker at the Rhode Island Locomotive Works, or it was called the Burnside Works then. B. W. Healey was "super." of the works, and sent for Flannigan to come to the office. Flannigan had a pretty good idea of himself, and sent back word that he "only done business in his boiler shop."

In the 80's, I think it was '84, I was running a division shop out West. It was the C. M. & St. P. The foreman of the shop attended the convention, and when he came back he told me he had learned a lot of new things there—among others, that the way to take out tubes was to enlarge a hole in the front flue sheet to, say, 2⅛ inches, and drive the flues back in the firebox, and then take them out the enlarged hole at the front end. I told him that we had been doing that for six years, only we made the hole 2¼ inches. This M. M. was very much surprised, as one of the men had told him that this idea was new; and no doubt it was—to him. And it is a good idea.

I would like to hear of Peter Backus, who was at one time foreman in Wilkebarre, Pa.

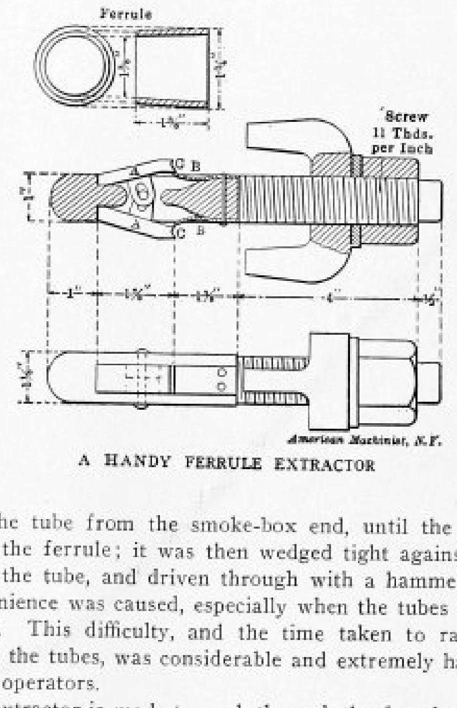
Omaha.

Old Crank,
Ex-Foreman.

* See Laying-Out Contest, our April issue.

Extracting Boiler Tube Ferrules.

The ferrule extractor has been designed to avoid the unnecessary labor that arises when extracting ferrules from the tubes of locomotive boilers. Previously a long bar was put

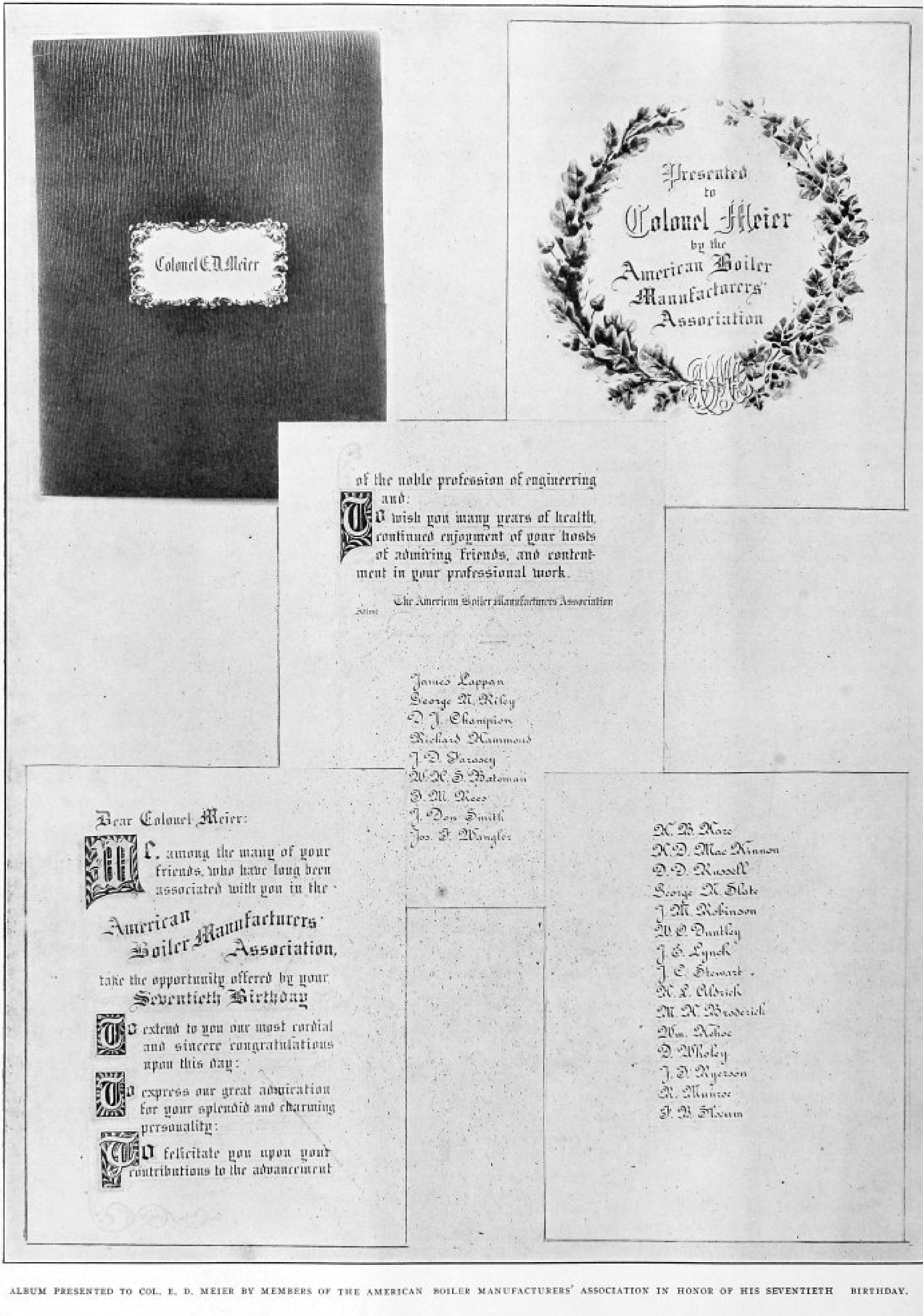


A HANDY FERRULE EXTRACTOR

down the tube from the smoke-box end, until the end was against the ferrule; it was then wedged tight against the inside of the tube, and driven through with a hammer. Great inconvenience was caused, especially when the tubes were full of soot. This difficulty, and the time taken to ram a bar through the tubes, was considerable and extremely hard work for the operators.

The extractor is made to push through the ferrule, the jaws *A* contracting to the size of the hole in the ferrule when being pushed through. When it is through the ferrule the jaws are pressed hard against the inside of the tube by the springs *B*. It is drawn against the end of the ferrule, and the bevels on the end of the jaws *C* give the jaws a secure catch, being drawn into position. The gland and nut are then put on, the nut being screwed with an ordinary screw key, thus extracting the ferrule.

I have designed and tested this tool, which gives every satisfaction, and when made of tool steel it is absolutely reliable. —J. H. Edington in *American Machinist.*



ALBUM PRESENTED TO COL. E. D. MEIER BY MEMBERS OF THE AMERICAN BOILER MANUFACTURERS' ASSOCIATION IN HONOR OF HIS SEVENTIETH BIRTHDAY.

Boiler Explosions in England.

The following extract from the report of the committee of management of the Manchester Steam Users' Association in England is of interest, as it shows what may be done by careful and rigid inspection toward reducing the number of boiler explosions and the resulting fatalities:

"As many as 22,656 examinations were made of boilers during 1910, including feed-water heaters or fuel economizers, 9,675 of these being 'internal,' 'flue' and 'entire' examinations, the highest number ever yet recorded.

"The firebox of a locomotive crane boiler enrolled with the association had collapsed and rent during the year, resulting in personal injury to several workmen. The matter, the report stated, was still under investigation, with a view to determining the actual cause, which could not at present be stated. At the end of fifty-six years' working the committee was able to report that no life has ever been lost by the explosion of any boiler under the association's guarantee.

"Outside its ranks the association had recorded during the year 1910 the occurrence of 85 explosions, killing 20 persons and injuring 71 others. Of these, 24, killing 9 persons and injuring 34 others, may be termed 'boiler explosions proper,' while the remaining 61, killing 11 persons and injuring 49 others, may be termed 'miscellaneous explosions'—those arising from steam pipes, stop valves, kiers, drying cylinders, bakers' ovens, etc. In addition to the above, one explosion arose from the bursting of a kitchen boiler, by which one person was killed. These figures are higher than for several years past, but in many cases the explosions were of a comparatively trifling character, though subject to investigation under the provisions of the Boiler Explosions Acts, 1882 and 1890."

A record of fifty-six years without a single fatality from boiler explosions is indeed remarkable. Just imagine the opportunities presented to a similar association in this country! —*Power.*

Care of Gage Glasses.

In the boiler room the gage glass very often receives but scant attention. When one breaks every engineer knows it is not a very comfortable matter to shut the valves leading to the glass and replace it. Spare glasses should always be kept on hand for just such emergencies and in the keeping of these spare glasses some care is called for. For instance, it is very common to find spare glasses strung upon a wire, and unless a soft wire like copper be used, the glass, if moved much, is sure to be scratched by the wire, which leads to its early breakage. It is singular how sensitive the inner surface of a gage glass is to injury of this sort, the slight friction of an iron or steel wire being sufficient to cause the glass to break from apparently no cause whatever. The experiment may be tried any time by rubbing the inner surface of a gage glass with an iron wire and then placing the gage glass carefully away. In a great majority of cases it will be found that if the glass has not broken spontaneously in the course of time, its life, when in service, will be very short. Another fault to be found with gage glasses in boiler rooms is that they are set in such poor shape and so ill lighted that proper care is seldom vouchsafed to them. It is an easy matter to place an incandescent lamp near the gage so that it may be readily seen at all times; but too often nothing of the sort is provided and the gage cannot be read with ease. This, coupled with the dirty conditions in the boiler room, soon obscures water in the glass altogether, so that it is a very easy matter for the fireman to make a mistake which may prove costly. If a gage glass breaks the fireman can bind up his arm and hand and close the lower valve without danger.—*Chester Adams, in the Electrical World.*

Duty to Safeguard Machinery.

In an action for personal injuries by an engineer, the particular act of negligence alleged and relied on was that the defendant had so located its engine and force pump in the engine room on opposite sides of the passageway leading from its main building to the engine room as to leave but a very narrow passage between the end of the shaft on the engine and the force pump, through which the plaintiff was obliged to pass in the discharge of his duties, and had negligently permitted the shaft and pump to remain in this dangerous position, so that the plaintiff, while in the discharge of his duties, without fault on his part, had his arm caught between the shaft and the belt, sustaining the injuries complained of. It was held that the jury were properly told that if they found that the plaintiff complained of the defective condition of the machinery, and that the defendant promised to have the defects remedied, but failed to do so within a reasonable time, and in consequence the plaintiff was injured, the defendant was liable, unless the jury believed that the plaintiff failed to exercise reasonable care and caution, taking into consideration his experience, and unless the danger was so palpable that no one but a reckless person would expose himself to it, even after such promise. The plaintiff's subsequent use of the machinery in the well-founded belief that it would be put in proper condition did not necessarily, and as a matter of law, make him guilty of contributory negligence. The question of whether the plaintiff had exercised due care in the circumstances was for the jury.—*Parfilt v. Sterling Veneer & Basket Company, West Virginia Supreme Court of Appeals.*

Fellow Servants Under Employers' Liability Act—Measure of Damages.

A boiler maker's helper recovered damages from his employer for injuries sustained under the following circumstances: He was helping a boiler maker engaged in repairing a boiler and renewing rivets with patch bolts in the side sheet of the boiler. A part of this work consisted in chipping out a hole with a hammer and chisel, in which work burrs or pieces of sheeting are cut off and thrown from the sheeting with great force. In working upon the boiler the boiler maker had used an air hammer, and plaintiff stood behind him out of danger. A chisel fell under the ash-pan in the firebox, and the boiler maker directed the plaintiff to get it. When he started to get it the boiler maker discontinued work, but while the plaintiff, in obedience to his orders, was getting the chisel, he commenced work on the fire-box, and just as the plaintiff had got the chisel and straightened up, the boiler maker cut a burr from the sheet which struck his right eye and totally destroyed its sight.

It was undisputed that the boiler maker was intrusted with authority to direct and superintend the plaintiff in the work. In that state of the evidence they were not fellow servants under the Texas statutes. (Rev. St. 1895, art. 45,609 and acts 1909, c. 10, the Texas Employers' Liability Act.) Under these statutes it was not essential, in order to constitute the boiler maker a vice-principal of the plaintiff, that he have the power to hire and discharge. The common law rule, to the effect that the employee's negligence would not be imputed to the master unless such power was conferred upon him, was abrogated by these statutes. The evidence showed that the vice-principal was guilty of negligence proximately causing the injuries. Two physicians testified that the plaintiff had only two-thirds normal vision in his left eye, and that its condition was due to sympathetic weakness from the injury to the right eye. Under these circumstances it was held that a verdict of $11,000 was not excessive.—*St. Louis, S. F & T. Ry. Co. v. Jenkins, Texas Civil Appeals.*

SOME RECENT DEVELOPMENTS IN TESTING.

BY F. W. SPELLER.

It is generally understood that much depends on the boiler tube, especially in locomotive service, this being relatively the weaker member, so that the usefulness of the boiler is frequently determined by the strength of the weakest tube.

A variety of specifications have been drawn up, with that of the American Railway Master Mechanics' Association as a basis, to regulate the quality of the material and the manufacture of locomotive boiler tubes. At the present time each road has a specification of its own, usually differing in some points from the others, but in general they require a flanging, flattening or crushing down test on one out of each lot of 100 or 250 tubes. In the manufacture of lap-welded tubes we have found it necessary, in order that the tubes will be as far as possible uniformly satisfactory, to make such tests on each end of every tube, and have designed a special machine to make these tests on the crop ends as they are cut off.

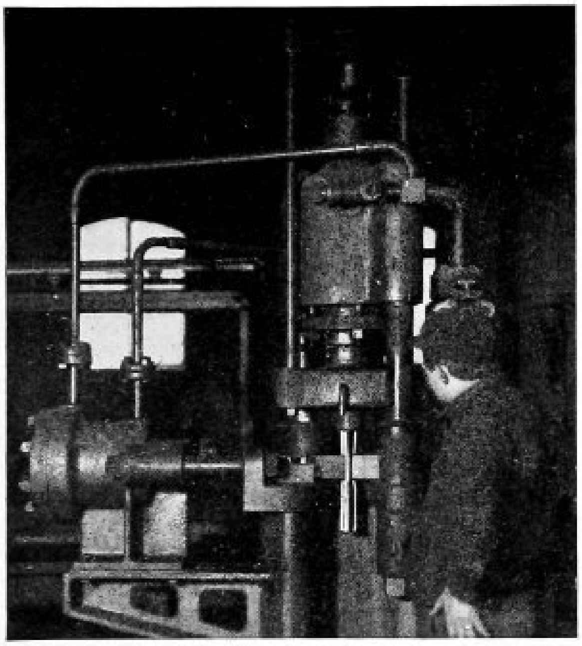


FIG. 1.—FLANGING MACHINE, SAMPLE OF TUBE AT FIRST STAGE OF TEST.

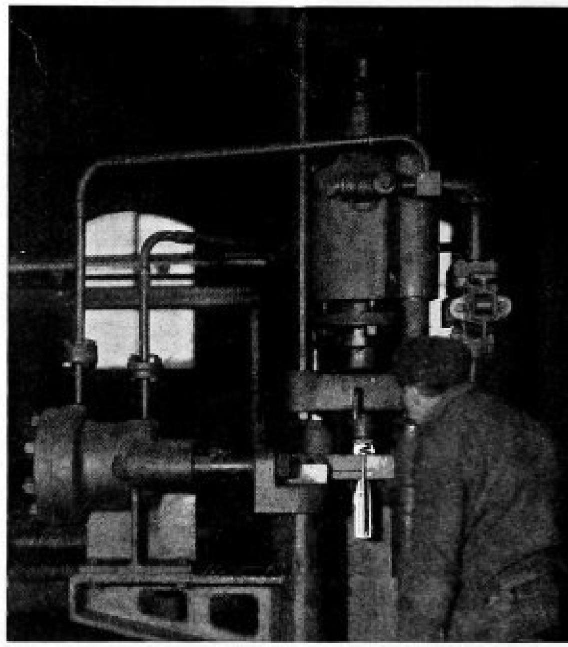


FIG. 2.—FLANGING MACHINE, SHOWING FINISHED TEST.

Fig. 1 is made from a photograph of this machine showing the crop end or short piece from a tube in the act of being flattened down in the horizontal grips, which hold the piece while a flange is turned by a die. At the same time the sample is crushed down in the direction of the axis of the tube, as shown in Figs. 2 and 3. The machine is operated by hydraulic power, both horizontal and vertical cylinders being controlled by the same lever. The flanging die is preferably magnetized by a coil so as to keep the sample in place until the grips take hold. By placing the machine in a convenient position it may be quickly operated by the man who cuts off the crop end, thereby enabling him to separate tubes which are not welded or which show other defects. While experimenting with flanging dies for this machine, we received one from James H. Gibboney, chief chemist Norfolk & Western Railway Company, which proved quite satisfactory for the purpose. This test, made on every tube, makes it practically certain that the weld is as strong as other parts of the tube, and that the physical properties are uniformly up to the standard required.

Among the various requirements in specifications written for locomotive boiler tubes there are naturally in each many excellent provisions, some of doubtful value, and a few clauses which tend to produce the opposite result from that for which the specification was written.

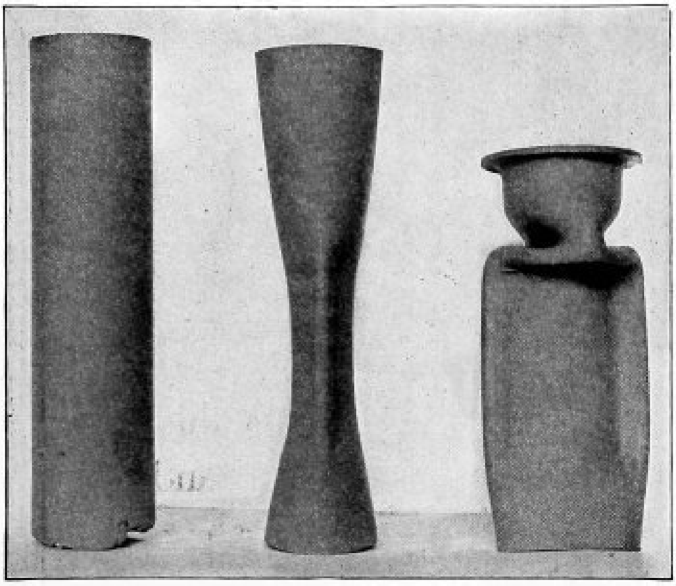
Locomotive tubes, whether seamless or lap welded, must sooner or later be safe-ended, hence the welding quality of the metal should be one of the first considerations in manufacture. Some specifications now written restrict the chemical composition in some particulars, so as to hamper the manufacturer in making a good welding steel. There is no difficulty in making steel with a maximum of .03 percent phosphorus if necessary, but there is reason to believe that .05 phosphorus is a more reasonable maximum limit which does no harm, and, with other conditions the same, will give a tube better adapted to service and much more easily welded.

Another restriction which experience teaches is operating against the best quality in locomotive tubes is unreasonable sulphur requirements. The highest sulphur allowed in samples taken from individual tubes is, in some cases, .035 percent, which means that the ladle test must not exceed .03 percent. With producer gas this means that the heat must often be held and a heavier burden of lime carried, which tends to render the steel "dry" in welding and more liable to be crystalized or burned. If there is any advantage in a closer sulphur specification than, say, .05 percent on samples taken from individual tubes, we would be glad to learn what is gained thereby from those who have had more experience. Personally, I have not found a case of failure which could be attributed to the sulphur being as high as .05 percent; on the other hand, there are undoubtedly countless numbers of tubes giving good service which carry close to this amount of sulphur.

Analyses of the surface of beads taken from tubes after being in the boiler some time show that sulphur is absorbed from the hot flue gases, so that if there is any advantage in using steel of .03 sulphur, it would appear to be only temporary. The results of this investigation are given in the diagram, Fig. 4. The engines from which these tubes were taken had been operating on different roads under widely different conditions, but in each case the tubes had all given equally good service and were being removed for safe-ending. It also appears from a comparison of the sulphur taken up

by individual tubes under the same conditions that there is no consistent relation between the original sulphur and the amount absorbed, so that it does not follow because the tube was originally low sulphur that it would therefore show comparatively low sulphur after being subject to the action of the hot flue gases; the results rather suggest that the low sulphur tubes are more susceptible to sulphurizing by the hot flue gases.

A study of records in lap welding may throw some light on the relative influence of variations in sulphur contents. For example, two heats which had been rephosphorized gave the



(a) (b) (c)

FIG. 3.—(a) CROP END BEFORE TESTING. (b) SAME AFTER FLATTENING. (c) FINISHED TEST.

following welding records, each piece being tested in the flanging machine after the first run through the welding furnace and rejected if there was any indication of an opening at the seam:

Heat No.	No. of Pieces.	Chemical Analyses S	P	Mn	C	Percent Not Welded.
3,432	1,272	.054	.036	.43	.105	14.7
30,522	1,401	.027	.037	.47	.113	20.2

The average of nine heats of steel which ran .03 percent sulphur or less showed 20 percent more rejections on account of bad welds than eight heats where the sulphur ran over .04 percent, these heats being nearly the same in other respects.

As to the effect of foreign elements in these amounts on the corrosion of steel under ordinary conditions, we have no evidence that their presence has any decided effect one way or the other in well-made steel, and the grade of soft steel made exclusively for the manufacture of pipe certainly belongs to this class. The degree of uniformity obtained even between individual Bessemer heats made for this purpose is, it is safe to say, as good as that shown in the records of the most highly refined product of the open-hearth furnace, and uniformity, both physical and chemical, is undoubtedly a large factor both in welding and in corrosion.

The supposed beneficial effect of great purity has, I believe, been greatly over-estimated. Some time ago the writer found by using the sensitive ferroxyl test that cross sections of steel which had all the variations due to segregation would not show a regular difference of polarity under repeated tests made on the same section, the explanation evidently being that external influences, such as finish and accidental irregu-

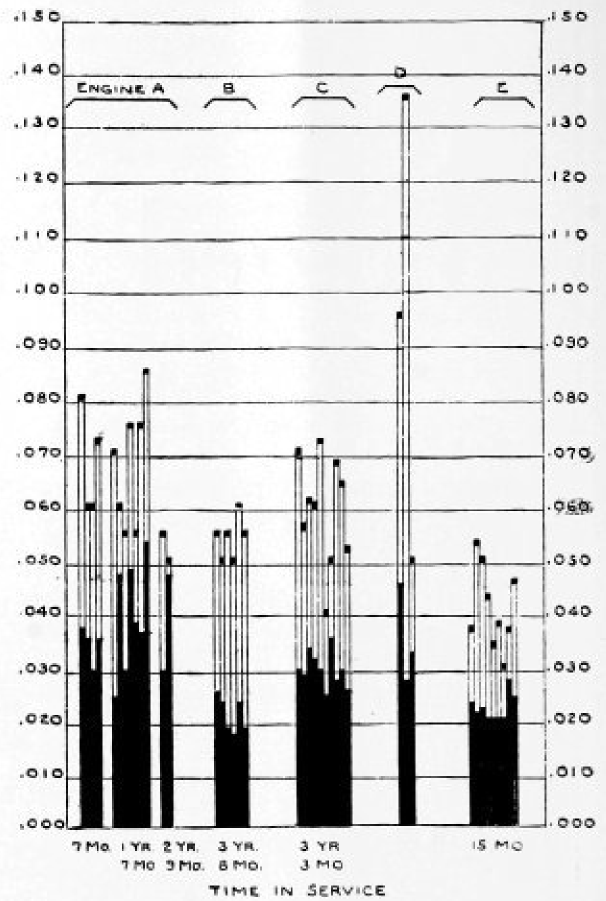


FIG. 4.—DIAGRAM SHOWING AMOUNT OF SULPHUR ABSORBED BY TUBE ENDS FROM FLUE GASES IN LOCOMOTIVE FIRE BOX.

Percent sulphur, lower shaded portion, original S, upper open portion, increase S in bead.

larities in oxidation, predominated and overpower the much smaller differences in potential, due to irregularities in the metal itself.

We believe it would be to the advantage of all concerned if a standard specification was agreed upon for boiler tubes, with which there could be no objection to a test on the ends of each tube along the lines described above, provided the chemical requirements were not unnecessarily restrictive.

INSTALLING BLIND STAY-BOLTS.

BY H. S. JEFFERY.

In a locomotive where the firebox is between the frames a number of firebox stay-bolts are hidden from view from the outside by the frames and various pads and brackets and other parts of the boiler. Holes can be made in the pads and brackets so that the stay-bolts can be removed, but holes cannot be made in the frame when the frames are fastened to the boiler, as shown in Fig. 1; here the stay-bolt must be removed from the inside of the firebox.

The stay-bolt is taken out of the firebox side sheet by cutting off the head and then drilling into the bolt a hole considerably beyond the sheet, Fig. 2. Then the part of the stay-bolt marked A is crushed in, allowing the stay-bolt to drop down in the water leg; it is supposed that the stay-bolt is being removed because of fracture. Since stay-bolts usually break at, or near, the outer firebox sheet, it need be released only on the firebox side sheet end.

To remove the burr in the outer sheet is most difficult. If the stay-bolt is broken off within, or flush with the sheet, it is not so difficult to drill out the burr. If, however, the stay-bolt projects beyond the sheet, the greatest care must be taken in order not to spoil the hole in the outer sheet. The projecting end of the stay-bolt is sometimes cut off flush with the sheet and then the burr drilled out—by some cut out; but the latter is slow work. The hole through the stay-bolt burr of the outer sheet having been drilled, it can be crushed in and removed.

The hole is now ready to re-tap, which is done with a spindle tap, Fig. 3. The end *a* fits into the stay-bolt hole of the outer sheet in order to guide the tap properly when tapping

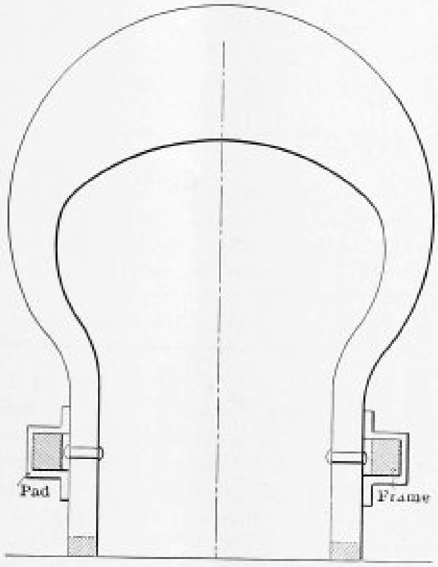


FIG. 1.

the threads in the firebox furnace sheet. Without the guide the chances are the tapping would not be in line with the hole in the outer sheet.

The spindle tap is made with a number of threads *b*, which guide the tap when tapping the hole in the outer sheet. Threads having been tapped in the two sheets, the stay-bolt is put in, and it should be a very tight fit, as it can only be driven on the firebox end, the end between the frame and the outer sheet has to be upset as best it can; it is frequently done by a wedge driven in between the frame and the projecting end,

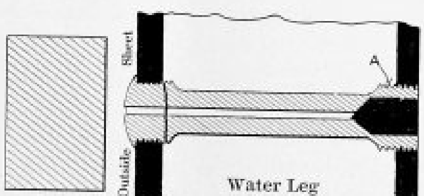


FIG. 2.

the wedge serving as a holding-on bar when the stay-bolt end, firebox side, is being riveted over. If the fit is tight and the threads in the outer sheet are very good, it will be steam tight, and will be sufficiently upset by the wedge when the stay-bolt end is riveted over. If not steam tight it has to be further upset with the wedge, holding a holding-on bar on the stay-bolt during the operation.

TESTING STAY-BOLTS.

To detect fractured stay-bolts a small hole, called a tell-tale hole, is drilled in the center of the bolts to the depth of 1 inch to 1¼ inches. The whole purpose of the tell-tale hole is to serve notice that the stay-bolt is broken, which is shown by the steam escaping from it. This cannot be depended upon alone, as foreign substances frequently clog up the break, preventing the steam from escaping.

The method of testing rigid stay-bolts is to tap them from the firebox side and judge from the sound or the vibration if there is a break. Some, when testing, hold on the stay-bolt head a holding-on bar, while others fill the boiler with water and test the stay-bolts under about 50 pressure per square inch. The object of testing the boiler under pressure is to produce sufficient strain to cause breaks to separate.

Testing stay-bolts as desecribed is called a hammer test,

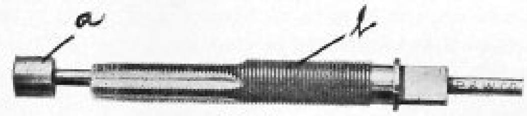


FIG. 3.

but it does not by any means find all the broken or fractured stay-bolts. Great skill is required in hammer testing, and trouble is found more by chance than by anything else. A fractured stay-bolt will sound different from a solid one; but if the fracture is light it will deceive the most experienced tester.

Tests should be made frequently, at least once a month, and aside from the tell-tale holes and the hammer test it is good policy to make an interior examination of the boiler. When a stay-bolt is fractured a water mark, different in color from the stay-bolt itself, appears at the fracture, thus enabling it to be discovered by an interior examination. A light of some kind fastened to a stick can be passed between the rows of stay-bolts so as to facilitate examination, and this visual test is equal to, if not superior to, the hammer test. The hammer test method requires an experienced tester, and he will miss many fractured bolts, while the interior examination

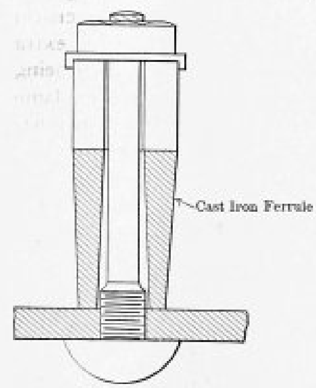


FIG. 4.

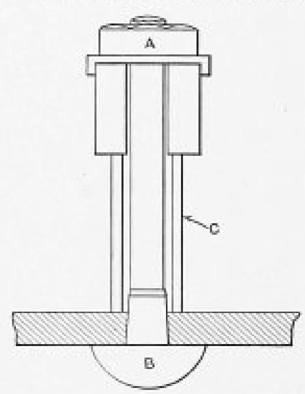


FIG. 5.

does not require much experience; by it an engineer can make an examination of his boiler whenever out of service. The engineer who safeguards the property of his employer and his life and the lives of others will constantly be on the lookout for defects in the boilers under his supervision, and if they are constructed with stay-bolts his time will be profitably spent in examinations of stay-bolts. More boilers of the locomotive type explode from fractured and broken stay-bolts than all other causes.

STRAIGHTENING CROWN SHEETS.

The crown sheets of locomotive and marine boilers frequently bulge down between the crown bolts or the crown bar bolts. This is more noticeable with locomotive boilers than marine boilers (in both cases it is due to not keeping the crown sheet clean).

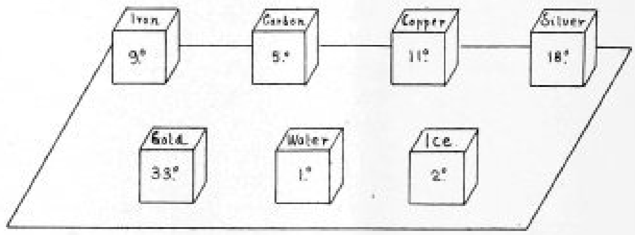
One of the troubles is that the crown bar is so close to the crown sheet that sediment readily collects, preventing the crown sheet being properly cooled by the water. The space between the crown bar bolts (they are usually spaced not over 4-inch centers) is taken up to a considerable extent by the ferrule between the crown bar and the crown sheet; which necessitates a number of washout holes in the outer wrapper sheet in order to thoroughly wash off the crown sheet. Examination will reveal that 90 percent of locomotives have no washout holes in the outer wrapper sheet.

When the crown sheet has bulged down between several crown-bar bolts (a vast number of locomotive boilers have the entire crown sheet, or nearly the entire crown sheet, in this condition) the usual practice is to heat the sheet between the bolts and drive it back to its former place. The crown-bar bolts are not usually removed until the sheet is straightened, when the sheet is forced back into its former place, they serve to prevent the crown-bar holes in the crown sheet from becoming unduly elongated, and, further, they hold the sheet in place so that it only will be forced upwards. After the sheet is straightened the crown-bar bolts are removed and the minor irregularities in the crown sheet are straightened. The crown-bar bolts are then installed; the usual methods of doing this are shown in Figs. 4 and 5.

If the crown-bar bolts are threaded and screwed into the crown sheet, Fig. 4, the threads in the crown sheet should be perfect and the crown-bar bolt made a tight fit, the crown-bar bolt head bearing fairly at all points against the crown sheet. When installing the crown-bar bolt, Fig. 5, the taper of the bolt under the head should be the same as the taper of the crown-bar hole in the crown sheet, and when the bolt is inserted it should go into within 1/8 inch of the crown sheet, and from that point be drawn in. This is usually done by means of the nut *A* on the crown-bar bolt, and while tightening up the nut and drawing up the crown-bar bolt, a cup shape set is placed over the head of the crown-bar bolt head *B*, and a few blows hit upon the set, thus forcing the tapering part of the crown-bar bolt to make a perfect joint in the crown sheet. The thimble or ferrule *C*, which is usually of extra heavy hydraulic pipe, serves to prevent the crown sheet being drawn up when tightening up the nut *A*. White lead, lamp wick, etc., should not be used under the head of the crown-bar bolt. The crown sheet and bolt should be metal to metal.

SOME NOTES ABOUT HEAT.*

Heat we measure by reference to some standard unit. Many different kinds of heat units have been suggested, but the one most generally used in engineering practice is known as the British thermal unit, abbreviated as B. t. u. Lately this unit represents the amount of heat required to raise 1 pound of pure water from 62 to 63 degrees F. Water is taken as the standard for the measurement of heat as it is taken as the standard of specific gravity. A cubic inch of gold weighs 19.6 times as much as a cubic inch of water. We therefore say that the specific density of gold is 19.6. Even as we find that the different substances, such as gold, silver, copper, zinc, etc., have different densities as compared with water, so we find that all substances have peculiar and distinct capabilities, taking up this curious motion known as heat. A pound of iron, for example, at a temperature of 100 degrees F. contains more than three times as much heat as a pound of gold at 100 degrees F., and only one-ninth as much heat as a pound of water at the same temperature. Now, why is this? We are compelled to admit that we do not know. Even as some bodies are much better conductors of heat than others, so some bodies have a greater or less capacity for absorbing the vibrations which constitute heat. In the figure is shown a number of substances on a hot plate, all weighing the same amount and all receiving the same quantity of heat. These cubes, of course, would not be of the same size, but we make them so for convenience. The number placed on each cube indicates the degrees of temperature to which it would rise, while water rises 1 degree. The ratio between the amount of heat required to raise the temperature of a body 1 degree and the same weight of water 1 degree is known as "specific heat," and it is useful sometimes to know how to make this calculation. The operation is exceedingly simple, and depends upon the fact that when two bodies of different temperatures are placed in thermal contact there will be a heat exchanged exclusively between the two bodies, and one will lose while the other gains. For example, suppose we wish to determine



EQUAL WEIGHTS OF DIFFERENT SUBSTANCES SHOWING DEGREES OF TEMPERATURE EACH WOULD RISE WHILE WATER RISES ONE DEGREE.

the specific heat of some new alloy: first determine its weight and temperature, then place it in water of known weight and temperature. In a short time the alloy and the water will have the same temperature. If the alloy was colder than the water its temperature would rise and the temperature of the water would fall, and *vice versa*. The quantity of heat remains the same after the mixture as before. It is the relative amount that each substance rises or falls in temperature that tells the tale. If the alloy weighed 1 pound and the water the same, and the temperature of the alloy falls 100 degrees while that of the water rises 5 degrees, then 100 degrees of the alloy equals 5 degrees of the water, and we know the specific heat of the alloy is just one-twentieth of that of water. The outline given below is a convenient form in which to express the above:

WATER.	Pounds.	ALLOY.	Pounds.
Amount taken..........	1	Amount taken..........	1
Degrees of change......	5	Degrees of change.......	5
Specific heat............	1	Specific heat...........	x

$5 = 100\ x$

$.05$ = specific heat of alloy.

* * * We now come to the consideration of the relation between heat and work. Everybody knows that hammering a nail will make it hot, but few people know that there is a direct numerical relationship existing between the amount of work done and the quantity of heat produced. Until at the close of the eighteenth century heat was supposed to be a fluid. Every scientist of note up to that time practically, with the exception of a few men, such as Bacon, Locke and La Place, thought that the reason mercury occupied more bulk when heated was on account of an invisible fluid which penetrated the mercury and caused it to expand. In 1789, Count Rumford noticed that the chips of steel from the boring of a cannon in the military workshops of Munich were so hot that he could not hold them in his hands. This puzzled Rumford, as he could not reconcile the theory that heat was a fluid with the fact that both the cannon and the chips were extremely hot, and that the heat had obviously arisen from the friction of metal upon metal, and not from the advent of some unexplained fluid. While he was trying to solve the

* Abstract from Heat, by J. Gordon Ogden, Ph. D.

problem, Davy, in England, demonstrated that two pieces of ice rubbed together in a vacuum would produce heat enough to melt the ice. Obviously the heat could not have come from the ice, but it could not come from the air, as that possible source had been eliminated by the vacuum. Where did it come from? Rumford thought it was produced by friction, and, in order to demonstrate the truth of his theory, secured a large piece of brass, hollowed it at one end, and fitted into it a cylinder of steel weighing 5 tons. By an ingenious mechanical contrivance attached to the cylinder, it was made to revolve within the brass tube thirty-two times a minute. Water was placed in a box around the brass, and at the end of two hours and a half the water actually boiled. Water had been transformed into heat without the shadow of a doubt. This experiment was, of course, a death blow to the theory that heat was a fluid, and was the absolute foundation of the belief that heat is a form of motion.

In 1843. Dr. Joule, of Manchester, England, carried out his classic experiment which revealed to the world the mechanical equivalent of heat. He took a paddle and made it revolve with as little friction as possible in a vessel containing a pound of water whose temperature was known. The paddle was actuated by a known weight falling through a known distance. A pound falling through a distance of 1 foot gives a foot pound of energy. At the beginning of the experiment a thermometer was placed in the water and the temperature noted. The paddle was made to revolve by the falling weight, and when 722 foot-pounds of energy had been expended on the pound of water the temperature had risen 1 degree and the relationship between heat and mechanical work was found. Joule used mercury instead of water later, and verified his original discovery. This simply means that the amount of energy required to raise a pound of water 1 degree of Fahrenheit is sufficient to raise it 772 feet against the force of gravity. Later more careful experiments determined that the correct figure was 778 pounds. Therefore, 778 foot-pounds represents one British thermal unit.

BEST METHOD OF CARING FOR FLUES WHILE OUT OF BOILERS.

BY A. N. LUCAS, GENERAL FOREMAN BOILER WORK, C. M. & ST. P. RY. CO.

This is an old subject, and has been threshed out a great many times. Still, I find there are a number of roads that do not appear to make use of the best practice in caring for flues and preparing same ready to go back in the boiler.

I notice there are but a few roads that weld on what we call a safe-end piece firebox end. When I say we I refer to the Chicago, Milwaukee & St. Paul Railway Company. The majority of all the flues we buy have a swede iron safe end welded on each flue. This swede iron safe end is more like a good steel tube, and is much better quality than the balance of the flue or what we term body grade, and will stand much more service and abuse at the firebox end than the ordinary body grade flue which a great number of roads are using, applying no safe end whatever, and when welding up flues they cut up this same body grade for piecing, which should not be termed safe ending.

And just think! Some shops are cutting these same pieces off with an old-style wheel cutter or square-nose tool, and then they make no attempt to remove the burr from the firebox end whatever. This prevents the flue end passing over the mandrel on the flue welder as readily as it should, and due to this fact the mandrel is some smaller than it should be; of course, this allows the flue to be contracted some at each weld or below the original size. Again, if the burr was taken off, as it should be, a larger mandrel could be used on the flue welder, and the flue would turn over for beading much easier and better with less liability of cracking and less chance for feather edge or burr around the bead after calking.

For welding 2-inch flues we are using a 1 11/16-inch mandrel; this is about the original inside diameter of the flue. We also heat and open up all flues at the front end to fit the hole in the front flue sheet; this does away with the shimming, which takes time and is poor practice.

Every weld on a flue is one more chance for a failure, because many times flues are slightly overheated at the weld and become quite thin just back of the weld. Leaks do develop at these points, and flues do break in two at the weld many times when being rattled or at other times in service, so I say the less welds you have on a flue the better. After a flue is rattled or cleaned it is our practice to inspect the flue thoroughly, and if there is any indication of the flue being light the flues are weighed up. A 2-inch flue weighing less than 1 2/3 pounds to the foot is scrapped, and a 2¼-inch flue must weigh 2 pounds to the foot, and a flue that has five or six or more welds on might weigh up all right, but the old part of the flue would not be good for further service.

Then, again, it is the practice of a great many roads to apply these pieces or weld on but one end of a flue. This I do not consider good practice. Many times you have a flue with five, six and seven welds, and many times when you watch the flue rattler when flues are taken out after being rattled you will find that flues are badly split up or jammed up on the front end, due to the quality and lightness of the flue. This would not occur as often with safe ends on both ends of the flue, and not at all with a steel tube. Our practice is to weld on both ends of the flue alternately. A flue put in service to-day, with a safe end at the firebox end, may run from one to two years, and when taken out the bead is cut off the firebox end and the front end cut off with a flue cutter, cutting off about 1½ inches from the end of the flue. Now, before welding this flue we again cut to length for welding and apply the safe-end piece on the opposite end for the firebox, then when the flue is welded we cut to length to go in the boiler, but only have to cut 1 inch off of the original safe end. This flue again goes in service for another year or two, and when flue is again taken out the bead is cut off the firebox end and at the front end with a flue cutter, and is then cleaned and cut for welding. This time we cut the original weld off, and the new piece or safe end is again welded on the front end, which leaves the flue with but two welds, and this operation continues through the life of the flue, and it always gives us a good new safe end for the firebox and the old safe end for the front flue sheet. By following this method we do not know what it is to split the flue at the front end or to damage a flue in the rattler. We have a better flue at all times than a flue showing five or six or more welds. I also believe that if all flues, steel or iron, were taken care of in this manner flues would be less liable to stop up. A great many might object to the cutting of this flue for welding, but unless you do this you cannot tell where the old weld will come at the front flue sheet. And the cost for cutting flues to length for welding is less than one-half cent per flue, or about 50 cents per hundred. I believe if this practice were carried out you would have a flue that was worth that much more to you at all times.

According to reports the steel industry is now operating at about 73 percent of its capacity. The improvement in this business has been manifest during the last month, and steel men seem confident that the improvement is permanent. Orders for railway work are now far below normal, but large equipment orders are pending.

LAYOUT OF A HOPPER FOR A CONCRETE MIXER.

BY C. B. LINSTROM.

In accordance with the request of Mr. Clyde E. Pring for a layout of a hopper for a concrete mixer which appeared in the June issue of THE BOILER MAKER, I herewith submit a development of it and an explanation of same, which I trust is the desired information.

From the drawings submitted by Mr. Pring I am not sure if I have formed exactly the correct idea of the shape of the hopper required. However, I have made a development of what I understand to be its shape from the data he has given. The drawings, as will be noted, are not drawn according to the scale given, as this is not of consequence in order to understand the principles of development.

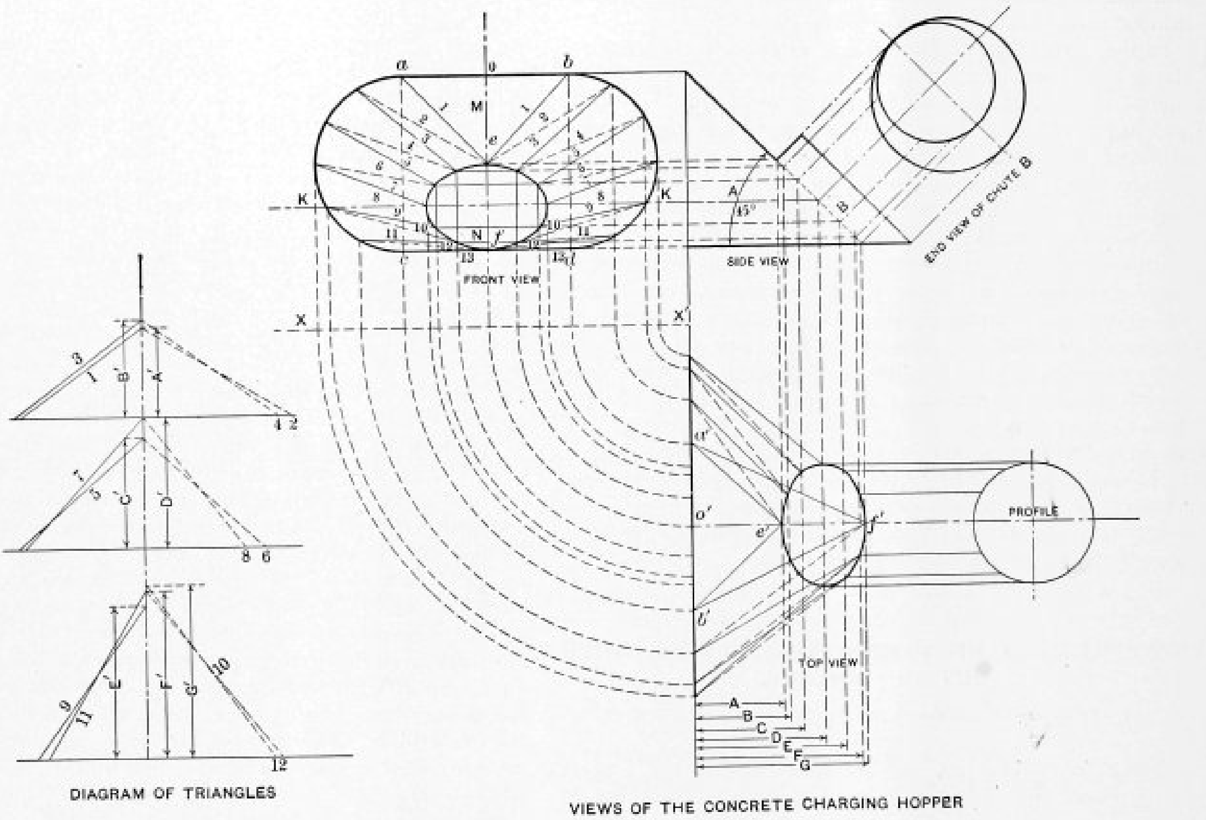


FIG. 1.—THREE VIEWS OF THE HOPPER, WITH DIAGRAM OF TRIANGLES.

CONSTRUCTION.

Fig. 1. This figure shows three views of the hopper designated part *A*. Fig. 2 shows the pattern of *A*. Figs. 3 and 4 are the respective views and pattern of the part marked *B*.

The main portion of the hopper, as at *A*, is an irregular tapering form, running from a wash-boiler opening into a round one. The wash-boiler opening lies in a vertical plane, and the round in a plane at an angle of 45 degrees to the horizontal. This will be better understood by referring to Fig. 1 in the side elevation, which shows the relative positions of the two openings. The front view shows how the sides taper from the irregular opening to the circular one. In this construction it is necessary to work up first the top and front views before the triangles can be found for developing the pattern.

After the side elevation or view has been drawn according to dimensions, show the position of the part *B* relative to the side view by drawing an end view of this chute. Then to the left of the side view draw the profile of the wash-boiler opening. Below the side view locate the top view. The hole in the hopper will appear elliptical or foreshortened in this view. Its true form is found by development and as follows:

Divide the small circle which represents an end view of the hole in the elevation into a desired number of spaces. Project the divisions on the circle to the inclined side of the hopper as shown. On the axis of the top view locate a profile equal in diameter to the hole in the hopper, and divide it into the same number of spaces as contained in the end view. Parallel to the axis of the top view draw the parallel lines as shown. From the side elevation drop the corresponding lines to the top view until they intersect the horizontal projectors. Through the points of intersection between these lines draw the ellipse.

The ellipse of the front view is now found very easily. With x-x' as a base line and x' as a center, swing the spaces of the profile of the top view around to the line x-x. The spaces of the profile must, of course, be first located on the vertical base line. In this case it is the edge which represents the edge line of the wash-boiler end. At right-angles to line x-x' these points are then projected up through the front view an indefinite distance. Corresponding projectors are then drawn from the side view intersecting the vertical ones. Through their points of intersection draw the ellipse.

In view of the straight portion on the large opening it will be best to make a triangular section at both top and bottom of the hopper. In this problem the top triangle section is shown from *a* to *c*, *e* to *b* and *b* to *a* in the front view. The bottom is shown in the top view from *a'* to *f'*, *f'* to *b'*, *b'* to *a'*. The portion around the triangle sections is irregular and runs from the circular section of the wash-boiler end into the hole of the end of chute. Consequently the semi-circular ends of the large profile are divided into the same number of equal spaces as contained in the profile shown in the top view.

Solid and dotted construction lines are then drawn in both top and front views, as indicated by the Figs. 1, 2, 3, 4, 5, etc.

The diagram of triangles are then drawn. The heights are equal to the distances *A, B, C, D*, etc., of the top view, and the bases are obtained from the front view.

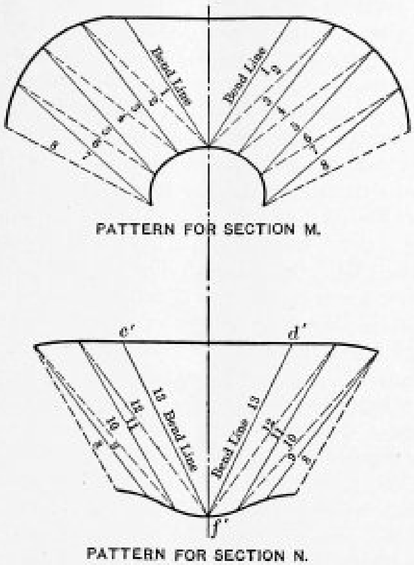


FIG. 2.—PATTERN FOR SECTION A.

The pattern will need no explanation, as the triangles are numbered to correspond to those given in the front view.

It will be noted that the pattern for the hopper is made in two sections, one section for the part designated *M* and another for *N*, shown in the front view. By this arrangement the seam lines will come on the side, through the line *K-K*.

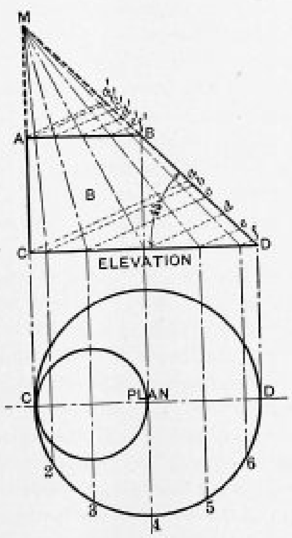


FIG. 3.—PLAN AND ELEVATION OF B.

The seam should not be placed on the bottom, as the rivets and edge of the plate would affect the flow of concrete. Sufficient material must be allowed at the small end for making the connection between the chute and hopper.

DEVELOPMENT OF CHUTE B.

Figs. 3 and 4 show the respective views of this connection, including its pattern. The views of the object were made larger than in Fig. 2 for the purpose of showing more clearly its construction. It will be seen from the plan and elevation that the connection is the frustum of an oblique cone. The taper is on one side only, as shown at *D B*, Fig. 3. The opposite side is straight and at right-angles to the line *C D*. The sides of the oblique cone in this case, if extended, inter-

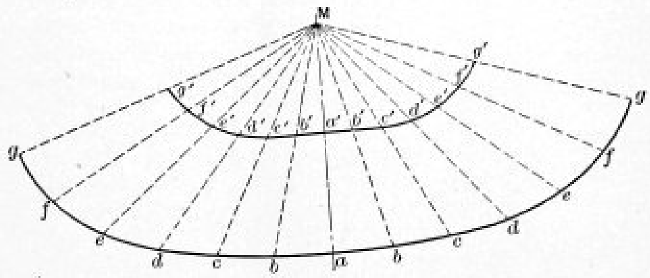


FIG. 4.—PATTERN FOR CONNECTION B.

sect at point *M*, as indicated on the drawing. If the sides were prolonged and did not intersect within a distance convenient for development of the object, it would then be necessary to lay it out by other methods. The application of the triangulation system in such a case would prove satisfactory.

In order to find the shape of a flat plate to form the frustum of such a cone, proceed as follows: Draw the elevation as at *A, B, C* and *D*. Extend the lines *A C* and *B D* till they intersect at the apex *M*. Below the elevation draw the circles which represent the large and small ends of the oblique cone. These circles represent views of the object when viewed directly down upon the elevation.

Divide the large circle into any number of equal parts, as shown from *c* to 2, 2 to 3, 3 to 4, etc. Then from each of these points erect perpendiculars intersecting the base of the elevation, as indicated at points 2, 3, 4, 5 and 6 on that view. Connect the apex *M* with these points.

To obtain the data for laying off the camber line at both top and bottom of the pattern, it will first be necessary to set off on the line *M D* of the elevation a distance equal to *M* to *A* and *M* to *C*, as shown from *M* to *a'* and *M* to *a*. From *a'* draw the line *a' A*; from *a* draw the line *a C*. Now, if the elevation is turned in such a way that the axis *M* 4 is at right angles to the line of sight, the line *a C* will be the base of a right cone. The portion lying within the line *a c, C D* will be the part to be added to the cone. Parallel to the line *a C* draw from the points 2, 3, 4, 5 and 6 the lines 2 to *b*, 3 to *c*, 4 to *d*, 5 to *e* and 6 to *f*. The portion above within the triangle *B A a'* is to be treated in a similar manner.

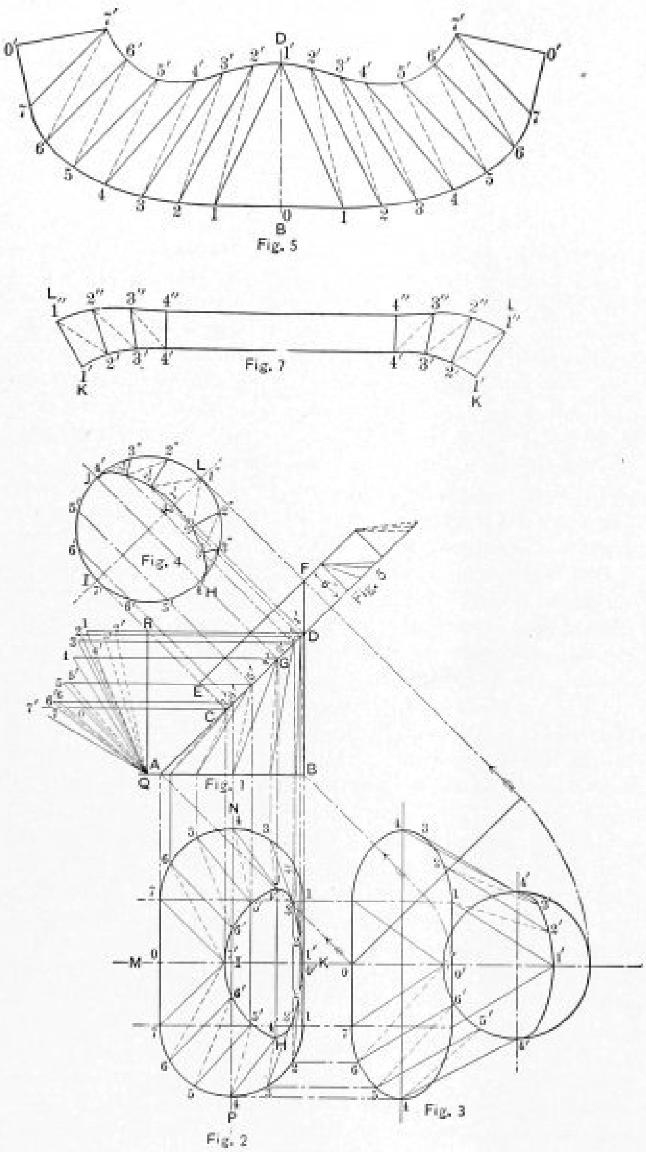
DEVELOPMENT OF PATTERN.

Fig. 4 shows the development of the pattern. Draw the center line *M a* equal to *M a* of the elevation of Fig. 3. With two sets of dividers set one equal to the spaces of the large circle of the plan view, Fig. 3. Then use the other to set off the true radial lengths of lines. The radial length *M* to *a* of the pattern is equal to *M* to *a* of the elevation, Fig. 3. *A* to *b* of Fig. 4 equals the space distance *C* to 2 of the plan. *M* to *c*, Fig. 4, is equal to *M* to *c*, Fig. 3; *b c*, Fig. 4, equals *C* to 2, Fig. 3; *M* to *d*, Fig. 4, equals *M* to *d*, Fig. 3; *c* to *d* equals *c* to 2, Fig. 3. The remainder of the pattern for the large end is determined in a similar way by transferring the true radial distance from the elevation to the pattern. The small end is developed by setting off from point *M* of Fig. 4 the true radial distances *M to a'*, *M* to *b'*, *M* to *c'*, etc., of Fig. 3 on their corresponding radial lines of Fig. 4. A curve drawn through the points of intersection will give the shape of the plate required to form the oblique cone. Laps are to be allowed in addition to the plate developed.

CHARGING HOPPER, CONCRETE MIXER.

In answer to the query in the June, 1911, issue of The Boiler Maker as to the layout of a charging hopper, I submit the following:

In some classes of sheet metal work forms arise for which patterns are required whose surfaces do not seem to be generated by any regular method. They are so formed that although perfectly straight lines can be drawn upon them



LAYOUT OF A CHARGING HOPPER.

(that is, lines running parallel with the form), such straight lines when drawn would not be parallel with each other; neither would they slant toward each other with any degree of regularity. Distances between lines running with the form measured at one end of some articles govern those at the other end, such as a truncated cone; but in this case these distances are continually varying and bear no relation to each other. Therefore, in the development of this pattern (being an irregular form) it becomes necessary to adopt the system of triangulation, and to measure up its surface, portion by portion, adding one portion to another till the entire surface has been covered.

To accomplish this a simple geometrical problem is made use of; this is the construction of a triangle when the lengths of the three sides are given.

From the three given dimensions only one triangle can be constructed. To carry out this system it simply becomes necessary to divide the surface into triangles, ascertain the lengths of their sides from the drawing, and reproduce them in regular order in the pattern; hence the term triangulation. On all flat surfaces measurements can be made in all directions, but when the surfaces become rounded and slanting the length of a line running parallel with the form cannot be measured either upon the elevation or the plan.

Fig. 1 gives us the altitude of the different triangles; this is equal to the vertical distance from the base line *A-B* to the points above 1, 2, 3, 4, 5, 6, 7, and shows the side view of the article when completed. We develop the piece *ABDC* first; Fig. 2 shows the plan of this piece *MNKP*; its upper surface *IJKH* is not regular, one portion, HIJ, is a semi-circle and the other portion, *HKJ*, is elliptical, Fig. 4; and besides being irregular in shape it is off center, and is inclined in position as shown by *CD*, Fig. 1. Fig. 3 shows a view looking at Fig. 1 at an angle of 45 degrees, as shown by the three arrows. This view is not absolutely necessary, but it is wise to draw it. The curved line *IJKH* (Fig. 2) does not give the correct distance around the top opening, and therefore a view of the top opening must be made as shown in Fig. 4. Projected lines 1'-1' and *GHJ* from Fig. 1 will give you the points *H-K-J*, through which must be drawn a curved line elliptical in shape; divide said line into six equal spaces, and from these points draw perpendicular lines to *CD*, which will cut it at 1', 2', 3', 4'. The remaining portion of this opening, *HIJ* (Fig. 4), is a semi-circle, and should be divided into the same number of equal spaces as the first portion. Draw lines from these points perpendicular to the line *CD*, cutting it at 4', 5', 6', 7'.

To develop the opening in Fig. 2 draw lines of indefinite length from the points just found on line *CD*, Fig. 1, in the direction of Fig. 2 parallel to line *DBK*. The distances 6'-6', 5'-5', 4'-4', 3'-3' and 2'-2' (Fig. 2), measured in a straight line, and not on the curve, are equal to those in Fig. 4 of the same numbers. Then divide the curved portion of the base (Fig. 2) into the same number of equal spaces as the top; next draw lines across the plan, Fig. 2, connecting the points as shown; these lines are the bases of a number of right-angle triangles, the altitudes of which are shown in Fig. 1.

The next step is to determine the true lengths which these lines represent.

The lines upon the plan (Fig. 2), of course, only show the horizontal distance between points which they connect. The vertical height above the base of any of the points in the upper curve can easily be found by measuring from its position upon the line *CD* (Fig. 1) perpendicularly to the base *AB*. Having both the vertical and the horizontal distance given between any two points, it is only necessary to construct with these dimensions a right-angle triangle, and the hypothenuse will give their true distance apart.

In getting the true lengths of these lines it will be necessary to extend the base line *AB*, as shown at the left; at any convenient point, as *Q*, erect a perpendicular line. Project lines horizontally from all the points on *CD*, cutting through this line; then on these lines mark off the bases of your triangles below the line *QR*, but be sure to place these bases on the line that represents the altitude of that triangle; this is clearly shown in Fig. 1, and the hypothenuse of each of these triangles will be the true lengths of the lines drawn on the surface of this article.

Having the triangles and the lengths of all the sides it is now necessary to construct, successively, each triangle as described before. At any convenient place draw a straight line *BD* of Fig. 5 equal in length to line *BD* or *QR*, Fig. 1. To do this work with the greatest economy it is necessary to have two pairs of dividers and one pair of trammel points. One pair of dividers is set to the spaces in Fig. 4 on line

HKJ, and the other to those in Fig. 2, 1-2, 2-3, 3-4, 4-5, 5-6, etc. The next step after laying down line *DB* is to construct the triangular flat surface, as shown at 0-1-1'-1, Fig. 5; then, using 1 as a center and 1-2' as a radius, strike an arc in the direction of 2', and using 1' as a center and 1'-2' as a radius, strike an arc cutting the arc just made; do this each side of the flat surface, and this will give one flat surface and two triangular portions of the article. The length of this dotted line 1-2' is found in Fig. 1 at *Q* 2', and the space 1'-2' is found in Fig. 4 at 1'-2'; the space 1-2, Fig. 5, is found in Fig. 2 at 1-2, 2-3, etc. Thus the operation is continued which will complete the entire pattern. But it must be remembered that the spaces 1'-2', 2'-3', 3'-4', Fig. 5, are equal to those in Fig. 4, on line *HKJ*, and that the spaces 4'-5', 5'-6', 6'-7', Fig. 5, are equal to those in Fig. 4 on line *HIJ*.

To develop the pattern for the piece *CEFD* the same explanation holds with one exception, and that is, all the triangles have the same altitude as shown in Fig. 6, and as Fig. 5 has been explained Fig. 7 is self-explanatory, excepting the straight portion 4'-4"-4'-4", which you can see in Fig. 4 to be nothing more than one-half of a cylinder 6 inches long.

C. REYNOLDS.

Tube Testing Trick.

During the Spanish flurry, which some called a war, there was quite an amount of hustling among mechanical people, and certain articles were found by the government not to grow on bushes ready ripe to pick. The consequence was that very often the government was obliged to take what it could get and make the best of it.

I was working for some people who had to re-tube a boiler for the government. The tubes could not be obtained from the mills under several weeks, but a lot of properly bent ones were on hand, but they had not been well cared for, being left in the weather, and the outsides were quite rusty and looked bad. It was a grave question whether they could be used, but it was thought that if they could be tested, and they would stand the proper pressure, that the necessity of the case was such that they would be accepted. But the trouble was that they were bent and with rather short bends, and the ends were "looking all ways for Sunday," as the boys say. They were all cut to exact lengths, so it was not possible to thread them to screw on a cap, so the inspectors got the "old man" (who was not very old), but they got him down to look at the tubes, and he asked how much pressure he should put on them, and the answer was 600 pounds. He looked at them a few moments, and said: "I will test them and have them ready in three working days." This suited the inspectors, and the next afternoon we began to test. The "old man" had sketched out the apparatus for testing these tubes, and the drawing, Fig. 1, shows what he made to do the trick with. I have used this idea several times since to great advantage.

The tubes were, I think, 1⅜ inches inside and rather light gage, and the quickest bend gave about 3½ inches straight run to use this stopper in.

To explain the drawing:

P is the tube; *CC* is rubber; *AA* is a hand-wheel, made of composition with a threaded hub; *BB* is a piece of machinery steel threaded to meet the hub of the hand-wheel. The diameter of *C* and *B* was about 1/16 inch less than the inside diameter of the tubes. On the end of *B* there was cut a pipe thread and two flats, *DD*. These latter were to allow a wrench to be used to hold *B* from turbing. In the ½-inch pipe there was fitted an angle valve, which was connected up with a hose to the water service, which had a pressure of about 50 pounds. One of these stoppers, as described, was used on one end of the tube and a similar one on the other end, except that instead of having an angle valve screwed onto the end; a tee was used and the side outlet was bushed with a reducer that had a ¼-inch outlet, to which was screwed the gage. A short nipple and an ordinary lever cock was made up in the tee. These stoppers were pushed into the pipe, the wrenches put on the part *B* and the hand-wheels *A* turned, which drew the head of *B* up against the rubber *C*, which, of course, butted up against the hand-wheel as shown. Between the hand-wheel and the rubber was a ring, *KK*. It is plain, therefore, that when you sat up on the wheel you compressed the rubber endways and expanded its diameter, and we found no difficulty in making it hold up to 600 pounds. When the gage showed that pressure, the man at that end of the tube called out, the water was shut off at the angle valve and re-

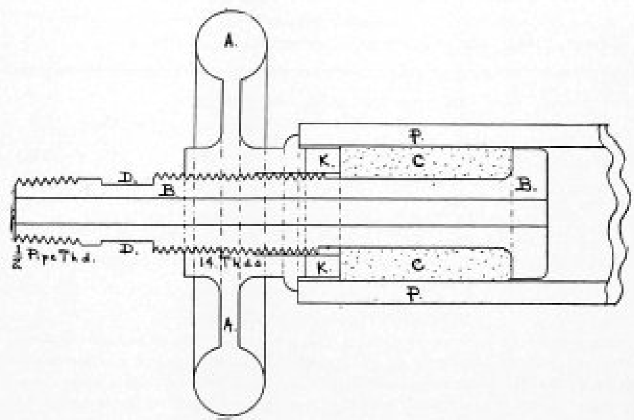


FIG. 1.

leased by the use of the lever cock, and the wheel slacked up and the stops were taken off. We were able to test about twenty of these an hour.

The only difficulty we found was that if the inside of the tube got wet the rubber slipped sometimes, but this was not often. When it came to cutting the rubber the "old man" did a trick I had never seen before. He got some rubber springs which had a hole about the right size to fit over the stem of part *B*, and he turned off the outside of the rubber to the proper diameter by means of a scratch-all and water, and he turned them off as easy as if it were cheese. If I remember right, however, the rubber was in three pieces, but, of course, this made no difference.

I tested some quite large tubes with this apparatus, but not quite to so high a pressure. The rig did not cost much, and I hope that it may be of some use to your readers.

Washington. TUBE STOPPER.

Is it Necessary to Bevel Plates Before Calking?

One of our subscribers, who has been associated with the boiler-making trade for many years, and who is fully aware that it is customary at the present time to bevel plates for calking, wishes to know if there is any good reason for doing this and if it is necessary.

We invite our readers to send their opinions regarding this point for publication in our next issue. Is beveling necessary? Can you do a successful job at calking without beveling or chipping the plate? What tools would you use? What is the difference in the cost of doing this work by different methods? A full discussion of this question will be of great help to all boiler makers.

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CIRCULATION STATEMENT.

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

NOTICE TO ADVERTISERS.

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

At the Boston meeting of the American Boiler Manufacturers the question was discussed as to the value of laws which regulate the material, design and construction of boilers. It was asserted that such laws were not elevating to the craft of the boiler maker or effective in their operation; that there were other conditions of manufacturing that existed which could be equally well legally regulated with a view of protecting life. The record of the past four years was pointed to as conclusive evidence, however, that the laws regarding boilers in the State of Massachusetts had worked to very great advantage, and that there was absolutely no room for debate on the point.

Let us lay aside the question of the advantage or disadvantage of enacting laws from a humanitarian standpoint and simply regard the matter from the commercial side. We all know that in obtaining prices we often find wide differences in them, and, when it comes to looking over the bids with care, it is found that these differences are very largely due to the bids not being made on the same article. One bidder proposes to use such and such grades of material and make the article in a certain prescribed way; others use different material and a different construction. Often prices have to be made abnormally high because of the specification, which is personal, and in which is found much that is unnecessary and disadvantageous. The President remarked that there was no material too good to go in a boiler, and with this we quite agree; but, at the same time, a silver milk pail is really of no advantage, and too good material in a boiler is hardly commercially wise.

Now, if laws were enacted and made general which would require certain grades of material to be used in a boiler under certain conditions, and that certain constructions were admissible and acceptable, all who bid on boiler work could do so on an even footing and all with an even chance. With the present condition it is clear that the boiler making business may run the serious risk of embarrassment by a multiplicity of State laws. Safety in Massachusetts in a boiler is just what it is all over the world. Certain water conditions may demand more modifications or certain working conditions may demand such, but the fundamentals must be the same everywhere. It is no easy task to get concerted action in this matter, yet none will assert that boiler building is so new an art as not to be capable of accurate and specific determination or that among the American boiler makers there are not those who combine the scientific and practical knowledge, backed up with that all valuable third quality, experience, to frame rules which would be advantageous to all boiler makers throughout the country and the world.

In our observation of many boiler shops we have been surprised that so often excellent appliances are supplied, but the workmen are allowed to rig up all sorts of very rickety makeshifts to use them, thereby largely nullifying their money-saving values. Here, we think, the foreman is, to a very great extent, at fault, as by a little forethought he could provide proper rigs and hand them over to the men so that they would not have to be running all over the shop to pick up a few bolts and nuts and knees or ratchets, oil cans, etc., but could get at the work at once. The outlay in money for an electric or air drill is wise, and its use will cut cost, but if in order to employ it the workman has to build a cob house its purchase really was a mistake. Often, however, proprietors are at fault in not being willing to allow the expenditure of a few dollars to have convenient appliances for the use of labor-saving tools, and it is not at all uncommon, we are sorry to say, that a foreman's request to get out convenient tools is turned down, largely, perhaps, because it is known that a "prophet has little honor in his own country," but it is really because the proprietors do not go often enough into the shop and see with their own eyes what is actually wanted.

COMMUNICATION.

Single Riveted Joints and Remarks.

EDITOR THE BOILER MAKER:

We read about education and its values, and to my mind we get education and knowledge mixed up. I rather look on knowledge as knowing how to plant orange groves, while education is knowing where to plant them to make them pay. Anyway, I cannot call myself an educated man, but I know something about boilers. Now, that knowledge may not be accurate, but by it I make a living. When we crack hickory nuts, we dig out the meat and throw away the shells. I have been trying to dig out meat regarding boilers, and I am offering it to your readers. I want to acknowledge, frankly, that I cannot always make my observations of practical operations meet the rules I read in books. I have never been in a position where I could make many tests myself, so have to take the words of others in such matters; but I do feel that sometimes the "high-brow" fellows take one swallow as an absolute indication of spring. What little I have done with tests has been, at times, very misleading to me. Here are some of the results of my experience. If I am wrong some one can set me right. I am putting down my rules on boiler seams, and I think they are simple enough for most people to remember.

MY RULES CONCERNING SINGLE-RIVETED HORIZONTAL BOILER SEAMS UP TO ONE-HALF PLATE.

To find the size of the hole to drill in the plate multiply the thickness by 2:

Thickness of plate.......	1/8	3/16	1/4	5/16	3/8	7/16	1/2
Size of rivet hole........	1/4	3/8	1/2	5/8	3/4	7/8	1

2. To find the pitch of the rivets in the plate multiply the diameter of the holes by 4:

Hole in plate..............	1/4	3/8	1/2	5/8	3/4	7/8	1
Pitch of rivet.............	1	1½	2	2½	3	3½	4

3. To find the position of the centers of the rivet holes from the edge of the plate lay off from the edge of the plate a distance equal to the diameter of rivet hole:

Thickness of plate.......	1/8	3/16	1/4	5/16	3/8	7/16	1/2
Edge to center of hole....	1/4	3/8	1/2	5/8	3/4	7/8	1

4. To find the strength of the seam multiply the thickness of the plates by the length of the seam. and this result by the tensile strength of the material; then take the percentage of this amount as shown on the table below:

Thickness of plate.......	1/8	3/16	1/4	5/16	3/8	7/16	1/2
Efficiency percent.........	.70	.67	.65	.64	.62	.60	.58

All the rules but the last are dead easy; this is how I work the last one: We have, for instance, a sheet 1/4 inch thick. The seam is 36 inches long. Then we have 1/4 to 36 inches = 9 square inches. Taking the tensile strength at 50,000 pounds we have 50,000 × 9 = 450,000. Now my table says that 1/4 inch thickness of plate would have 65 percent of the strength of the solid material. Sixty-five percent of 450,000 = 15,750. We will suppose the shell is rolled up and has only one seam, and that it is 20 inches inside diameter.

Then we have an area of 36 inches multiplied by 20 inches, or 720 square inches. If we divide our 15,750 by 720 we will have 218 +, and this is the number of pounds per square inch that could be put on the cylinder before it would give out in the seam. It is evident that as 218 pounds will part the seam, we could not use any such pressure in the cylinder, so we have to divide this 218 + by some figure, we will say 2, and this we call the factor of safety; and if the tank is only to hold water pressure where leakage would do no damage, this factor of safety is all right; but if steam is to be used this factor of safety should not be less than 4; therefore, we could not put more than 54½ pounds on the cylinder properly. This factor of safety must always be determined after proper consideration of all conditions.

The single lap seam is the least strong of any of the forms of seams. It is found that by making the joints butt and by using a plate single riveted, no advantage is gained in strength, but the expense is very much increased; but if two plates are used, one on the out and the other on the inside, there is a gain in strength of approximately 20 percent. It is asserted that riveting, if properly done, results in a certain amount of friction between the plates, which adds to the strength of the seam over and above the holding strength of the rivets. It is also asserted that the metal left between the rivet holes is greater in tensile strength than the rest of the material. I presume this is only true when the hole is punched, as in punching a hole the metal is somewhat compressed. Drilled holes give greater strength than punched holes. Punched holes that are afterward reamed are as good as entirely drilled holes.

It seems to me that the first rules given are of use to boiler makers who do the laying out, but the last rule is not of any value to the man in the shop; but, of course, a man who is laying out work to-day stands a chance of owning a shop by and by, and the more he learns of his work the better off he is.

The matter of double seams is another story, which I may tell later. "SEAM."

N. B.—I hope this will please "Kicker."

The Compound Curve Layout in the March Issue.

EDITOR THE BOILER MAKER:

Referring to the request of Mr. William Lockyer for further information concerning my article on compound curve appearing in your issue of March, he says that either he or I must have made a mistake. My original explanation I have carefully examined and found it to be correct. Mr. Lockyer says that I stated plainly that line 14-15, Fig. 2, has to be equally divided. If he reads this article again he will find that I do not say that, but I do say that this line is to be divided into equal spaces as far as the line *N*-4'-4-*N*. The line 12-13 can be divided into equal or unequal spaces; but if divided into unequal spaces there will be unequal sections in the pipe, as the spaces on this line determine the length of each section at the center of the pipe, and I like to work from center lines; therefore I have divided this line into equal spaces as far as the line *N*-4'-4-*N*. That is, I have commenced spacing from each end of the lines 12-13 and 14-15, ending at the line *N*-4'-4-*N*, having spaced the same number of equal spaces on each portion of each line. I marked on each of these lines a number of points. Now, if you wish to draw lines parallel to the base line from these points on each line they would be almost the same as one line, and it would, therefore, be very hard to explain that there were two lines instead of one. It will be noticed, therefore, when a pair of small dividers is taken and this line is gone over, which I state must be equally divided as far as the line *N*-4'-4-*N*, that it is not equally divided, because I have dropped the line (on the line 14-15) down so it can be seen there are two lines. I wish to say that it is not wise to attempt to scale drawings in most publications, especially where there is an explanation to guide one, as many of these drawings are reproductions of amateurs and they may let one in bad. CLARENCE REYNOLDS.

Louisville, Ky.

Intersecting Cones.

EDITOR THE BOILER MAKER:

In answer to the query regarding the laying out of intersecting cones, published in the March, 1911, issue of THE BOILER MAKER, I submit the following:

First draw the center lines *A B* and *C D*. Draw the plan, Fig. 1, and elevation, Fig. 2, as shown. Divide the circle of the plan in eight equal spaces; project the points to the base of the elevation, and draw the elements of the cone. Next construct the small or intersecting cone perpendicular to the center line of the intersecting cone; draw the base line *G H*, and draw the semi-circle *G I H*, and divide it in four equal spaces, projecting the points *K I J* to *G H*, locating *L M* and *N*. From *E*, Fig. 2, drop a perpendicular on *C D*, Fig. 1; from points *L M N*, Fig. 2, drop perpendiculars on *C D*, Fig. 1; construct triangles in plan as shown; make *L L*, *M M* and *n n*, Fig. 1, equal to *N L H G* and *N L*, Fig. 2, respectively.

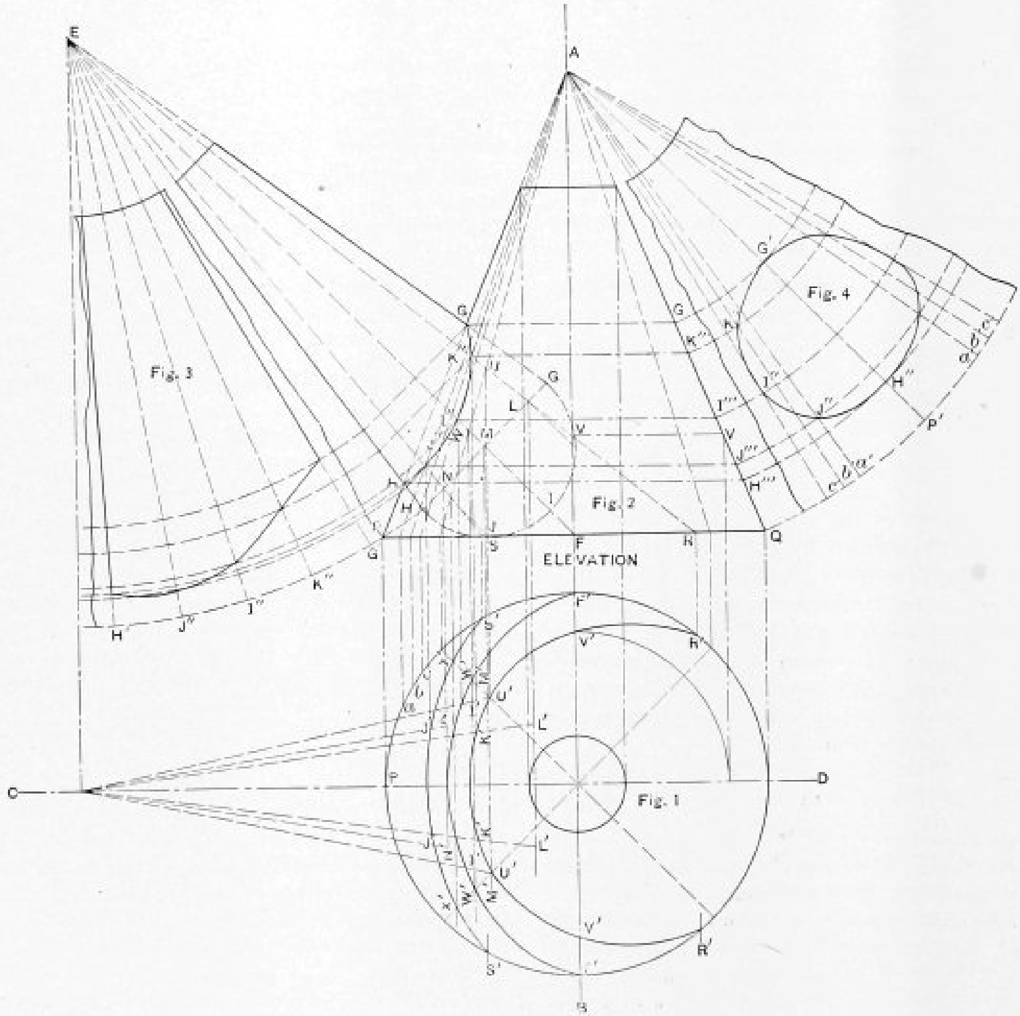
From the vertex *E*, Fig. 2, draw the elements through *L M* and *N* on the base of the large cone *P Q*, projecting the points *R S*, Fig. 2, to the plan, locating *R'* and *S'*, and project the points *U V W* and *X*, Fig. 2, to the plan, locating *U' V' W'* and *X'*. Note the points *U V W* and *X* in the elevation are points where the elements of the two cones intersect each other, and corresponding points are located in the plan.

Draw a smooth curve through *R' V'* and *U'*, Fig. 1, then project point of intersection *K'* with the triangular section of the small cone to the elevation, locating *K"*, draw smooth curves through *F' W'* and *S' X'*, Fig. 1, and project the points of intersections with the triangular sections of the small cone to the elevation, locating *I"* and *J"*; draw a smooth curve through *G' K" I" J"* and *H'*, Fig. 2, which is the line of intersection.

From this the pattern, half of which is shown in Fig. 3, can be developed.

To develop the opening, Fig. 4, draw lines from the vertex *A*, Fig. 2, through *K" I"* and *J"* to the base of the large cone *P Q*, and project to the plan, locating points *a b* and *c;* project points *G' K" I" J" and H'*, Fig. 2, at right angles to *A B* on *A Q;* with a radius *A Q*, *A H'"*, etc., draw the curves as shown in Fig. 4, draw *A P*, Fig. 4. On both sides of *P* step off *P a*, *P b* and *P c* equal to *P a*, *P b* and *P c*, Fig. 1, draw a smooth curve through the corresponding points, which completes the opening.

In practice the profiles should be divided in more equal spaces, as eight are not sufficient. SUBSCRIBER.



LAYOUT OF INTERSECTING CONES.

Expanding Boiler Tubes.

EDITOR THE BOILER MAKER:

I have done some expanding of boiler tubes, and I have had good luck with their being tight, and I am going to tell the other name for "good luck" in expanding tubes—it is "going slow." I mean by that you must use the expander slow enough to allow the metal in front of the rollers to "flow." If you do not do this, and go too fast, the rollers will simply jump over the little waves of metal which rise in front of the rollers, and you will not get a tight joint. I have watched this matter of rolling a long time, and this "good luck" business I do not take much stock in. Do your work right, and if you do not know how to do it say so. There is too much bluff in the boiler makers of to-day, and it makes a lot of trouble. I know a man who wanted a foreman's job, and he told the boss he didn't know anything about marine work and he did not get the job. Another fellow came along, and he said he knew all about marine work and landed it, but his bluff was soon called and he got fired. The boss got "peeved" (that is the new-fashioned name for mad) because fellows can do so much with their mouth and so blamed little with their hands, and you can't blame the bosses if they do get hot under the collars.

A lot of first-class boiler makers are to be found in this country to-day, and most every good one reads THE BOILER MAKER, and that makes them better.

I think boiler makers ought to put down their ideas and send them in, so we can all profit by what other people know, and I hope this slow-rolling hint will be remembered.

New York. EXPANDER.

Drilling Out Stay-Bolts.

EDITOR THE BOILER MAKER:

The drawing which I sent you shows an arrangement for drilling out stay-bolts on the outside of a locomotive boiler when applying a new firebox. This device is a great time-saver, doing away with the use of the ordinary "old man" or drilling knee, which has to be moved along from place to place on the boiler in order to reach the various stay-bolts, while in the apparatus which I show it requires but a moment to make it fast to the boiler, and the drill can be located anywhere the entire length of the firebox without moving the frame at all by only shifting one or the other 7 by ½-inch plates.

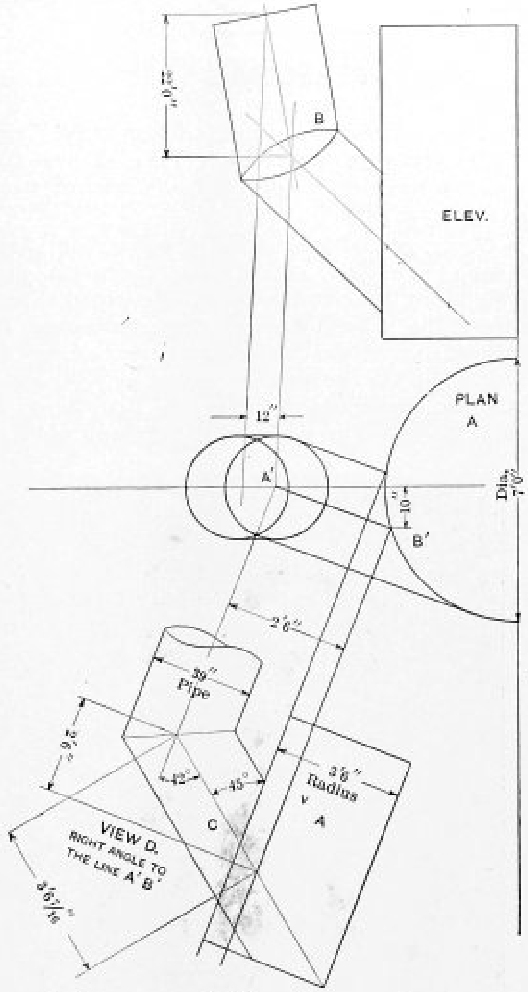
Another excellent feature of this arrangement is that it permits the use of several air motors at the same time when you have hurry-up work. The holes at the left-hand end of the tee-irons allow ample adjustment for various lengths of boiler. It should be noticed that the 7 by ½-inch plates are just turned over on one end and hook over the top tee, and, of course, hang against the lower tee, as shown.

Stroudsburg, Pa. W. H. SNYDER.

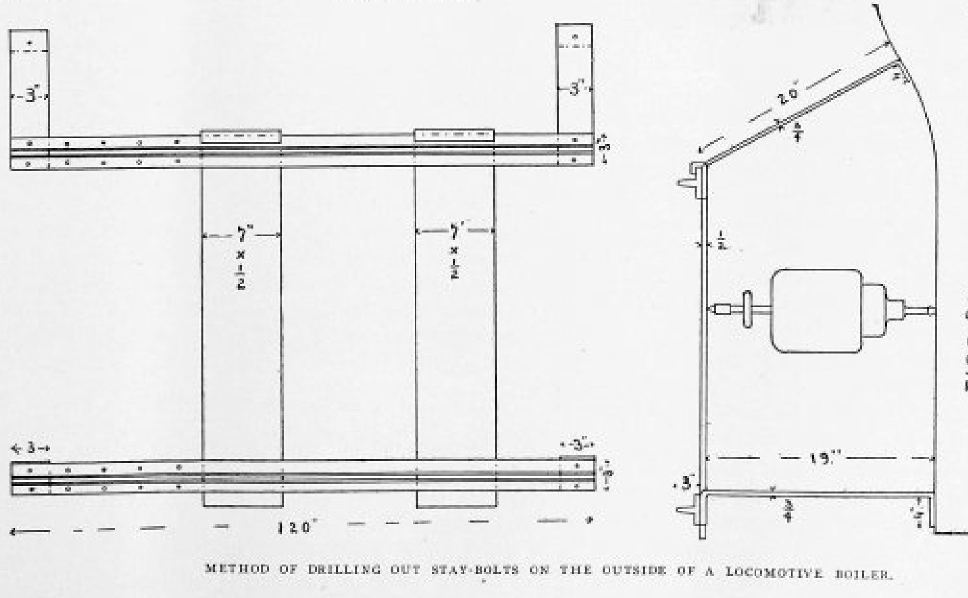
A Layout Wanted.

EDITOR THE BOILER MAKER:

Being a reader of THE BOILER MAKER, and having a job to do similar to the one I am sending, I would like to get information on the subject through your columns. What I would like



to know is, how to get the line of intersection where *C* intersects the pipe *A*. The elbow *B* is a flat 42-degree elbow, but



METHOD OF DRILLING OUT STAY-BOLTS ON THE OUTSIDE OF A LOCOMOTIVE BOILER.

when it is connected to the pipe *A* it is twisted over till it is 12 inches out of plumb in 22 inches, as shown in the elevation. I cannot get onto the twisting very well. I hope the views shown will be understood. I will be glad of any information on the development of elbow *B* and where *C* intersects *A*, as well as the hole in pipe *A*. Geo. A. Jones.

New Castle, Pa.

PERSONAL.

James J. Fletcher, formerly superintendent of the Casey-Hedges Boiler Company, Chattanooga, Tenn., is now vice-president of the newly-organized Laxatan Company, manufacturers of chewing gum.

Andrew Green, general foreman boiler maker of the Beech Grove shops of the New York Central Lines, has spent an active life in the boiler-making trade. He started to learn the business at the Wabash Railway shops, Springfield, Ill., at the age of 12 years, and worked with this company for eight years, leaving them to accept a position as boiler maker for the Chicago, Burlington & Quincy at Beardstown, Ill. From here he traveled through the West and South and East,

ANDREW GREEN.

working at many different shops, but finally stopping in Chicago, and taking up boiler-making work in the many contract shops in that city. Later he went to Indianapolis, Ind., and began work for the Pennsylvania Railroad Company and the old I. D. & S. as boiler maker and as foreman for I. D. & S., finally accepting the position of foreman boiler maker at the Shelby street round-house, from which position he was promoted to assistant foreman boiler maker at the Brightwood shops. The latter position he held for nine years, and was then promoted to the position of general foreman boiler maker at the Beech Grove shops of the New York Central Lines, which is one of the largest and best equipped boiler shops in the United States.

M. M. McCallister, formerly foreman boiler maker of the Erie City Iron Works, Erie, Pa., has been appointed superintendent of the company's boiler department.

B. F. Throckmorton, formerly of Cleveland, Ohio, has been appointed foreman boiler maker of the Erie City Iron Works.

A. Anderson, formerly traveling boiler inspector for the National Lines of Mexico, has been appointed general foreman boiler maker, with headquarters at Aguascalientes.

E. W. Cantwell has been appointed foreman boiler maker of the Cleveland division of the C. C. C. & St. Railroad, vice J. R. Cushing, deceased. Mr. Cantwell was formerly boiler inspector of the Cleveland division.

Ross Sturgeon, formerly layerout at the Philadelphia Iron Works, has accepted a position as foreman boiler maker at the Quaker City Iron Works, Philadelphia, Pa.

Harry Fuller, of Clinton, Ia., who has been connected with the Chicago & Northwestern Railroad Company since Jan. 2, 1875 (the last twenty years as foreman), has retired from active service on account of ill health. Mr. Fuller first went to work for the South-Eastern Railroad Company at Ashford, Kent, England, in 1863.

E. H. Fredennick has been appointed boiler inspector for the Erie Railroad at Galion, Ohio.

Roy Lake has been appointed assistant foreman boiler maker for the Erie Railroad at Meadville, Pa.

LEGAL DECISIONS OF INTEREST TO BOILER MAKERS.

Duty to Warn Employee of Danger.

In an action by a molder's helper for injuries from the explosion of molten iron poured into a wet ladle, the jury were instructed that whether it was the duty of the master to give warning was a question for the jury under the circumstances, because it was not essential to warn a man of dangers which in the natural order of things he must appreciate. The use of the words "must appreciate" was held not to be misleading where the courts later instructed that it was for the jury to say whether the experience the plaintiff had at the time of the accident would have rendered it unnecessary that he should be warned of the danger to be apprehended from bringing molten iron into contact with water.—*Borkowski v. American Radiator Co., Michigan Supreme Court.*

Employing Laborers Ignorant of Language Not Necessarily Negligence.

In an action for damages for injuries to an employee by the fall of a fire-front, the negligence relied on was that the defendant's foreman procured laborers to aid in raising and holding the fire-front who were foreigners and not able to understand the English language, and when ordered by the employee to hold on they let go, and shoved over the fire-front and it fell. It consisted of a plate of steel weighing from 1,000 to 1,300 pounds. It was held that it would not be negligence for a master to employ such laborers in such work where they were used to the performance of common labor, and if they should deliberately permit the front to fall while they were holding it on edge, with the absolute certainty, apparent to the most ordinary intellect, that it would fall upon their boss, their act would be of such extraordinary stupidity, or malice, as not to be ascribed wholly to their ignorance of the language in which the order was given, and the master would not be bound to anticipate it.—*Riggi v. Wicks Bros., Michigan Supreme Court,* 130 *N. W.* 683.

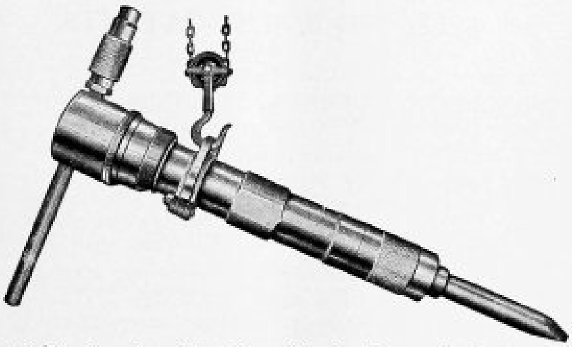
A Correction.

On page 190 of our July issue an article was published on "Boiler Mountings and Fittings." Since the publication of this article we have found that the material was copied by our contributor from Seaton's *Manual of Marine Engineering.* We wish to apologize to the author and publishers of this book for using such an article unintentionally.

ENGINEERING SPECIALTIES.

Boyer Rivet Buster.

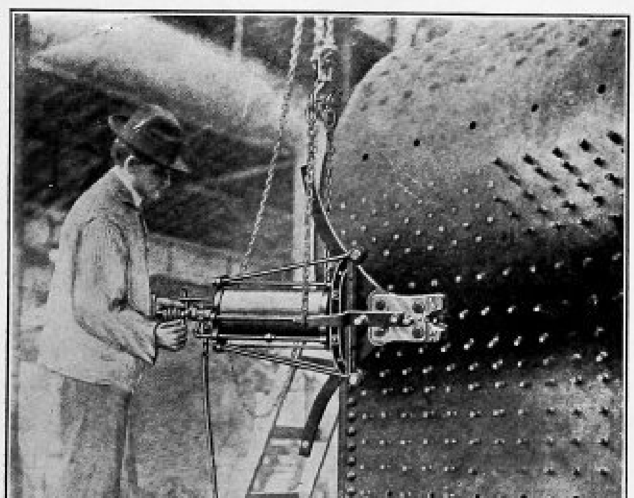
The name "rivet buster" strikes us as most attractive for the tool that the Chicago Pneumatic Tool Company, Chicago, Ill., is placing on the market. Here is a most compact tool, weighing only about 125 pounds, which will do the work in a small fraction of the time that the hand operation takes, and in so doing it cuts the labor cost most satisfactorily. In one case it is reported that to cut out a certain number of rivets



cost $48 by hand and but $22 with the "buster." It should not take very long to convince a purchasing agent that here was a remarkable chance to make a judicious investment. It can be used on rivets up to 1¼ inches diameter, and requires only 100 pounds pressure. The connection is 1-inch hose, and its portability would recommend it for a number of operations other than those above referred to. The illustration gives an idea of its neatness, and according to the claims made for it its purchase can be made without any fear of not having the little tool meet every requirement.

The Helwig Pneumatic Stay-Bolt Clipper.

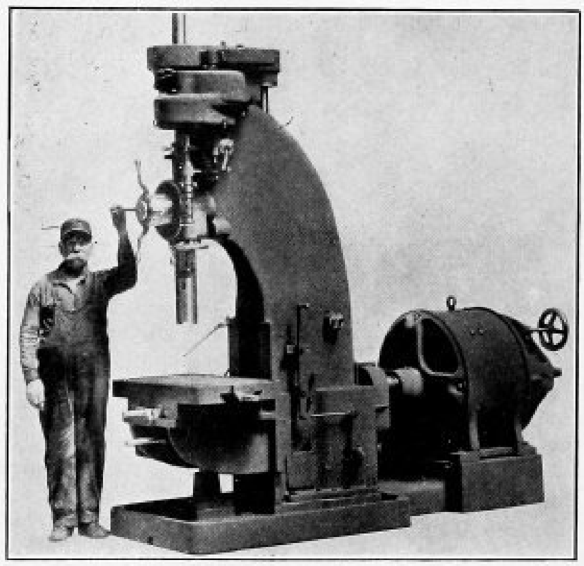
The pneumatic stay-bolt clipper, illustrated, which is manufactured by the Helwig Manufacturing Company, St. Paul, Minn., is constructed in such a manner that it can be used by unskilled labor for quick and efficient work. It is designed



to cut the stay-bolt off square without any jar or injury to the sheet, leaving the bolt as tight in the sheet as when first put in. The machine can be adjusted for leaving the desired length of stay-bolt for riveting. Any length of stay-bolt can be cut, as it cuts from the side, enabling the operator to see just what he is doing. It is claimed that one helper and a boy can cut off stay-bolts at the rate of 780 an hour. The machine has small inserted knives, which, when worn, may be replaced at little cost. One pair of these small knives, when the machine is properly installed, it is claimed, will cut from 16,000 to 20,000 bolts. When operating the machine it is suspended from a light boiler crane. The cutter is built in two sizes, one of which is designed for cutting 1½-inch bolts and less, weighing 210 pounds, and the other for 1¼-inch bolts and less, weighing 170 pounds.

A 36-Inch Swing High Duty Drill.

The Foote-Burt Company, Cleveland, Ohio, build in seven sizes a high-duty drill which was exhibited at the recent Master Mechanics' convention. The machine illustrated is called the No. 25½ high-duty drill with a 36-inch swing. This machine has a capacity for high-speed drills up to 3½ inches in solid steel to their full cutting edge capacity. It is built of high-grade material of the most rigid construction. All bearings are bronze-bushed except the main driving shafts at the base and top of the machine, which are Hyatt high-duty roller bearings. All feed changes are made through a quick-change gear device, operated by levers located at the front of the machine within easy reach of the operator. Nine changes of geared feed are provided, any one of which is instantly available without the necessity of stopping the ma-



chine. Power feed is provided with adjustable automatic stop and hand stop. Hand feed is through worm and worm gearing and quick traverse of spindle in either direction accomplished through a spider hand-wheel located at the front of the machine. The table is of the bracket knee type, having a large, square lock bearing surface on the upright to which it is securely gibbed. It is further supported and elevated by a square thread telescopic jack-screw, located underneath slightly back of the spindle, to permit boring bars and other tools passing through the table. The regular drive consists of a four-step cone pulley mounted on the base at the rear of the machine, driven from a countershaft located on ceiling; 2 to 1 back gears are located in the base of the column, operated from a lever on the side of the machine.

As shown in the illustration, motor drive can be used, consisting of a 20-horsepower, 4 to 1 variable speed, 300 to 1,200 revolutions per minute motor, geared directly with a 2 to 1 reduction and back gears, giving spindle speeds of from 37½ to 600 revolutions per minute. The spindle speeds, with belt drive, run from 25 to 200 revolutions per minute, and the countershaft at 400 revolutions per minute. The net weight of the machine is 7,000 pounds.

Some Recent Drilling Records.

At the recent joint conventions of the Railway Master Mechanics' and Master Car Builders' Associations, held at Atlantic City, June 14-21, 1911, great interest was aroused by some phenomenal results obtained in a demonstration test of twist drills. As the durability and efficiency of tools are such important factors in economical production these results should be welcomed by all interested in this subject.

The Cleveland Twist Drill Company, of Cleveland, had a Foote-Burt No. 25½ high-duty drill press (described in another column of this issue) in operation in connection with their exhibit, and the results obtained from tests of Cleveland milled and flat twist drills taken from stock are tabulated below:

Size and Kind of Drill.	Material.	R. P. M.	Feed Per Revolution.	Inches Drilled Per Minute.	Peripheral Speed in Feet Per Minute.	Cubic Inches Metal Removed Per Minute.
1¼" Paragon	Cast Iron 3½ Inches Thick	500	.050	25	163.5	30.68
1¼" "		325	.100	32½	106	39.88
1¼" "		475	.100	47½	155	58.29
1¼" "		575	.100	57½	188	70.56
1½" "		300	.030	9	117	15.90
1½" "		325	.100	32½	127.6	57.43
1½" "		335	.100	33½	131.5	59.19
1½" "		355	.100	35½	139.4	62.73
1¾ "		235	.100	23½	107.6	56.52
1¾" "		350	.100	35	160	84.19
2⁵/₁₆" "		190	.050	9½	115	39.90
3" "		120	.100	12	94	84.82
1¼" "	Machine Steel 4½ Inches Thick	350	.030	10½	113.7	12.88
1¾" "		225	.040	9	94.8	18.66
2⁵/₁₆" "		165	.020	3¼	100	13.65
2⁶/₁₆" "		200	.020	4	121	16.80
2½" Milled		150	.015	2½	98	11.04
2½" "		150	.040	6	98	29.45
2¾" "		175	.040	7	114.5	34.36
1¾" Paragon		275	.030	8½	125	19.84
3" "		150	.030	4½	117.8	31.81
3¼ "		150	.030	4½	127	37.33

The first tests were made for the purpose of demonstrating what is good shop practice, *i. e.*, the drills were put through at speeds and feeds that would be economical under average shop conditions. Then, to demonstrate the reserve efficiency and durability of the drills, "stunts" which demanded extremely high rates of speed and feed were attempted.

The highest rate of speed in drilling known to machine shop practice was attained by a stock 1¼-inch Paragon flat wist high-speed drill in successfully removing 70.55 cubic inches of cast iron in one minute, repeatedly cutting through a heavy billet at the record-breaking rate of 57½ inches per minute—nearly an inch per second. This drill ran at 575 revolutions per minute, with 1/10 (.100) inches feed per revolution, successfully withstanding the terrific strain of this extreme speed and feed. Before attaining this maximum performance, which was approached gradually, numerous other Cleveland drills were put through at the rates of 25, 32½, 33½, 35 and 47½ inches per minute, as can be seen from the complete record of the tests. In no case was the limit of strength of the drills reached, but the speed of 57½ inches per minute could not be exceeded on account of the inadequate capacity of the electric feed wires which brought current to the motor driving the drill press.

Drilling at such high speeds and heavy feeds is not to be recommended as economical shop practice, and this performance will in all probability not be repeated in many shops. These results were only made possible by carefully established ideal conditions, such as absolute rigidity in the machine, uniform and sufficient driving power, solid clamping of the work, perfect grinding of the tool and most expert handling. They are of value chiefly as demonstrating the power and rigidity of the machine and the exceptional reserve strength of the drills.

Another noteworthy test was made with a 2½-inch milled drill from stock. It drilled 68 holes through a billet of machinery steel 1¾ inches thick without being reground. This drill was operated at 150 revolutions per minute, with a feed of .015 per revolution, removing a total of 1,418 cubic inches of material. Although the drill was still in good condition the test was cut short at this point by the convention coming to a close. This test demonstrated what can be done all day long in any shop properly equipped, and is indicative of what results should be expected in economical high-speed drilling.

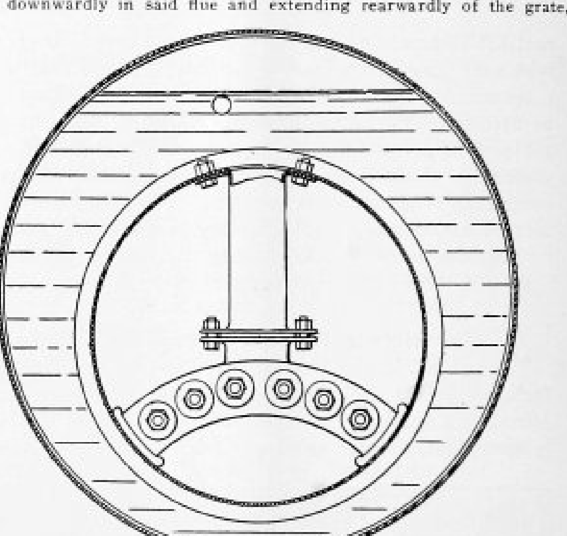
SELECTED BOILER PATENTS.

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

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

991,442. COMBINED FIRE AND WATER TUBE BOILER. LADISLAUS HAUBENTALLER OF UJSZASZ, AUSTRIA-HUNGARY.

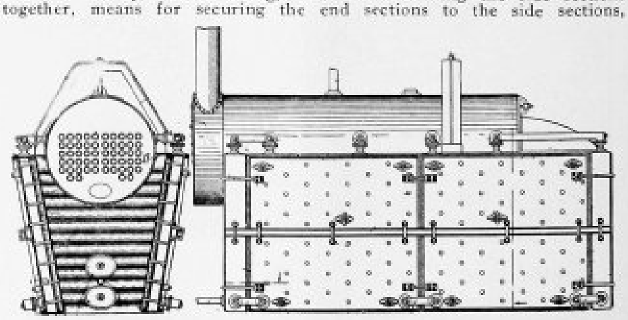
A boiler comprising in combination, an outer hollow structure having a relatively large flue therein eccentrically disposed with respect thereto, a grate in said flue, a group of water tubes above said grate and inclined downwardly in said flue and extending rearwardly of the grate,



a chambered member connected with the forward upper end of said tubes, a tubular connection between said member and the upper portion of said structure, a tubular member extending downwardly in said flue and including an arch-like portion connected with said tubes, said arch-like portions being connected at its ends with said structure at the lower portion of the flue thereof.

993,480. BOILER. SAMUEL M. WALKER, OF LOS ANGELES, CAL.

Claim 2.—A boiler comprising a cylindrical casing, a closed firebox formed of approximately rectangular hollow side and end sections, extending from the base to a point about half way up the sides and ends of the cylindrical casing, means for securing the side sections together, means for securing the end sections to the side sections,



brace bars extending the length of the closed firebox and clamps securing the brace bars to the side and end sections, pipes and couplings connecting the side sections, pipes and couplings connecting the end sections to the side sections, a supply pipe connected with the forward end section, pipes and couplings connecting the side and end sections with the cylindrical casing, an arched cover plate resting on the top of the rear side sections and against the rear end of the cylindrical casing and means for supporting the rear end of the cylindrical casing upon the rear side sections. Two claims.

THE BOILER MAKER

SEPTEMBER, 1911

THE DESIGN OF A DOUBLE-ENDED MARINE BOILER.

BY JOHN GRAY.

Many boiler makers are familiar with the design of a single-ended boiler and the details and calculations for same, but are not so used to double-ended boiler design. In the January number of THE BOILER MAKER I went into the subject of single-ended boilers. I now propose to consider the double-ended type. In designing a double-ended boiler the main features are very similar to those of a single-ended one, only they differ, of course, in length, and instead of having a back end there are two front ends. A double-ended boiler can be made either with a separate firebox or with a common firebox—one with a common firebox and the same heating surface as above example, we have the breadth of firebox at 5 feet and length of tube 8 feet, which gives us 21 feet long against 22 feet in the separate boxes. Thus with the common box we save 1 foot in length, which means, beside saving in the boiler, a very valuable saving in stokehold space. It now becomes a question of supporting this great breadth of box. It can be seen how impossible it would be to support it with an ordinary girder only, as in the narrow type of box. The Board of Trade does not allow a greater compression stress on tube plates than

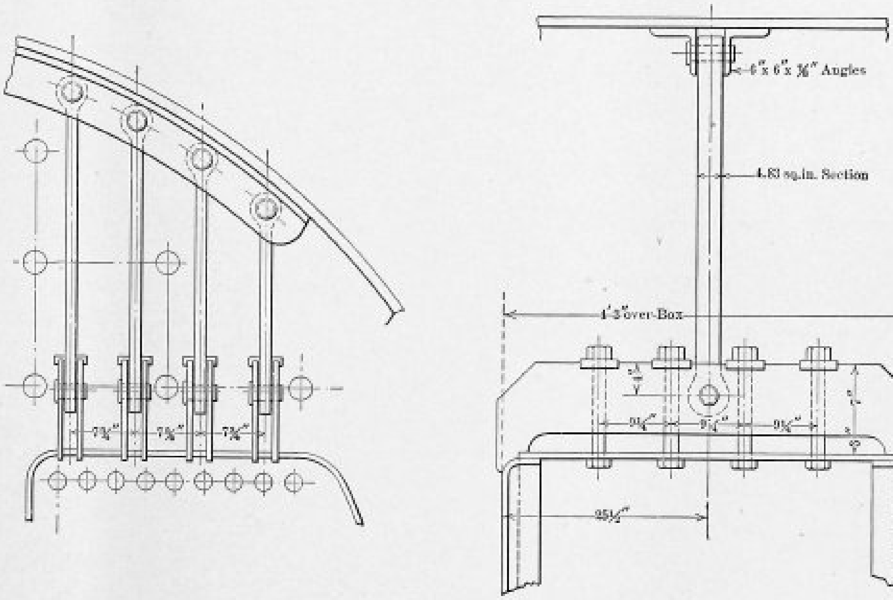


FIG. 1.—SINGLE HANGING GIRDER STAYS.

common to both ends of the boiler. I think the best practice is to have separate boxes and a water space in the center, only, while this has the benefit of an extra water space, it adds a foot to the length of the boiler, which is a serious consideration, and a foot means a good deal of extra expense, as you have the circumference of the shell $\times$ 1 foot $\times$ weight of shell plus any extra weight required for tensile strength or survey demands. Then, again, you have the back of the firebox extra, which means also added plates and flanging, riveting, etc. Against which there are the hanging stays as fitted in the common firebox, but these do not account for the addition due to the two single boxes. The first consideration is in the respective breadth of boxes. Taking a boiler 22 feet long, with a water space in center of 12 inches. the box ought not to be less than 2 feet 7 inches, with a distance between tube plates of 7 feet 11 inches. Taking an instance of a boiler 14,000 pounds, and that is embraced in the following formula:

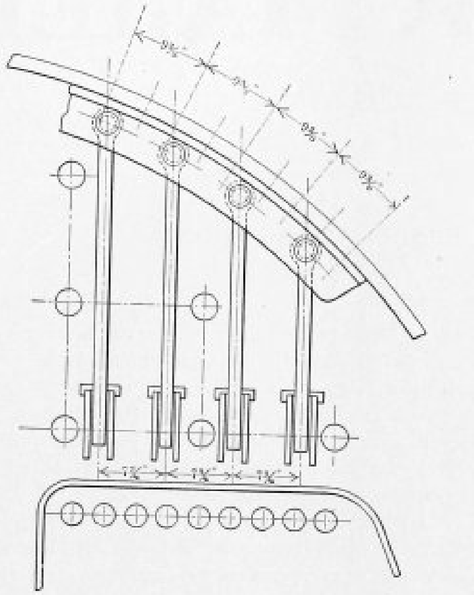
$$\frac{(D-d)\ T \times 28{,}000}{W \times D} = W\ P$$

Taking our $W\ P$ (working pressure) at 220 pounds, and working for thickness of tube plate, we have

$$T = \frac{W \times D \times W\ P}{(D-d) \times 28{,}000} = \frac{58.5 \times 3.75 \times 220}{(3\tfrac{3}{4} - 2.18) \times 28{,}000} = 1.1'',$$

or 1 3/32" thick. W is breadth of box as illustrated in Fig. 2, and D is pitch of tubes, d = inside diameter of common tubes.

It would not be good practice to have these tube plates anything approaching this thickness; indeed 13/16 inch or ⅞ inch at most is considered enough by most designers. So we assist it from the shell by hanging stays, reducing the thickness of plates and considering it as an ordinary flat surface. These hanging stays may have to take the full load on the top of the box, or they may be arranged to take only half this stress and the girder the other half. If they take half load then there will be one stay arranged, as in Fig. 1, and the



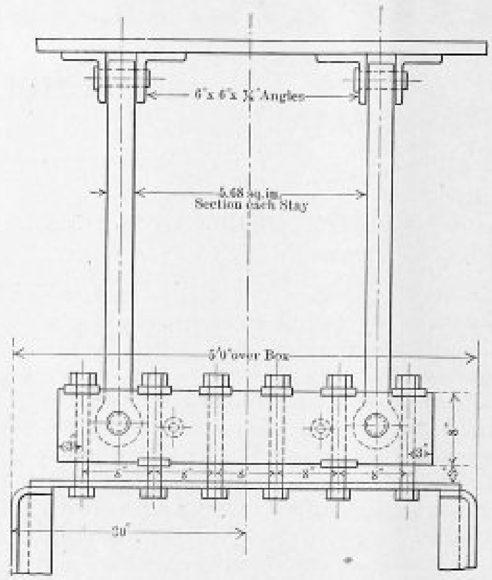


FIG. 2.—DOUBLE HANGING GIRDER STAYS.

strength may be found thus. Section of stay = area × 9,000 = total load on stay. Total load on stay = 25.5 × 7.75 × 220 pounds *W P* = 43,477 pounds, and the area of stay therefore

$$= \frac{43,477}{9,000} = 4.83 \text{ square inches.}$$

Assume we have a working pressure of 220 pounds. The stress allowed by the Board of Trade for stays is 9,000 pounds, and the load taken as half the breadth of box × distance between girders × *W P*. Now, in this type—*i. e.*, one stay in center—the girders would require to stand half the working pressure also, or as in the

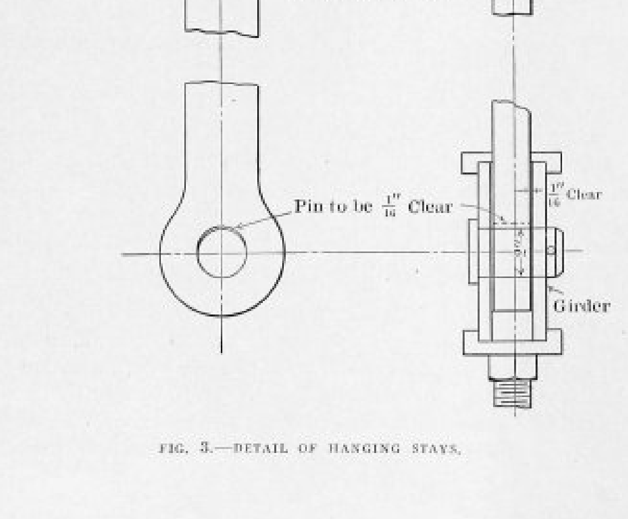


FIG. 3.—DETAIL OF HANGING STAYS.

hanging stays, half the load on the box equal to full working pressure, then

$$\frac{C \times d^2 \times T}{(W - P) \times D \times \text{Lin. feet}} =$$

$$\frac{990 \times 7^2 \times 1.25}{(25\tfrac{1}{2}'' - 9\tfrac{1}{4}'') \times 7.75 \times 2.125} = 226 \text{ pounds } W\,P.$$

Board of Trade. Lloyd's girder =

$$\frac{C \times d^2 \times T}{(L - P) \times D \times \text{Lin. inches}} =$$

$$\frac{10,660 \times 49 \times 1.25}{(24\tfrac{3}{4}'' - 9\tfrac{1}{4}'') \times 7.75 \times 24.75} = 219 \text{ pounds } W\,P,$$

which is a trifle weak and would require to be thickened a little. This style with one stay taking half load and the girder half load is probably the best and cheapest arrangement for boxes up to about 4 feet 3 inches broad, or 4 feet 6 inches broad, with pressures up to about 215 or 220 pounds. But above this breadth of box, as in boilers, say, about 21 feet long, it is better to adopt the two hanging stays and make them take the full load, as in Fig. 2. In this case the box is 5 feet broad and the *W P* again 220 pounds. The size of each stay will be found in the same manner as before. Area of stay × 9,000 = total load supported. Total load each stay supports = 30" × 7.75" × 220 pounds *W P* = 51,150 pounds. Area of stay $= \frac{51,150}{9,000} = 5.68$ square inches. The other hanging stay, of course, taking the other half of load. The Board of Trade girders for this type would require to be strong enough to stand half pressure, or the half breadth of box equal to full working pressure, thus,

$$\frac{C \times d^2 \times T}{(W - P) \times D \times \text{Lin. feet}} =$$

$$\frac{990 \times 64 \times 1.5}{(30'' - 8'') \times 7.75'' \times 2.5} = 223 \text{ pounds } W\,P.$$

$$\text{Lloyd's girder} = \frac{10,660 \times 64 \times 1.5}{(29'' - 8'') \times 7.75 \times 29} = 217$$

pounds *W P*, or barely working pressure. The hanging stays are usually left 1/16 inch clear at top side of girder pin and 1/16 inch at bottom side of top pin when the boilers are cold, to allow for expansion, and they are forged from a solid steel billet then annealed. See Fig. 3.

So much for stays and girders; there are now the pins or bolts to be considered at the bottom of firebox anchoring it to shell. See Fig. 4. The usual practice for these is to fix two angle-bars round the bottom of combustion chamber with a 13/16-inch plate between them. The number of bolts depends on the sectional area of the hanging stays. This area is made the same as the area of the hanging stays, taking into account, of course, the fact that the bolts are in double shear. Suppose we have 1 inch diameter of bolts, we saw the area of each hanging stay was in our first instance 4.83 square inches, and if we take a wing box we find there may be four hanging stays. Sectional area of the hanging stays will be, therefore, $4.83 \times 4 = 19.32$ square inches. Number of bolts at 1-inch diameter $= .7854 \times 1.75$ (for double shear) $\times N = 19.32$ square inches.

$$N = \frac{19.32}{.7854 \times 1.75} = 14.1, \text{ or say, 15 bolts.}$$

We have fifteen bolts at 1 inch diameter to be fitted underneath the combustion chamber to balance the hanging stays. We cannot get the whole fifteen in one line or we would block up the through space from end to end of the boiler at that part, so we put in two rows of, say, eight bolts each. See Fig. 4, and for details of these angles and bolts see Fig. 5. Some companies, instead of having bolts, use turned pins about 1⅝ inches diameter, and, of course, fewer of them; and instead of a plate between two angle-bars we use two plates, one on either side of a T-bar. This style certainly has the advantage of being much more easily fitted in the boiler shop than the one illustrated, but we have double the plating and a T-bar, which is not as easily obtained as an angle, unless in large quantities. However, it is a matter of shop practice, the strength being the same in both cases. The same remarks apply to the center box. The area of bolts will correspond to the area of hanging stays. Regarding the pins through the hanging stays at girder and shell ends the diameter is found in the usual way, *i. e.*, diameter of pins $= d^2 \times .7854 \times 1.75 \times 11{,}000$ pounds shear = total load on one stay:

$$d = \sqrt{\frac{\text{load}}{.7854 \times 1.75 \times 11{,}000 \text{ pounds}}}$$

load on stay, as we saw in first instance, was 43,477 pounds.

$$\therefore d = \sqrt{\frac{43{,}477}{15{,}114}} = 1.75'' \text{ diameter, or, say, } 2'' \text{ diameter pins}$$

to allow for surface chafing, etc.

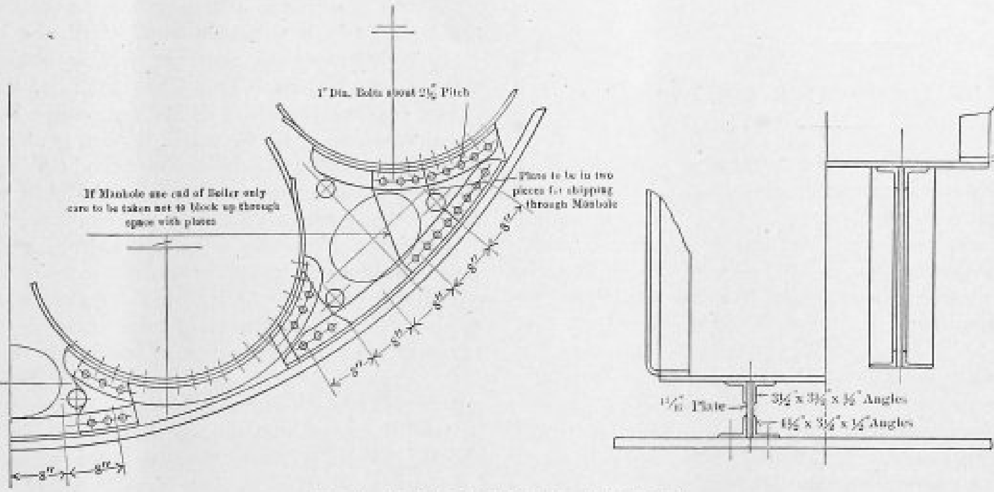


FIG. 4.—STAYING THE BOTTOM OF FIREBOXES.

The angles on shell also must be made deep enough to resist shear, and depth may be found as follows: Total load on hanging stay = 43,477 pounds, depth $= \frac{\text{load}}{\text{shearing stress}} \times$ the thickness of angle $\times$ number of sides to shear =

$$\frac{43{,}477}{9{,}000 \times .875 \times 4} = 1.38''$$

Depth of angle, therefore, will be $1.38'' + 2''$ diameter of pin $+ 1.38'' +$ thickness of leaf $= 5.635''$, or, say, $6'' \times 6'' \times \frac{7}{8}''$

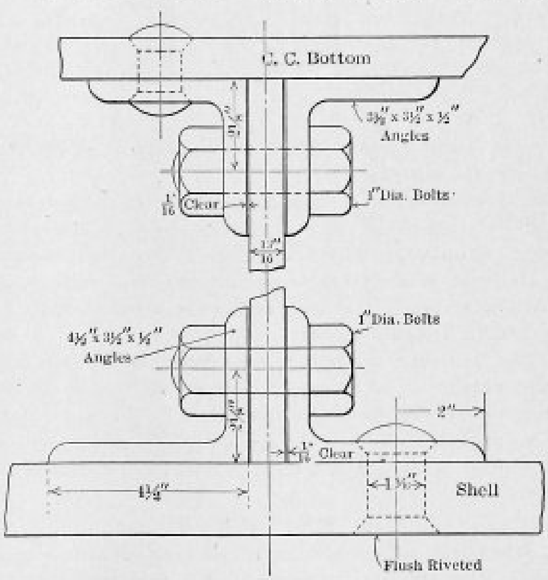


FIG. 5.—DETAIL OF PLATES AT BOTTOM OF FIREBOX.

angle-bars on shell. I have taken the shearing stress at 9,000 only, against 11,000 pounds in the pins, as there is a tendency for the angle to burst as well as shear. The rivets in these angles are usually made the same as those in shell, but their size can be worked out as follows:

$$d = \sqrt{\frac{\text{load}}{.7854 \times 12{,}000 \times 2}} = \sqrt{\frac{43{,}477}{18{,}850}} = 1.5'' \text{ diameter.}$$

That is, $1\frac{1}{2}$ inches diameter and two rivets in each stay. The pitch should be arranged so that two rivets come just in the way of each stay. See Fig. 2. The rivets, of course, being zig-zag in each leaf, as indicated by the dotted lines in sketch.

The foregoing remarks give an idea of how to proceed with the design of a double-ended boiler; but different places have different practices, of course, but the main features are the same everywhere.

THE LOCOMOTIVE BOILER*.

Power for the propulsion of a locomotive is generated in the boiler, therefore a complete study of the engine must necessarily begin with the boiler as a basis. A clear understanding of its construction and the idea on which it is based, is essential to a thorough grasp of the locomotive problem in general. Its possession renders much more intelligible the all-important associated questions of combustion and fuel economy.

No matter what mechanical skill may be evinced in the design of larger and more powerful locomotives, with a multiplicity of cylinders, and with most ingenious valve gears for steam distribution, its mission fails unless the boiler is at all times prepared to meet the demand imposed upon it. For this reason boiler making, or properly boiler design, has in the last few years resolved into a science, the importance of which cannot be overestimated.

The work of the boiler designer has of late become a very difficult proposition, in view of the stringent requirements of modern railroading. There was a time when the locomotive was designed, in a measure, to suit the boiler; when practically but two types of the latter sufficed, one for passenger and the other for freight engines.

To-day, however, the boiler is schemed out to gain certain tractive results. The increased power required to draw the heavy trains of the present requires it to be very much larger, both in outer shell and firebox, and its weight, when filled with water, forms a large percentage of that of a complete locomotive.

THE CROWN-BAR BOILER.

Contrary to popular impression, and even of many engaged in railroading, the locomotive boiler has remained practically unchanged since the first one of the horizontal type was placed on an engine. The progress in its development has been along the lines of higher grade steel, more accurate and permanent methods of performing the work connected with its construction, and the perfecting of formulas for determining the factors of safety and the strength and proportion of its parts. Whatever slight changes have been made in its shape were to meet the demand for increased size and capacity, without in any way conflicting with the original principle on which the first boiler of the multi-tubular type was built.

For many years, at least half a century, the type which has met all requirements in passenger service, and with the addition of a longer firebox for freight service as well, was that known as the wagon-top boiler, with a short, narrow firebox and crownbars, which is illustrated in Fig. 1. This form is still much in evidence in this country in the older engines of the New York, New Haven & Hartford, the Erie, the Baltimore & Ohio, and the Southern, and, in fact, examples of it may be found on any of the long-established trunk lines.

The extreme simplicity of the locomotive boiler, a feature as prominent in early days as it is now, is plainly apparent in the drawing, and it should be understood that the arrangement of the principal component parts of the most modern type is exactly the same, regardless of shape or size.

It consists of an outer cylindrical shell of steel, composed of several sections riveted together, and includes at the rear end a firebox, around which there is a complete water circulation, as shown. A large number of tubes carry the heat and gases resulting from the combustion in the firebox through the body of water in the boiler shell to the smoke-box, whence they escape through the smoke-stack into the atmosphere.

It will be noted that the top sheet of the firebox, or crown sheet, is supported from the wagon-top portion of the shell by sling stays, called "crown stays." These are attached to crown-bars, which are placed at equally spaced small intervals along the top of the firebox. The importance of properly staying or supporting the crown sheet was early recognized by designers, and this system of crown-bars was evolved as early as 1840.

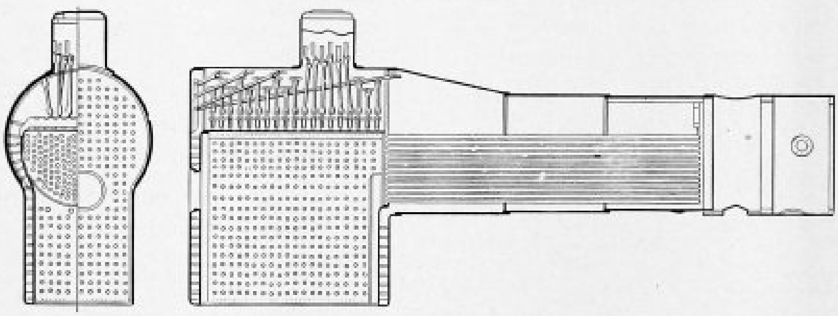


FIG. 1.—WAGON-TOP LOCOMOTIVE BOILER.

It is a thoroughly adequate arrangement, and would no doubt be countenanced now were it not for the fact that the close arrangement embodied allows mud and sediment to accumulate quickly, and this being in a practically inaccessible location causes much trouble from burned sheets.

This early type of boiler did not employ over 140 pounds pressure to the square inch, although instances are recalled of 165 pounds allowed by some roads; therefore the arrangement of bracing was not nearly so complete as in the latter-day developments. As shown in the illustration, the back head of the boiler, in addition to the stay-bolts securing it to the firebox, was further strengthened by diagonal braces connected to the wagon-top portion of the shell. The front flue sheet at the smoke-box was also braced by similar diagonal rods, which were riveted to the first or second cylindrical course of the boiler.

CHANGES IN THE FIREBOX.

The first change of any importance in this, which might be called the first standard boiler of the United States, was in 1882, or thereabouts, when the Wooten type was patented, and put into service on the Philadelphia & Reading Railroad, and on the Erie & Wyoming Valley Railway. This departure was

* By Robert H. Rogers in *Railroad Man's Magazine.*

entirely in connection with the firebox, the cylindrical part of the boiler containing the tubes remaining exactly the same, as it subsequently has through all the various types which have been evolved.

As shown in Fig. 2 the firebox was tremendously widened and lengthened in the Wooten construction, giving three or four times the grate area of the type from which it was de-

side sheets, of the flue sheet below the flues, and of the interior of the flues themselves. In the early wagon-top form, similar to that illustrated, this heating surface was limited to about 125 square feet for the fire-box sheets, and, as the number of tubes was generally about 218, 2 inches in diameter and 11 feet 6 inches long, their heating surface was 1,230 square feet, making a total of 1,355 square feet. The grate

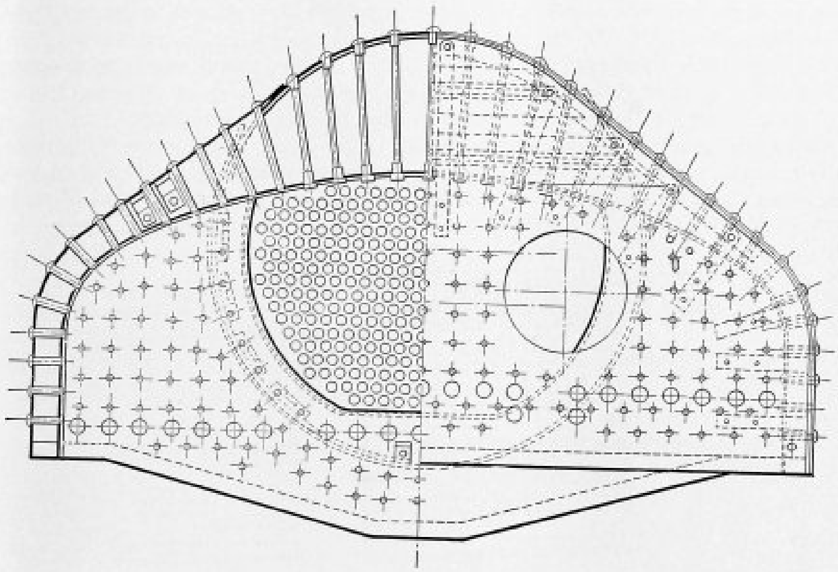


FIG. 2.—WOOTEN FIREBOX.

rived. It was, in fact, made as wide as the clearances along the line would permit, and this, of course, necessitated placing the cab ahead of it. Thus the type of locomotive known as the "Mother Hubbard," which is so popular on the Lehigh Valley, the Reading, the Lackawanna and the Jersey Central, came into being.

The Wooten firebox was designed primarily to afford larger heating surface and also to burn an inferior grade of coal. It will be easily appreciated, from a study of Fig. 1, that in-

area on the passenger engine boilers of this type was seldom more than 20 square feet, and on the largest freight locomotive not more than 36 square feet.

DETAILS OF THE "DIRT BURNERS."

This very first Wooten firebox immediately increased the grate area to 69 square feet, and the heating surface of the firebox to 184 square feet. Owing to the extreme width of the firebox it was necessary to have two fire doors, and the

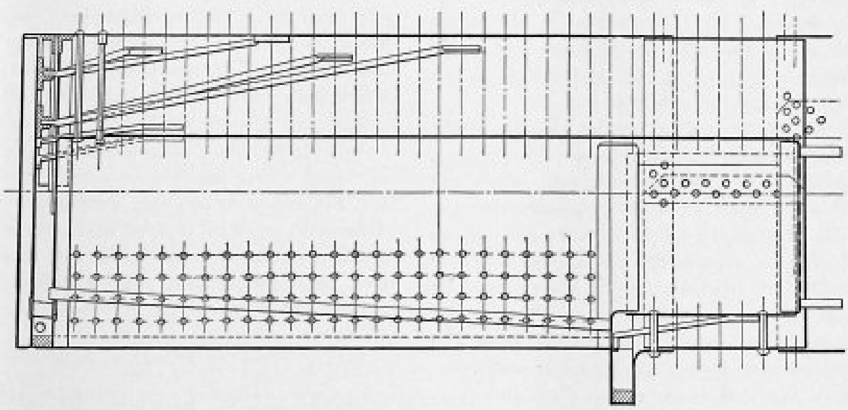


FIG. 3.—BRACING OF BACK HEAD IN LONG FIREBOX BOILER.

sufficient heating surface and restricted grate area were glaring faults in that early design. They were not so prominent at that time, as the trains were light and the schedule not unduly fast, but with the increase in tonnage behind the engine they became readily recognizable, and very skillful firing, with the best of coal, were indispensable to secure the results desired.

The total heating surface of any boiler is the area in square feet of the inside of the firebox, which includes the area of its back, or door sheet, that of the crown sheet, of the two

wide spread of grate allowed poor coal to be burned with great success. They were, in fact, referred to by the roads which used them as "dirt burners," and on the Reading they would burn with good results even the culm from the mines.

As shown in Fig. 2 the Wooten boiler has a wide, curved crown sheet, and it must perforce abandon the crown-bar and the crown stays for supporting the sheet, hence with the advent of the first one of this type came into existence the system of radial staying, which remains the practice to-day.

These stays are clearly illustrated in the drawing referred to. It will be seen that they screw up through the crown sheet from the fire side, and through the upper shell of the boiler about three-sixteenths of an inch on the outside, which projection is riveted over. They are very much similar to the shorter stay-bolts which unite the firebox side sheets with the outer sheets of the boiler shell.

Their use has been found very satisfactory, and they have been adopted as standard in all types of boilers. They do not obstruct the crown sheet, as in the crown-bar design, and permit the sediment to be readily washed off.

Despite the practicability and efficiency the Wooten firebox, with the exception of the roads mentioned, was not received with general favor, and its use seems to be limited to where anthracite coal is burned, which requires a very large grate area. It was principally opposed on account of the fact that its extreme width necessitates placing the engineer's cab in the center of the boiler, thus separating him from the fireman. This is considered such a grave objection in some localities that legislation forbids the use of the engines of this type—for instance, in Indiana and Illinois, and possibly in Ohio.

FLEXIBILITY IN THE FIREBOX.

The next change in fireboxes was the introduction of the Belpaire, which was first put in service on the Pennsylvania Railroad, and remained the standard on that system for many years. It is extensively used in this country and abroad, and has many features of merit. Its construction is shown in Fig. 4, and it will be noted that the only change from the original wagon-top form (Fig. 1) is the flattening of the wagon-top sheet on top and also on the sides.

This form of boiler has an advantage in that the flat plates are more or less flexible. In a boiler like that shown in Fig. 1, if the inside plates of the firebox become heated while the outside plates remain cold, they expand and push the top outward. This strain is transmitted to the outside shell above the firebox by the braces or stay-bolts, and as the circular form of the center shell gives it great rigidity the parts must be severely strained in turn. In a Belpaire firebox the flat plates above it can spring or bend, and they thus allow the inside plates to expand without injury to the other parts.

As shown in Fig. 4, in addition to the radial stays and stay-bolts, additional provision is made for bracing by means of longitudinal and transverse rods, thus securing an additional element of strength not attained in the types previously illustrated. Although there is nothing to be urged against the Belpaire except the somewhat more expensive construction, and a certain amount of weight added to the boiler without a corresponding increase in heating surface, it has not been generally adopted, and will probably make no further headway in this country.

These three types—the wagon-top, the Wooten and the Belpaire—supplied all requirements for many years, from 1840 to 1895, approximately. With the exception, of course, of engines equipped with the Wooten boiler, all were built with narrow fireboxes, as shown in Figs. 1 and 4, narrowed that they might go between the locomotive frames and the wheels.

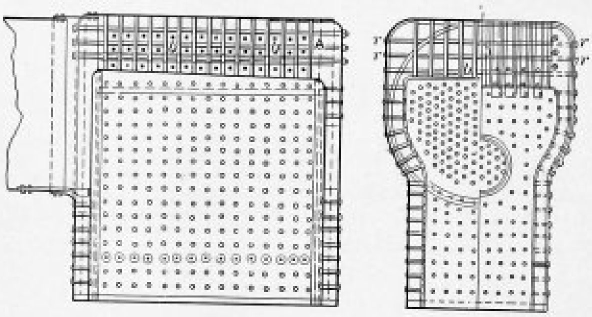


FIG. 4.—BELPAIRE FIREBOX.

ENLARGING THE GRATE AREA.

In 1885, or thereabouts, when the present remarkable development in the locomotive really began, it was realized that these narrow fireboxes had seen their day, and some scheme must be devised for widening them without resorting to Wooten's idea. In other words, it was not desired to widen them to the extent which would necessitate placing the cab ahead, but still enough to secure the extra grate area which the requirements demanded.

This was impossible of realization in the instance of the passenger engines of the period on account of the high driving wheels, but the plan was tried of raising the mud, or foundation, ring of the firebox to the top of the frames, and widening it so that the outside of the firebox occupied the whole of the distance between the driving wheels. This made possible a considerable increase in grate area, and with it the heating surface and steaming capacity of the boiler.

The demand for increased power still continuing, the next step was to place the firebox back of the driving wheels, and then widen it so as to extend over a pair of trailing wheels of small diameter that were used to carry it. This can reasonably be called a marking point in the history of the locomotive, and was first done by the Baldwin Locomotive Works in their "Columbia" (4-4-2) locomotive, shown at the Chicago Exposition in 1893. This made it possible to obtain a firebox whose dimensions were limited only by the clearances of the right-of-way and the ability of the fireman to shovel coal.

With these possibilities the size of locomotive boilers rapidly increased. The tubes have been lengthened from 12 feet or less, the common practice during the early stages of this development, to 18 or 19 feet, while tubes 22 feet long are in use. Heating surfaces have increased from 1,200 square feet to over 5,600 square feet, and working steam pressures to 235 pounds per square inch in some instances.

APPLICATION OF BOILER TUBES.

The type of boiler now generally used in the United States and Canada is illustrated in Fig. 5. It is what is termed the extended wagon-top type, with round top and wide firebox. This firebox is from 5 feet to 6 feet wide, and extends over the frames, and excepting on those engines in which the firebox is placed back of the driving wheels, over the driving wheels also. The grate area varies with the size of the boiler, but it is generally from 45 to 55 square feet.

The water spaces surrounding the firebox, between it and the outer shell, have been considerably increased during the past few years. Instead of water spaces at the mud-ring of 3½ to 4 inches, a number of roads are now using 5-inch spaces, and an engine with a 6-inch wide mud-ring has been built.

This larger water spacing increases to a certain extent the weight of the boiler, but it is compensated for by tapering the cylindrical part or barrel.

The tubes are usually 2 inches in diameter, although some roads use 2¼-inch tubes on large engines. The usual spacing from center to center of a 2-inch tube is 2¾ inches, and for a 2¼-inch tube, 3 inches. The tubes are usually arranged in vertical rows, and number about from 350 to 400, a vast increase over what was considered sufficient in the old days.

The method of securing tubes in the flue sheets, particularly in the firebox sheet, has always been somewhat of a problem, as leaking at that point operates seriously against efficient engine performance on the road. It has now, however, been perfected to a point which entitles it to special mention.

Tubes are usually made of charcoal iron, although many of steel are in use, and the endeavor is to secure the best possible material for their construction. The hole in the tube sheet is generally made the same diameter as the tube, viz.: 2 inches for a 2-inch tube.

The end of the tube is reduced in diameter to 1⅞ inches, and a copper ring or ferrule, 1/16 of an inch or less in thickness, and the same width as the thickness of the tube sheet, is placed in the hole in the sheet. The ferrule is then slightly rolled to hold it in place, and the tube inserted until its end projects about 3/16 of an inch beyond the sheet within the firebox. The tube is then tightened in the copper ferrule by means of an expanding roller.

A prosser expander, so called. is next introduced into the end of the tube, and manipulated to form a shoulder in the tube at the back of the flue sheet. This shoulder is the part which accomplishes the last operation in setting the tube, that of turning over the projection mentioned with the beading tool.

At the front end of the boiler no copper ferrules are used on the tubes. The hole is usually one-eighth of an inch larger than the actual diameter of the tube, and the latter is slightly enlarged before being put in place, and is expanded into the sheet by a roller expander. Some roads depend entirely upon this expanding to hold the tubes, while there are others that bead about 20 percent of them by the use of the beading tool.

TELLTALE FOR BROKEN BOLTS.

Stay-bolts, which unite the firebox to the outer shell, and which are clearly indicated in the different illustrations, are made of wrought iron, generally 1 inch in diameter, although sizes from ⅞ of an inch to 1⅛ inches are used to a certain extent. After being screwed in the ends project about 3/16 of an inch, and this is riveted over, both on the firebox side and on the outer shell. These bolts, owing to the expansion and contraction of the boiler, and other strains to which they are subjected, very frequently break, and they are therefore made of the very best material. The general practice in this connection is to also drill a hole down the center of the bolt, 3/16 of an inch in diameter and about 1¼ inches deep, in the end of which is screwed into the outside shell of the boiler.

When the bolt breaks the water will escape at the fracture into the hole, and the leak will thus indicate the defect and danger. The latter is much greater from this cause than is usually supposed, and despite the rigorous inspection requirements of States and railroads it is quite common, on taking a boiler to pieces, to find that a large number of the stay-bolts are broken.

Experience shows that when stay-bolts break the fracture nearly always occurs next to the outside boiler sheet, so that if the holes are drilled as mentioned in the outer ends of the bolts they will, in nearly all cases, show when a bolt is broken.

To minimize the breakage of stay-bolts, which is one of the most serious problems with which those responsible for the maintenance of boilers have to contend, various forms of flexible stay-bolts have been patented, and are in quite extensive use. The type of bolt that has been adopted by many of the railroads, and which has proved successful, is known as the "Tate."

In this arrangement a brass sleeve is used in the outside sheet to serve as a seat for the round head of the stay-bolt. The latter is screwed into the firebox sheet in the usual manner until its round head comes up against the round seat in the sleeve. Then it is headed over on the firebox side and a cap screwed on the sleeve.

It is, of course, evident that the round head, being free to move in the sleeve, secures a great amount of flexibility for the bolt, while at the same time not lessening its staying qualities. Flexible bolts are generally applied to fireboxes where the amount of breakage of rigid stay-bolts is exceptionally large, and the number of flexible bolts is usually about 30 to 40 percent of the entire number of staybolts in the firebox.

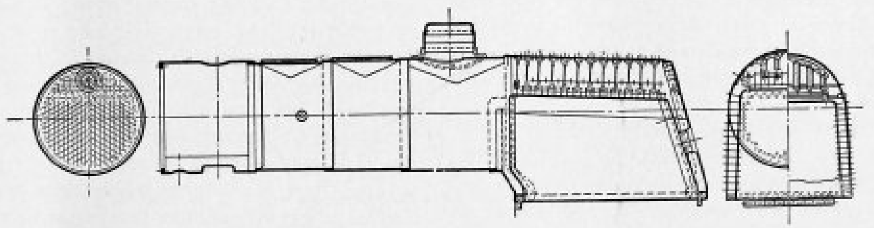


FIG. 5.—EXTENDED WAGON-TOP LOCOMOTIVE BOILER.

A LARGE SAFETY FACTOR.

The enormous strains to which a high-pressure locomotive boiler is subjected necessitates the utmost refinement in the proportion, and especially in the proper staying of the parts, and to this end the form and arrangement of the braces become of the utmost importance. As has been explained, these extend from the back head to the boiler shell and from the front flue sheet to the shell. There are other stays and braces in addition to these which are in evidence wherever their necessity is indicated.

Boilers in this country are generally designed with five as the factor of safety; in other words, to withstand five times the working pressure to which they will be subjected while in service, and all stay-bolts and other strengthening devices are proportioned in accordance with this factor. It will thus be appreciated that the liability to explosion is exceedingly small. It is, in fact, impossible for the modern, carefully designed boiler to so fail without a pronounced defect in one of the component parts which careful inspection would have indicated.

The various sheets are made from open-hearth steel, and the tests to determine the fitness of this material before acceptance are very severe. A strip when "pulled" in a testing machine must show a tensile strength of not less than 55,000 pounds per square inch before the fracture occurs, and while undergoing this strain the elongation or stretch before the break takes place must not be less than 25 percent. In other words, the test piece, originally 8 inches long, must stretch to 10 inches before fracturing.

The cold-bending test is also particularly exacting. In it a specimen from the boiler sheet, 1½ inches wide and as long as may be conveniently desired, must stand bending flat down on itself without showing any sign of fracture on the outside or bent portion. One strip is bent without any treatment, and another is first heated to a light cherry red, then in moderately cool water and bent.

In addition to these stringent physical tests, each sheet is also tested chemically. The chemical requirements for firebox sheets, as determined upon by the majority of roads, are as follows:

Carbon, 0.15 to 0.25 percent; phosphorus, not to exceed 0.05 percent; sulphur, not to exceed 0.04 percent; manganese, 0.30 to 0.50 percent.

These requirements are absolutely insisted on by the railroad companies in the purchase of steel for their own use, and when they have locomotives built by outside firms they reserve the right for their own inspectors to check the tests on all steel which the builders may purchase for use in their locomotives, and even make the chemical tests in their own laboratories.

It is safe to assert that with the care and watchfulness accorded this important detail, the chance for a defective sheet getting into a new boiler is about 1 in 10,000. In addition to the safeguards which the above described tests prove, there are others in the actual working up of the sheets into the required boiler shapes.

Some of these operations—flanging and punching, for instance—imply very rough treatment, and if the sheet is in any way defective they will leave an impress upon it which will not escape the keen eye of the inspector, who remains at the works until the last locomotive is delivered to his company.

STAY-BOLTS "PULLED" AND TWISTED.

Stay-bolts and tubes are also subjected to rigid standard tests, the conditions of which cannot possibly be evaded. When "pulled" in the testing machine the former must not break at less than 48,000 pounds to the square inch, with not less than 28 percent stretch in 8 inches. A cold rod of this material must stand bending over on itself without fracturing.

In another test a rod is clamped rigidly by one end in a machine, and the other end rotated in a small circle until the rod breaks. To be accepted in this test a ⅞-inch diameter rod must stand 3,000 revolutions, an inch diameter rod 2,200 revolutions, and 1 1/16-inch rod 1,500 revolutions. It will be readily appreciated that these tests represent vastly more severe treatment than the part will ever receive in service, and if the sample behaves satisfactorily under them the material which it represents must be acceptable.

The physical tests to determine the suitability of boiler tubes are very interesting. Before leaving the manufacturer's works each one is subjected to an internal pressure of 500 pounds to the square inch, and is plainly marked on the outside:

"Knobbed charcoal iron, tested to 500 pounds pressure."

The railroad company, or the purchaser, then reserves the right to reject the shipment, either in part or as a whole, should it fail under the additional tests which are imposed before the tubes are applied to the boiler.

The most important of these is known as the "expanding test." The end of a section of tube 12 inches long is heated for 5 inches of its length to a bright cherry-red heat in daylight. It is then placed in a vertical position on a block of iron, and a smooth-taper steel pin, at a blue heat, is driven into the end of the tube by light blows of a 10-pound hammer.

The requirement of this test is that the sample of tube must stretch or expand to one and one-eighth times its original diameter without splitting or cracking. One tube is so tested for each lot of 250 tubes.

TEST FOR THE TUBES.

A crushing test is next in order following this procedure. A section of tube 2½ inches long is placed vertically on the anvil of a steam hammer, and subjected to a series of light blows.

It must crush to a height of 1⅛ inches without splitting in either direction and without cracking or bending at the weld. Tubes which meet these requirements will stand the rather hard treatment without injury of rolling, prossering and beading, which they must undergo while being applied to the boiler.

When completed a new boiler is given a hydrostatic test of at least 25 percent above the working pressure. For instance, if it is designed to carry 200 pounds of steam it is first given a water-pressure test of 250 pounds.

It is then fired up and tested under steam at 230 pounds per square inch. Under the regulations of the majority of railroads the hydrostatic test must be repeated annually, and made a matter of record which the locomotive carries in the cab.

After being placed in service the locomotive boiler is subject to quite rapid deterioration, and unceasing vigilance, coupled with a great amount of work, is necessary to properly maintain it. The outer shell may be said to last indefinitely, but the parts subject to renewal in their order of prominence are the stay-bolts, flues and the firebox. Where rigid bolts are used, and under normal conditions, the modern boiler breaks on an average about five stay-bolts per month, although the total may reach to fifteen.

The effort is made to renew these on occasions when the boiler is washed, so that the locomotive will not be detained from service, and as in bad-water districts a boiler must be washed as frequently as once a week or oftener, the renewal of broken bolts can be effected without loss of road time. They can be detected either by the steam and water escaping from the telltale hole, as has been mentioned, or by the hammer test, which latter is generally depended upon.

In making this examination the inspector, who, through long experience, has an ear particularly trained to detect any variation in sound, raps each bolt on the outside of the sheet with a light hammer. Those that are fractured give a dull response, something quite similar to the sound produced by striking the sheet itself, while the hammer rebounds from the good ones and the ring is solid.

The broken bolts are quickly removed by air drilling, the hole retapped and a new one applied and riveted. An expert has been known to renew eight of these during the two hours required to wash a boiler.

REPLACING BROKEN STAY-BOLTS.

It is of the utmost importance that broken stay-bolts be replaced promptly, as the strains which they bore formerly are transmitted to those adjacent, and the area of breakage is liable to extend with great rapidity. In several States, notably New York, the law has assumed jurisdiction over this matter, and the State Inspector checks up the renewal of bolts by the road.

In the new Federal boiler inspection law the United States government will also become a party to the inspection, and severe penalties will be imposed in instances where renewals are neglected.

The radial stays, those connecting the fire-box crown sheet to the upper shell, are not subject to breakage, which is rather a fortunate circumstance, as their renewal is usually attended with considerable difficulty. The hammer test is not so conclusive in this case, owing to the much greater length of these stays compared with stay-bolts, and their condition cannot be definitely determined without an interior inspection of the boiler.

Hence it is a positive requirement that on the occasion of the annual hydrostatic test, the dome cap will be removed so that the inspector can enter the boiler for this purpose.

WEAR AND TEAR ON TUBES.

The life of tubes is extremely variable, depending on the service in which the engine is engaged, but principally on the quality of the water used in the boiler. The length of time before the tube must be removed on account of the firebox end being so damaged by rolling and beading through repeated tightening that it will no longer hold, is from five to six months up to three years and over. In relatively good-water districts the average amounts to about one year.

On removal the defective end is cut off and a new piece welded on, whereupon the tube is reapplied. This process is called "safe ending," and it may be resorted to from four to ten times, where the quality of the water is such that no pitting of the body of the tube occurs. The shortest life of the body is from two to three years, while some roads report tubes lasting as long as fifteen years.

Tubes are principally damaged through the efforts made to keep them tight in the firebox flue sheet. This end is subjected to extreme variations in temperature, and its bead is liable to damage through close proximity to the intense flame, consequently "leaking flues" is one of the most common reports in the instance of arriving engines at a terminal. They are tightened usually by introducing a flue roller and re-expanding them, a process which requires about one minute per tube if the leak is not bad.

Although necessary, the rolling process is very destructive to the tube, as it thins it at every operation, and for this reason many roads have abandoned it in favor of the prosser tool, which has been described and which tightens the flue by shouldering it behind the flue sheet.

The life of fireboxes varies with the quality of water used and the type of the box. Some roads with locomotives of an older type, having fireboxes similar to Fig. 1, report boxes twenty years old and over, but the general experience with modern engines using 180 to 200 pounds boiler pressure is that the life varies from two to four years in bad-water districts and up to ten years and over where water is good.

The exact life of fireboxes is difficult to determine, from the fact that the various sheets composing them do not last the same length of time. Where the nature of the scale is such that the sheets become easily overheated and the service is severe, side sheets in engines of the wide firebox type are occasionally replaced in from one to two and one-half years, while crown sheets, which do not deteriorate so quickly, give considerably longer service.

A great deal depends on the care and attention given to the washing of the boiler, a detail which, despite the regulations in vogue, is frequently slighted.

The renewal of a firebox is about the most expensive operation which can be resorted to in connection with a locomotive. It means the complete dismantling of the engine as a preliminary, in order to remove the boiler; the removal of all the tubes; the drilling out or breaking of all stay-bolts (nearly 1,000 in a modern boiler), and the removal of the mud, or foundation, ring and the interior firebox bracing. The cost of this work, including labor and material, does not fall short of $2,000 in a large modern boiler.

When in service the boiler is relieved of excess pressure by automatic safety valves of some approved form, which are located usually on top of the steam dome. Three of these are employed; the first, or "working" pop, being adjusted to open at working pressure, say 200 pounds, and the other two at 202 and 205 pounds. The adjustment of these appliances is beyond the control of the engine crew, and they are removed and tested monthly to determine whether they are in proper condition.

The all-important information for the engineer concerning the height of water in the boiler is indicated by the water-glass and by the gage cocks. The location of these devices and their position in relation to one another on the back head of the boiler is made according to a standard method of application.

It will be noted in this case that the lowest gage cock is placed at 3 inches above the highest point of the crown sheet, and the water is just beginning to show in the glass.

The usual practice on the road is to carry the water with the glass not less than two-thirds full, or at least two solid gages of water. There is always a false indication in the glass when the engine is working hard which must be reckoned with, as the rush of steam through the throttle valve to the cylinder tends to lift the water level, sometimes amounting to one gage, and consequently two gages with the throttle open means usually about one gage with it closed.

No detail of an engineer's work is of more importance than maintaining the water at the proper level. Two thirds at least of the accidents to boilers have resulted from its falling below the danger point, either through carelessness or through the failure of the injectors to work.

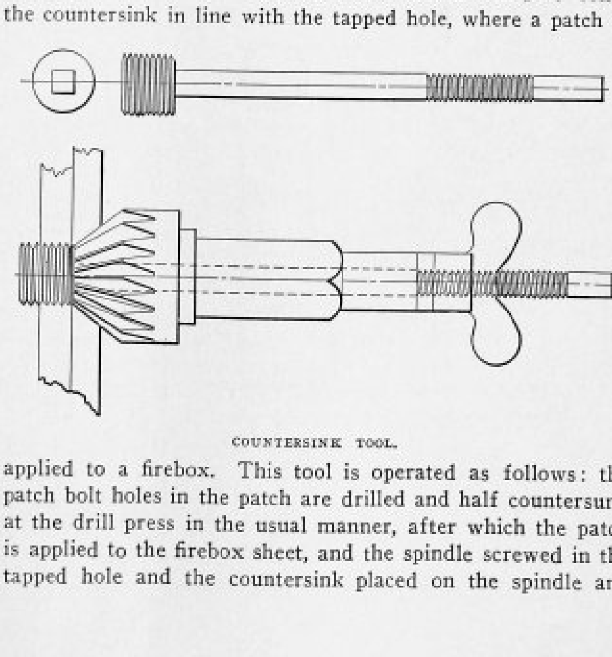
When this occurs, the crown sheet, no longer protected by the water, becomes overheated in an incredibly short time, and if this condition continues it will soften to the extent that the steam pressure will force it away from the supporting radial stays, with a resultant violent internal explosion. It is safe to say, however, that no man running an engine allows his attention to be diverted from this important detail for very long. The day of taking chances with water has gone by long ago.

The remaining appurtenances of the locomotive boiler, grates, ash-pans and the various front end arrangements, are reserved for consideration in the next article of this series, which will take up the general subject of combustion, the various locomotive fuels and their proper handling to secure the best results. The province of the boiler designer is simply to produce an apparatus which will generate the amount of steam desired, and the production of the latter lies in altogether different hands.

A Countersinking Tool.

A correspondent of *Railway and Locomotive Engineering* writes as follows:

Attached illustration shows a hand tool as used to bring the countersink in line with the tapped hole, where a patch is applied to a firebox. This tool is operated as follows: the patch bolt holes in the patch are drilled and half countersunk at the drill press in the usual manner, after which the patch is applied to the firebox sheet, and the spindle screwed in the tapped hole and the countersink placed on the spindle and



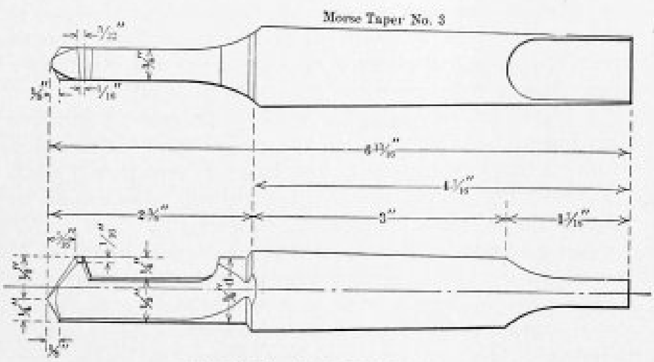
COUNTERSINK TOOL.

fed to its work by the thumb nut shown. This brings the bevel or countersink in line with the tapped hole and makes a perfect fit for the bevel on the patch bolt. The drawing gives details and will be plainly understood.

BOILER SHOP KINKS.

BY C. E. LESTER.

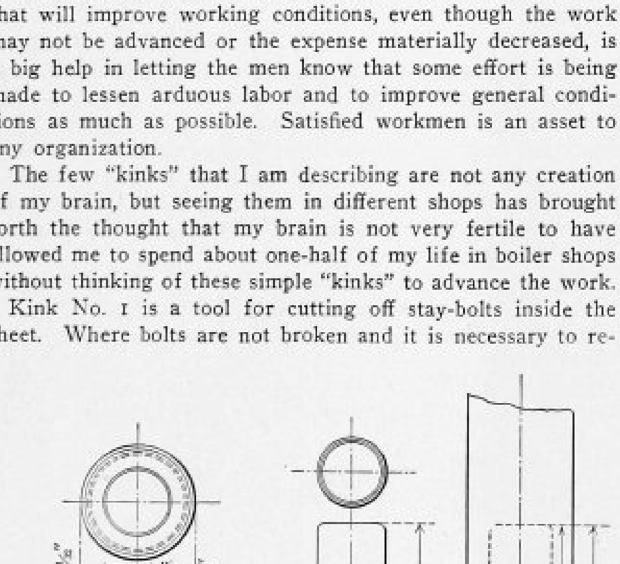
To get a maximum output with a minimum expenditure for labor and material is, of course, one of the very essential features of shop operation for the shop foreman to consider, and every idea advanced by anyone that appears to have any merit should be given serious consideration. An innovation that will improve working conditions, even though the work may not be advanced or the expense materially decreased, is a big help in letting the men know that some effort is being made to lessen arduous labor and to improve general conditions as much as possible. Satisfied workmen is an asset to any organization.



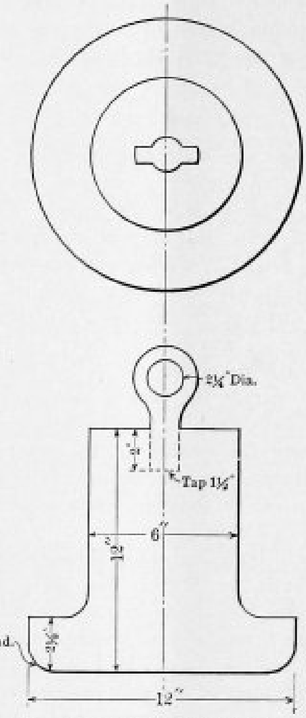
KINK NO. 1, STAYBOLT CUTTER.

The few "kinks" that I am describing are not any creation of my brain, but seeing them in different shops has brought forth the thought that my brain is not very fertile to have allowed me to spend about one-half of my life in boiler shops without thinking of these simple "kinks" to advance the work.

Kink No. 1 is a tool for cutting off stay-bolts inside the sheet. Where bolts are not broken and it is necessary to remove large quantities of them considerable labor is involved (where stay-bolt breaker cannot be used) in cutting bolts loose inside the sheet. The stay-bolts are first drilled in the regular manner. The cutting tool used with a motor is inserted in the hole made by the drill, and the center point of the tool being off center follows the center made by the drill and forces the cutting edge of the tool through the burr around the hole in a very few revolutions. A great many more bolts can be cut off in equal time in this manner than two can do with hammer and chisel.



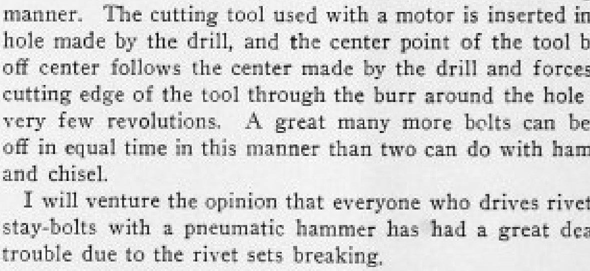
KINK NO. 2, RIVET SET AND PLUNGER.



KINK NO. 3, STRAIGHTENING BLOCK.

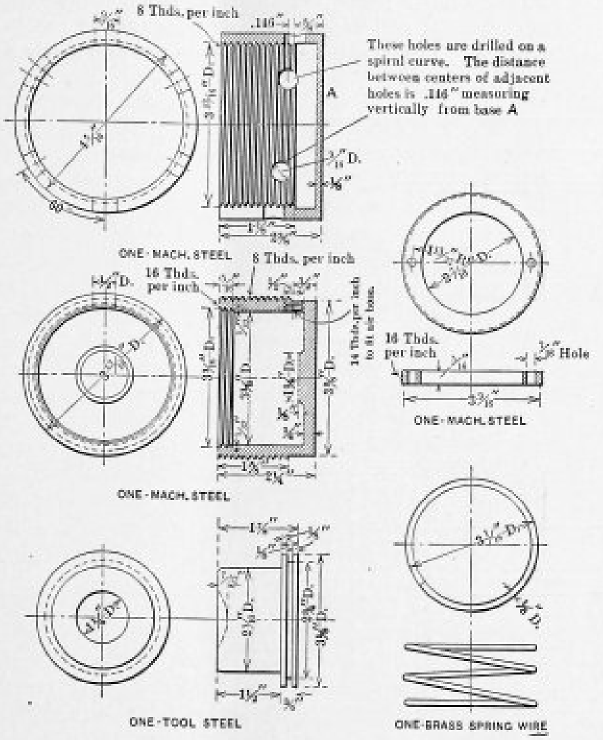
I will venture the opinion that everyone who drives rivets or stay-bolts with a pneumatic hammer has had a great deal of trouble due to the rivet sets breaking.

Kink No. 2 shows a set designed by one of our tool room operators that has given excellent results. Quite a number of these tools have been in service for several months, and they have given such good results that making them a standard tool for the system is contemplated. They are, of course, somewhat more expensive than the ordinary set, but as one of them will usually outlive ten of the ordinary pattern it appears that the costliest set is the most economical one to use.



KINK NO. 4, PNEUMATIC HOLDER-ON.

Kink No. 3 is a dropping block used by the flanger. When annealing and straightening large sheets after flanging usually the flanger has a flatter with a long iron handle so that he can keep fairly well away from the hot sheet, but the strikers



DETAILS OF PNEUMATIC HOLDER-ON.

are obliged to run in and strike a few blows and then hustle back from the hot plate to keep from getting burned.

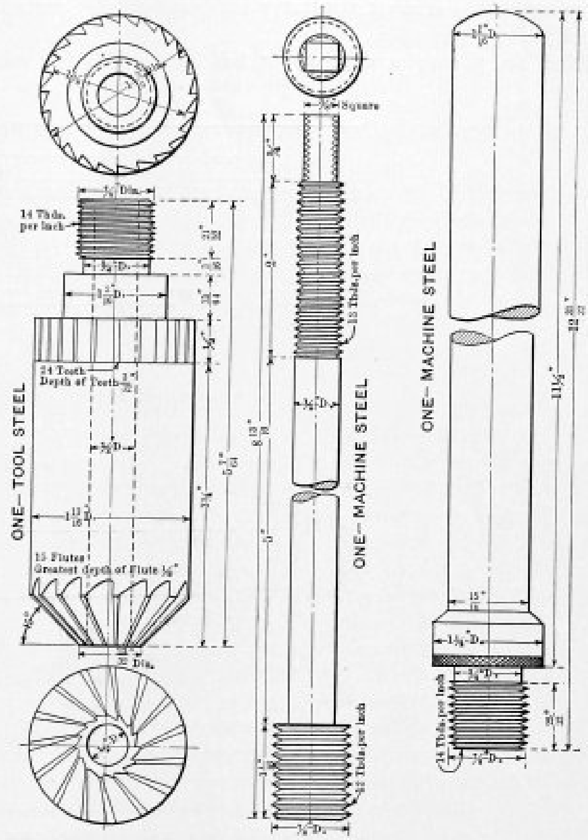
By inserting a 20-foot flue in the eyebolt in the top of the straightening block, shown as kink No. 3, and dropping it on the plate where necessary, two men can successfully straighten a sheet in one-half the time that four men could the old way, and without getting their face and hands scorched.

The dimensions of the block we are using need not necessarily be followed. Our block is made from a prony truck center casting for one of our standard engines, and doubtless any railroad casting storage will have one something similar in contour and size that will answer the purpose fully as well as the one described.

Kink No. 4 is a pneumatic rivet holder-on, to be used in narrow water spaces. The advantages it has over those generally used is its adjustability.

The threading arrangement between the inner and outer shell and the air inlets drilled on a spiral curve gives a large range of adjustment.

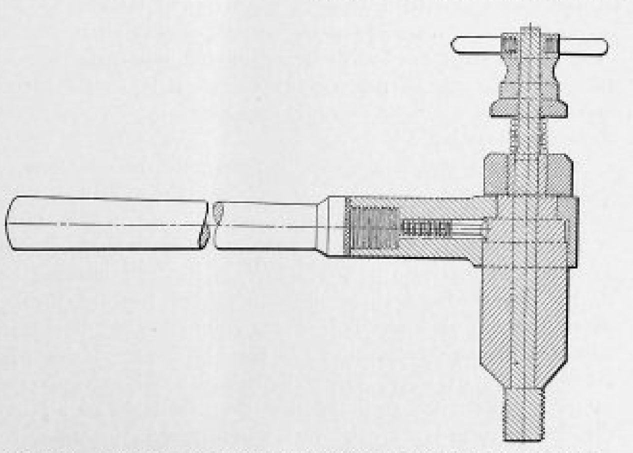
Kink No. 5 is a countersinking tool for patch bolt holes to



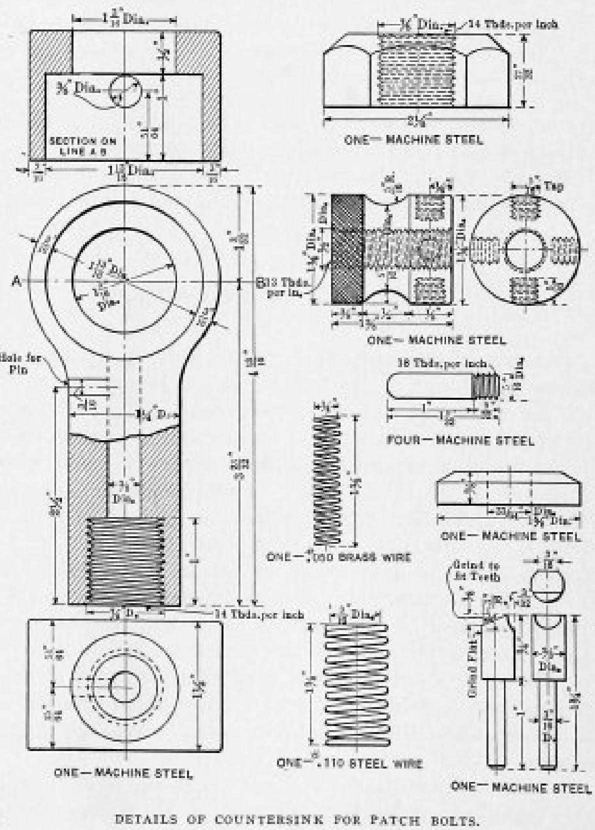
MAIN PARTS OF COUNTERSINK FOR PATCH BOLTS.

get the angle of the countersink in line with the angle that the hole is tapped out.

Kink No. 6 is an oil-burning device for heavy work, and it is



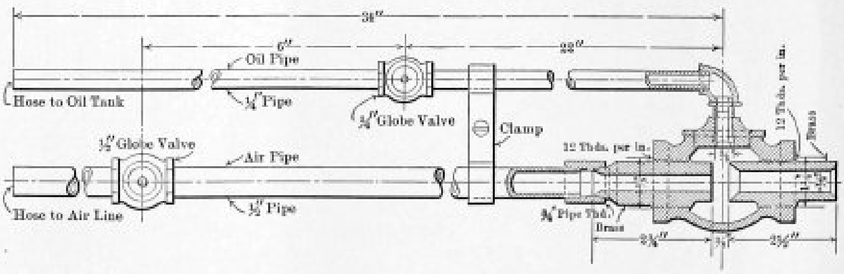
KINK NO. 5, DEVICE FOR COUNTERSINKING FOR HEAD OF PATCH BOLT.



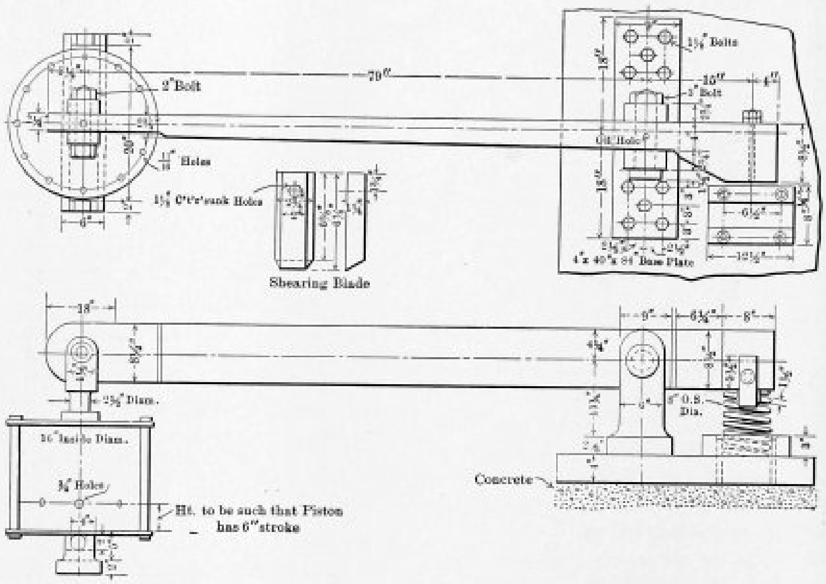
DETAILS OF COUNTERSINK FOR PATCH BOLTS.

an exceptionally efficient apparatus for heating heavy material rapidly.

Kink No. 7, coupler rivet nipper, has filled a long-felt want for an efficient tool to eliminate the hard labor connected with cutting out the large rivets in coupler connections.



KINK NO. 6, OIL BURNER FOR HEATING FRAMES AND OTHER HEAVY IRON.



KINK NO. 7, COUPLER RIVET NIPPER.

Material for the construction of this device as well as all others described may be found around any railroad shop.

STEAM BOILER ECONOMICS.

The interpretation of steam boiler tests in relation to the causes of efficient or wasteful operation is a problem which will be of interest so long as the present indirect methods of obtaining the stored energy of coal remain in vogue. In spite of the attention given of late to the theory of combustion, it is safe to say that in no branch of engineering are generalizations more difficult. Nowhere does the analysis of local conditions mean more as contrasted with attempts to set forth principles of operation to be applied on a large and varied scale. The fundamental principles of efficient combustion are well appreciated by engineers in touch with the best power plant practice, but the number of factors involved in each installation is so great that it is necessary to look to the individual test to point the way to a closer union between what is theoretically desirable and what may be realized in actual service.

In an exhaustive paper presented before the recent Congress of Technology at Boston, Mr. George H. Barrus reviewed the results of thirty years' experience in steam boiler testing, supplementing his well-known book on tests carried out in an earlier period. The later tests, which have not previously been made public, have a special bearing on questions of furnace efficiency, and illustrate both the advance of the watertube boiler and the extended use of flue gas analysis in modern practice. No attempt was made to draw general conclusions from the tests, which were very numerous, but each one was considered separately, and conclusions drawn upon specific results, with particular reference to the sources of inefficient operation or the means of effecting an improvement in the conditions. In some instances comparisons were made between different methods of operating the same installation, and in others the effect of fuel characteristics was analyzed. In view of the great number of tests included, only passing mention can be made of the conclusion drawn in a few special cases, but these are thoroughly suggestive in relation to the conditions existing.

In two tests the object was to determine the economy resulting from the admission of air over the fuel bed. The boiler was of the horizontal return-tubular type, with a rating of 94 horsepower, the ratio of heating to grate surface being 34 to 1, and the ratio of grate surface to draft opening 12.7 to 1. The products of combustion passed forward through outer tubes and backward through inner tubes, air being admitted through perforations in the fire doors. Using bituminous coals of about 13,500 British thermal units average calorific power, it was found that the admission of air over the fire increased the evaporation per pound of combustible about 10 percent, from 10.23 pounds to 11.35 pounds from and at 212 degrees, the draft between the damper and boiler being about 0.3 inch, and the temperatures of the escaping gases 510 degrees with the air admission and 515 degrees without it. In a third case a special form of furnace was used, admitting air over the fuel bed through perforated tiles in the bridge wall and combustion chamber. The products of combustion passed under a transverse arch before leaving the chamber and entering the tubes, the opening for air admission being 3 square inches per square foot of grate area. The air admission resulted in an increased evaporation of 9 percent.

The disadvantages of a thick fire were clearly shown in two tests upon a 119-horsepower horizontal return-tubular boiler, having a ratio of heating to grate surface of 45 to 1; grate surface to draft opening, 5.6 to 1, and a percentage of 46 for the proportion of air space in the grates. The grates were of the plain type. With a fire thickness of 12 inches, the percentage of CO in the gases was 1.1, compared with 0.1 with a 6-inch fire, and the evaporation was 11.5 pounds with the thicker fire and 12 pounds with the thinner. A portion of the loss in economy was due to the different capacities of the boiler in the two tests, 165 percent of the rating being developed with the thick fire and 142 percent with the 6-inch bed of fuel.

The importance of a clean heating surface was illustrated by two tests of a 133-horsepower horizontal return-tubular boiler, the evaporation per pound of dry coal being 10.08 pounds before cleaning and 10.6 pounds afterward, the output being practically the same in each case. Another boiler of the same rating in this plant was equipped with a shaking grate, and the evaporation was increased to 11.05 pounds, probably on account of the reduction in air space. In another test, a gain of 14 percent in coal consumption was secured in a 310-horsepower horizontal return-tubular boiler by lengthening the furnace and equipping it with a firebrick arch of the hanging type, under which the products of combustion pass before leaving the furnace. A novel furnace arrangement was tested in a 280-horsepower vertical return-tubular boiler with 2½-inch tubes, having a small central water leg and a central steam drum. Thirty percent of the total surface was used for superheating. The furnace was brick-lined and protected by an iron jacket, and the grate constantly revolved at low speed about the water leg as a center, firing being by a single door as the various portions of the grate reached the door. On New River coal an evaporation of 12.8 pounds per pound of combustible was secured, 87 percent of the rating being developed. The boiler efficiency was 80 percent, but when the boiler was crowded with a grate speed exceeding the economical limit, the efficiency fell at 132 percent of rating to 68.7 percent.

Incomplete combustion was responsible for relatively low efficiency in a number of tests on watertube boilers. In one case an evaporation of only about 10 pounds per pound of dry coal was obtained, the trouble being too close proximity of the heating surfaces to the furnace, the boiler rating being 240 horsepower. This incomplete combustion offsets in large measure the benefits of operating the boiler not far from its rating, and made of little avail a shortening of the grate surface which would otherwise have given an improved performance. In another test of a 354-horsepower watertube equipment, the low efficiency of about 65 percent was obtained, the boiler being of the vertical pass type with a hand-fired furnace and no provision for burning the volatile gases. Forcing the output of another boiler of 325 horsepower, rating from 105 to 175 percent of its normal output, reduced the efficiency from 74 to 64 percent. In another case where a mechanical stoker was in use, supplemented by spreading the fuel by hand tools, the efficiency was raised somewhat, and in another installation of two boilers the alternate system of operation reduced the smoke from 13.6 percent to 2.3 percent. Interior scale, forcing the capacity and neglect in maintenance, resulted in a low evaporation in another equipment.—*Engineering Record.*

SAVING BY OXY-ACETYLENE WELDING.*

About two years ago there was installed at the Collinwood shops of the Lake Shore & Michigan Southern Railway an apparatus for welding steel and iron by the oxy-acetylene process. It consists of a stationary type generator in which acetylene is produced by the automatic feeding of calcium carbide into water, the necessary supply of oxygen being obtained in cylinders which, therefore, do not form a part of the permanent equipment.

The acetylene generator has a carbide capacity of 150 pounds, the acetylene being generated under a pressure of about 5 ounces per square inch. The oxygen is obtained in cylinders each containing 100 cubic feet under a pressure of 1,800 pounds per square inch. This pressure, however, is reduced when the apparatus is in use to about 18 pounds per square inch at the point where it enters the blow-pipe, by means of an automatic pressure regulator, attached to the oxygen cylinder. The blow-pipes are of the well-known Fouché type. The acetylene generating apparatus, as above stated, is of the stationary type, but it is mounted upon a platform so arranged that it can be lifted by the cranes and transported to different parts of the shop. As the oxygen cylinders can be trucked, so far as the interior of the shop is concerned, the apparatus is practically portable. This permits it to be taken to the erecting shop and work performed on locomotives which are on the pit, or it can be taken to the boiler shop and repair fire-boxes, flue sheets, etc., without having to transport the boiler or use a complicated and extensive system of piping to carry the gases.

The longer this apparatus has been in use the greater has been the variety of work for which it has been found suited, until at the present time the many ways in which acetylene welding can be used to advantage is really surprising. Possibly the most valuable use of the apparatus in a railroad shop is for putting in patches or welding cracks in fire-box sheets, and at Collinwood it is very extensively employed in this way with most satisfactory results.

Some time ago it was decided to keep a record of the work which is being done by this apparatus for a period of time. Forms were prepared to show the gas consumption, time required, number of men, etc., as well as the expense of obtaining the same results if the welding apparatus was not available. A man was detailed to follow the machine for this purpose and sketches were made showing exactly the kind of work performed.

These reports are now very extensive, inasmuch as the machine is in almost constant use and a few examples selected at random are given below.

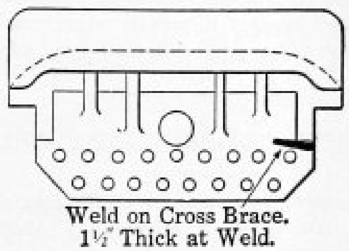
WELDING CAST STEEL FURNACE BEARER.

The following weld of a crack 5 inches long was performed on engine 5871. The crack was chipped out in the form of a "V" the entire length. The same method and welding was used as in welding a fire-box seam.

The total cost of labor and material for repairing the above fracture was as follows:

2 hrs. at $.50½ per hour = ...	$1.01
40 ft. gas and carbide = ...	.70
Total cost of welding............	$1.71

* Abstract from *American Engineer and Railroad Journal.*



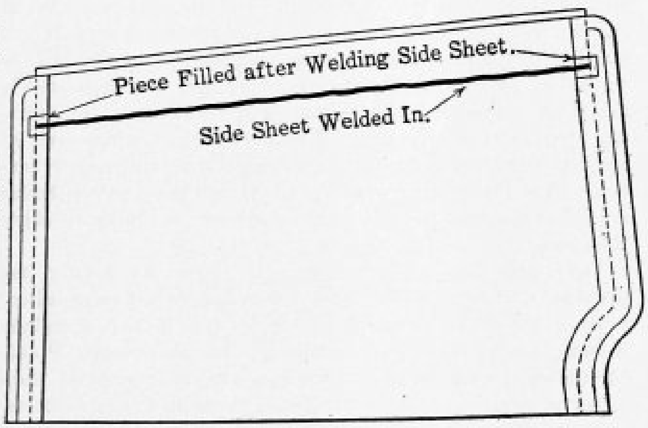
WELDING CAST STEEL FURNACE BEARER.

Comparing the cost of welding with the cost of renewing the above casting, the following figures show the saving:

Cost of New Casting:		
Material	$47.17	
Labor	11.91	
		$59.08
Cost of welding		1.71
Saved by welding		$57.37

WELDING SIDE SHEETS TO CROWN SHEET.

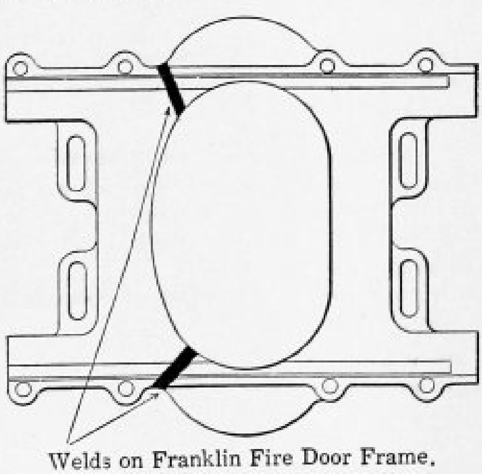
The edges of the sheets to be welded are first beveled at an angle of 45 degrees, then put in position and held on by means



WELDING SIDE SHEET TO CROWN SHEET.

of temporary bolts through the outside sheet in such a way that the sharp edge of the bevel joints form a "V" shaped groove on the inside of the fire-box.

A Fouché injector blow-pipe is used, starting at one end, the seam is heated to the fusing point, and No. 10 Swedish iron wire run in for fusion.



OXY-ACETYLENE REPAIRS TO FRANKLIN FIRE-DOOR.

This process is carried steadily forward until the end of the seam is reached. The metal, at frequent intervals, surrounding seam is heated to a cherry red and hammered. This relieves the strain due to uneven contraction of the metal.

On engine No. 5818 both side seams were welded in, the length of one side seam being 102 inches.

The following is an itemized cost of the above weld:

Labor—18 hrs. at 50½c. per hr. =	$9.09	
Material—380 ft. gas, carbide =	6.91	
		$16.00

After welding, no roundhouse repairs were necessary, such as calking, replacing rivets, etc., and it is considered that the welded joints soon pay for themselves in this way.

FRANKLIN FIRE-DOOR.

The material is cast iron and in welding cast iron a special cast alloy is used in conjunction with Feroflux.

The cost of welding is as follows:

9½ hrs. of labor at $.50½ per hr. =	$4.80
80 ft. gas, carbide and wire =	1.60
Total cost of welding	$6.40

The saving made in this case is as follows:

Cost of new casting	$12.00
Cost of welding	6.40
	$5.60

DEVELOPMENT OF IRREGULAR PIPE CONNECTIONS.

BY C. B. LINSTROM.

The constructions shown in Figs. 1 and 2 are representative problems of those commonly termed transition pieces. There is hardly a greater variety of shapes encountered in sheet metal construction than those found in irregular tapering forms of this kind. The development used for securing the required patterns is practically the same for all arrangements. It makes no difference whether the connection tapers from round to square, round to elliptical, etc., as any combination which is a modification of the above involves practically the same operations of development.

The method which affords the quickest and simplest solution is the triangulation process. The application of this form of construction to intricate problems generally involves only three distinct operations, however, in some cases four. If these steps in the development are thoroughly understood by the layer-out he has in his possession a valuable method which will stand him in good stead when he meets with some complicated problem.

CONSTRUCTION OF FIG. 1.

Fig. 1, acording to the side elevation, shows the object to be made up of a three-pieced elbow, which connects to a tapering form, the opening of which is rectangular at the base, as indicated on the drawing. Connections of this kind are usually used in hot air heating and in ventilation systems. In order to secure the pattern the construction of the plan and elevation will have to be accomplished first. It will be noted that the development of the elbow is not shown, outside of showing its front and side elevations. Therefore, the part under consideration is the transition connection.

The plan and elevations of same are drawn as shown. As the front elevation is foreshortened it requires a development in order to show it properly. This is readily done as follows:

First, draw the side elevation to the required dimensions. Locate the elbow in its relative position, and divide it into the desired number of sections. In cases of this kind where the

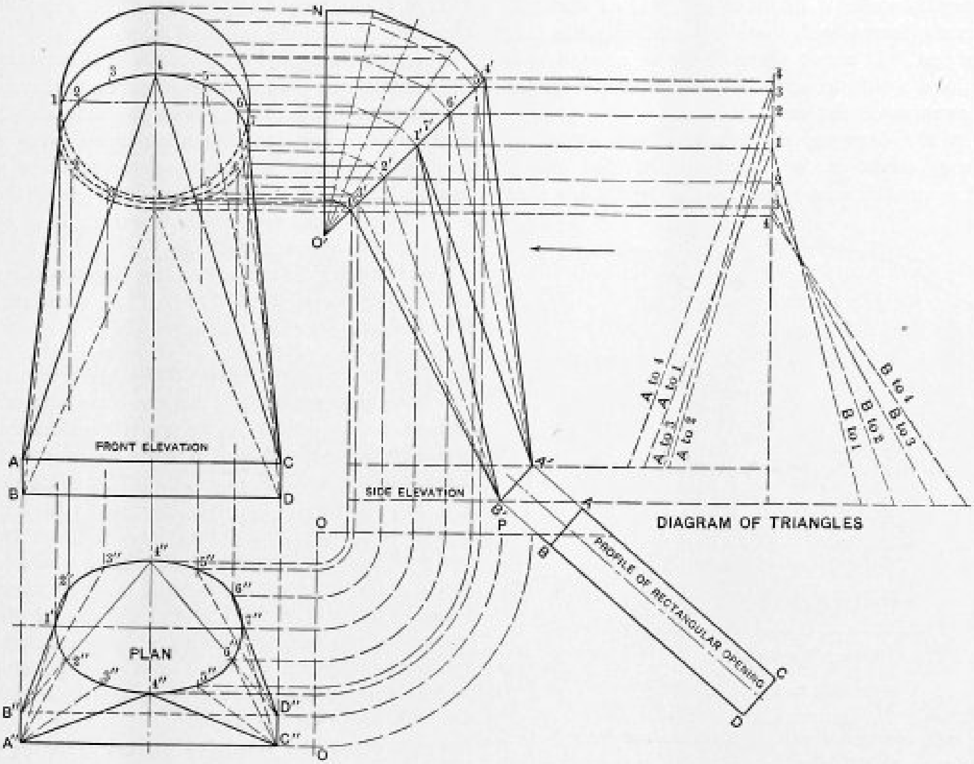

FRONT ELEVATION
SIDE ELEVATION
PLAN
DIAGRAM OF TRIANGLES
PROFILE OF RECTANGULAR OPENING
A to 4
A to 1
A to 3
A to 2
B to 4
B to 3
B to 2
B to 1

FIG. 1.

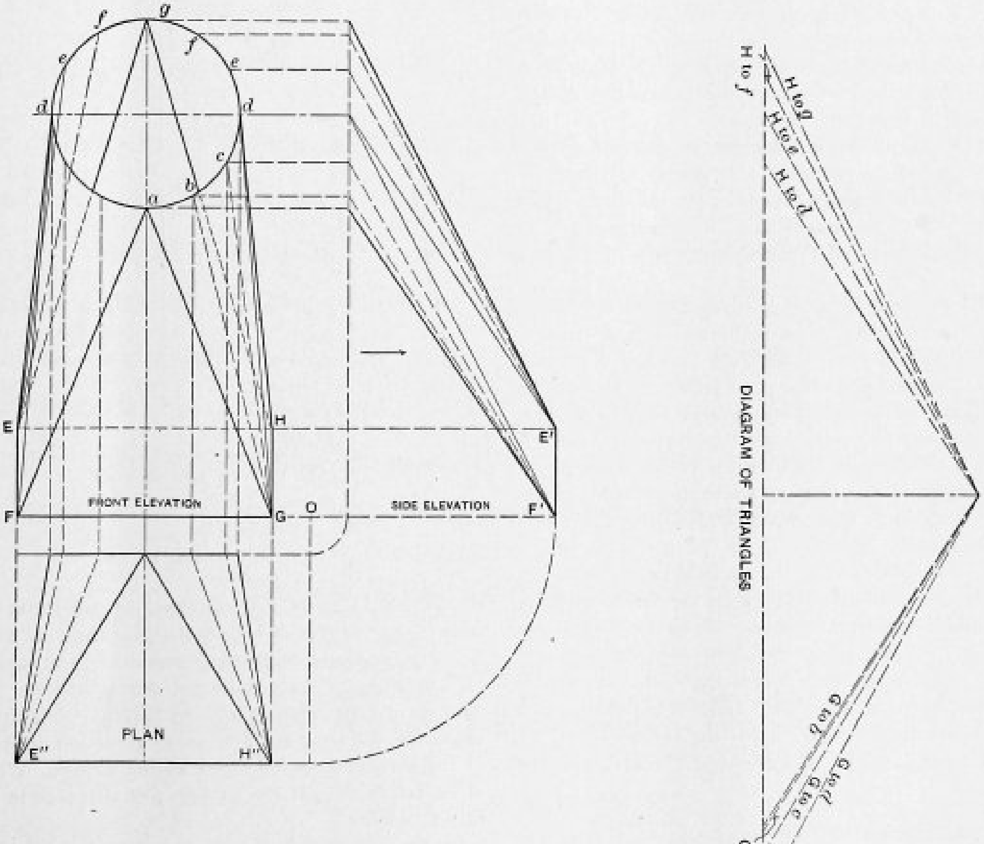

FRONT ELEVATION
SIDE ELEVATION
PLAN
DIAGRAM OF TRIANGLES
H to g
H to e
H to d
H to f
G to a
G to b
G to c

FIG. 2.

elbow is short and where the throat of the elbow is small, it is the best practice to make it in three sections, as this will give a uniform curve throughout, thereby facilitating the free passage of air or gas. If a two-piece elbow were used it is evident that the joint would be an offset, which would hinder to a degree the currents of air, etc.

Proceeding with the drawing, the profile of the elbow, as shown in the front elevation, is drawn and divided into a number of equal spaces. These points on the profile are then

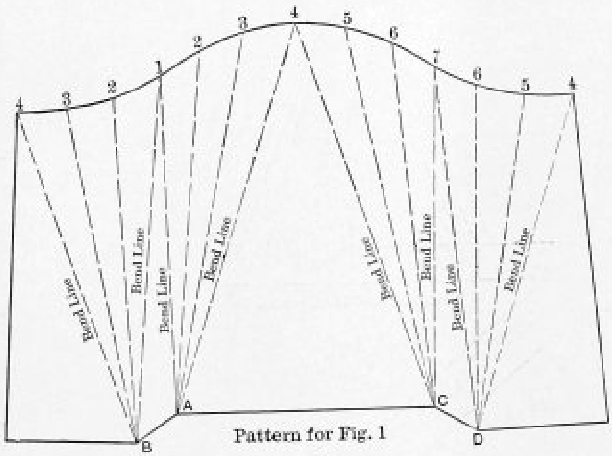


FIG. 3.

projected to the side elevation and located on the line N O'. With O' as a center, draw arcs through the points on line N O' to the miter line between the elbow and transition piece. Connect A' and B' of the rectangle with points 1', 2', 3'. 4', etc. A flat surface, triangular in shape, will be on four sides of the object. The side elevation shows the shape on one side, and its corresponding opposite side is the same as the side shown. The front elevation shows the shape of the other two. They are indicated on the drawing by the heavy and dotted lines A to 4, 4 to C, B to 4 and 4 to D.

A front view of the object will appear as outlined in the front elevation. The elbow sections will appear elliptical on account of their inclination away from the line of sight. The ellipses are obtained in the usual way by projection. The arrow indicates the position of the eye in viewing the object from the front.

In order to find the true lengths of lines for laying off the pattern it is essential to determine the horizontal projection of the construction lines shown in the side or front elevation. As the horizontal projection of a point, line or surface is shown in the plan this view, therefore, will be developed next.

To the right of the plan view, draw the vertical and horizontal base lines a convenient distance below the side elevation, and to the right of the plan so as to clear both views. Drop the points 1', 2', 3', 4', 5', 6', 7', A' and B' from this side elevation to the horizontal base line O P. With O as a center, swing the points from line O P to the vertical base line O O; they are then extended through the plan an indefinite distance. Corresponding points are then dropped from the front elevation to the plan. At the point of intersection between the vertical and horizontal projectors, draw the elliptical section and the rectangular opening A'' B'', B'' D'', D'' C'' and C'' A''. Construction lines are then drawn connecting the points A'' to 1", 2", 3", 4"; C'' to 4", 5", 6", 7"; D'' to 4", 5", 6", 7". and B'' to 1", 2", 3", 4".

CONSTRUCTION OF THE TRIANGLE.

As pointed out previously the required lines for laying off the pattern are found by finding the true lengths of the radial lines shown in the elevations and plan. The triangles are right-angle, the bases of which are secured from the plan and the corresponding heights from the elevation. The hypothenuses will be the required lines.

Through the points A' B' of the side elevation draw the two horizontal lines. Upon them erect the perpendicular as shown. The heights are projected from the side elevation to the perpendicular. The corresponding base lines are transferred from the plan and located upon the required side of the perpendicular. The sections on either side through the line 4"-4" of the plan are equal, therefore it is not necessary to draw all the given triangles.

The triangles on the left in the diagram correspond to those of the plan from A'' to 1", 2", 3", 4", those on the right from B'' to 1", 2", 3", 4".

DEVELOPMENT OF PATTERN.

Having now secured all the necessary data for laying out the pattern, a few general hints on its development will be given which should be sufficient to make its construction clear. Referring to the pattern, Fig. 1, it will be noted that it is made in one piece. In order to shape it properly to the best advantage it will be necessary to make it in at least two parts. This could be done by splitting it through the large triangular section 4 A C. This, of course, will result in having to make two seam lines, one at the top and bottom of the object. The spaces for the top, or where the piece connects to the elbow, are equal to those of the profile for the elbow. The base spaces from A to C, C to D, etc., are equal to those shown in the front and side elevations.

Assemblying the triangles in their relative positions is an easy operation, and a careful inspection of the drawings shows plainly how the lines are to be arranged. The patterns for

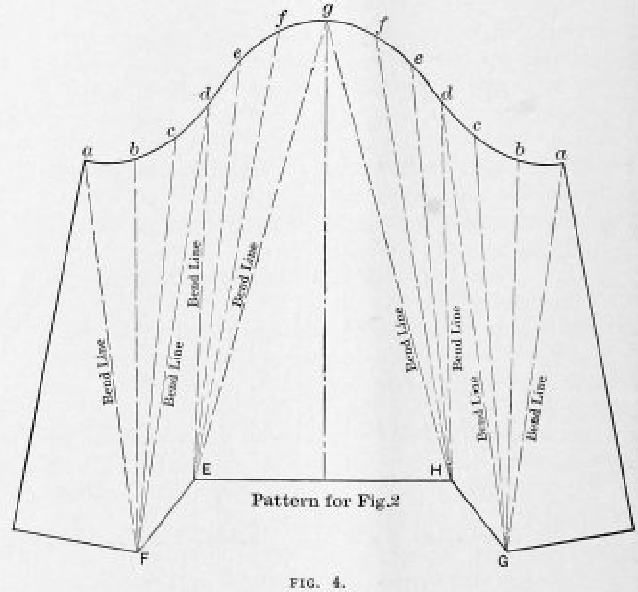
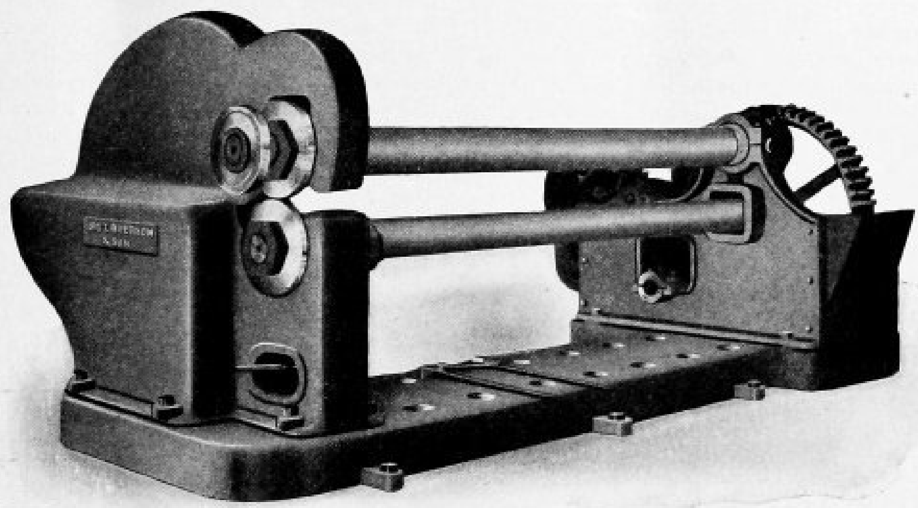


FIG. 4.

the elbow sections are obtained by projection. No lap is shown added; this is left to the discretion of the layerout.

Fig. 2, in many respects, is practically the same in construction as Fig. 1. The main difference between the two pieces is in their connection at top and bottom. The drawings clearly show the difference. The front elevation in Fig. 2 is taken in the direction as indicated by the arrow. What holds true in regard to the pattern of Fig. 1 is also true in the pattern of this problem.

In laying out any job it is essential to make the work as simple as possible and to make it accurate. Where the diagrams are simplified and the amount of work reduced there will be less chance for mistakes and losses.

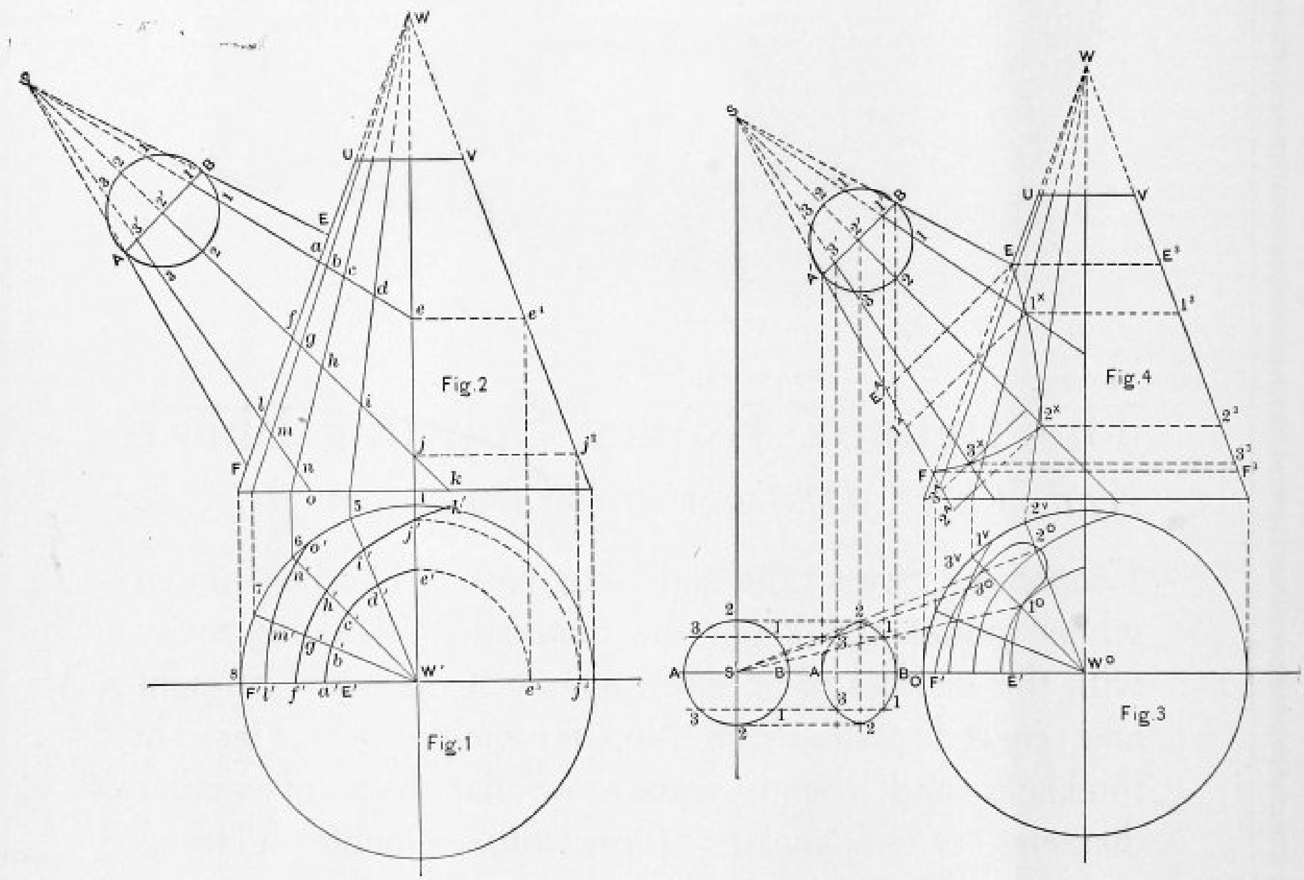


Layout for the Intersection of Two Right Cones.

BY W. E. O'CONNOR.

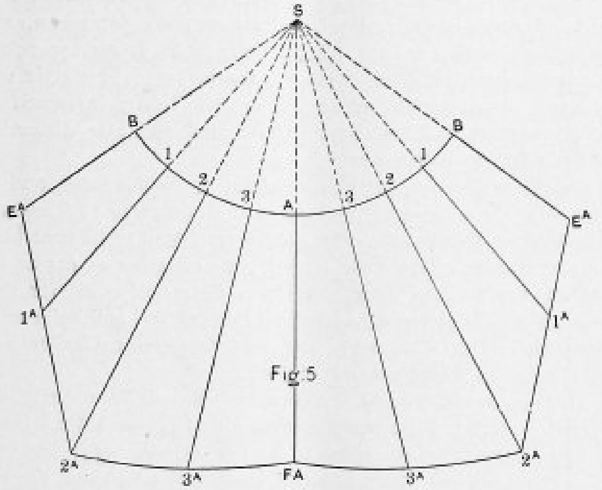
In order to convey to the reader this layout clearly, Fig. 3 and Fig. 4 have been drawn, although in practice Fig. 1 and Fig. 2 are all that is necessary, since points and lines having served their purpose may be erased. Also the division lines are elements of the small cone and are got by dividing the profile of the small cone as shown at *A, B*. However, in practice, to be more exact, these lines are best determined by drawing, adjacent to the base, a half plan and then proceed in the usual way. Hence the clearness of Fig. 2.

Commence by drawing the plan for the large cone in Fig. 1. Then draw the side elevation for the large and small cones in Fig. 2 on line *A, B*. In the top plan of the small cone draw the profile and divide this circle into eight equal divisions, as shown, *B*-1-2-3 and *A*. Project these points to the center line *A, B*, locating points 1', 2' and 3'. Now from point *S*, the apex, draw the division lines through the points 1', 2' and 3', and extend them until they meet the center line of the large cone at *e*, and the base line at *k* and *o*. Next divide one-fourth of the circumference of the plan, Fig. 1, into four equal spaces, as shown from 4 to 8. From these points draw division lines to the center *W*. Also project these points to the base of the large cone, Fig. 2, and draw division lines to the apex *W*, intersecting the division lines from the small cone as shown by the letters *b, c* and *d;* also *g, h, i* and *m, n*. Next project points *e* and *j* from the center line, Fig. 2, to the side, locating points e^2, j^2, and from these points drop perpendicular lines to the plan, Fig. 1, as shown by the points e^2, j^2. Now, with a radius equal to *W'*, e^2, and using point *W'* as a center, cut the line *W'*, 4 at *e'*. In the same manner locate point *j'*. The next step is to locate points on the division lines in plan, Fig. 1, to represent the horizontal cutting plans in elevation. To do this, drop perpendicular lines from points *a, b, c* and *d*, Fig. 2, to similar letters in the plan, Fig. 1, as shown, *a, b, c, d* and *e*. A curved line drawn through these points represents one-half the horizontal plan on line *a, e* in Fig. 2. In the same manner irregular curves *f* and *l* may be obtained. Since the lines *B-E* and *A-F* on the smaller cone intersect the large cone at points *E* and *F*, it is necessary to locate their true points of intersection. These points are shown in plan, Fig. 1, at points *E'* and *F'*, respectively, and no horizontal sections are needed on these two plans. The next move is to obtain the intersections where the division lines of the small cone will intersect these irregular curves in plan, Fig. 1. To do this with clearness, Fig. 3 and Fig. 4 have been drawn, which is an exact reproduction of Fig. 1 and Fig. 2, omitting all unnecessary letters and figures, as shown in Fig. 3 and Fig. 4.



INTERSECTING CONES FOR LAYING OUT PROBLEM.

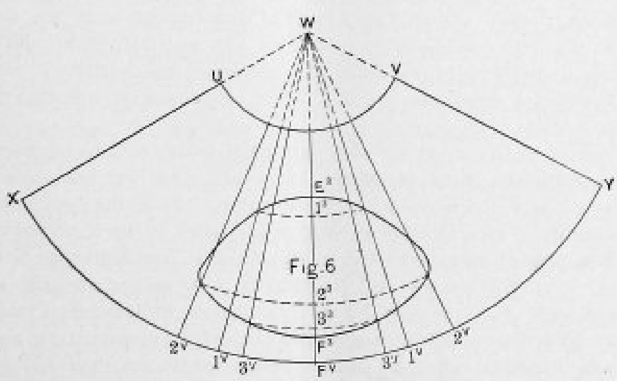
The plan view of the small cone, Fig. 3, is obtained by the intersections of the projectors from the side elevation, Fig. 4, with similar projectors in the plan view, Fig. 3, as shown *A*-3-2-1 and *B*. Now from points *S*, the apex in the plan view, draw the division lines through the points 3-2 and 1, and extend them, cutting irregular curves at points 3°, 2° and 1°. Trace a curve through the points *F'*, 3°, 2°, 1° and *B'* will represent one-half the intersection between the two bodies as they would appear viewed from above. Now project the points 3°, 2° and 1°, Fig. 3, to the side elevation, Fig. 4, cutting division lines at points 3^x, 2^x and 1^x. A curved line drawn through the points *E*, 1^x, 2^x, 3^x and *F* will represent the line of intersection between the two bodies viewed from the side. The next step is to project the points 1^x, 2^x and 3^x at right angles to the axis of the smaller cone to the side, as shown by points 1^A, 3^A and 2^A. To lay out the pattern for the small cone, as shown at Fig. 5, with the radius equal in length to *S, A,* Fig. 4, and using point *S*, Fig. 5, as a center, draw an arc *B-B* and equal in length to the circumference on *A, B,* Fig. 4. Divide the arc into the same number of spaces as the profile, Fig. 4, in which eight are used as shown, *B*, 1, 2, 3, *A*, 3, 2, 1 and *B*. Through these points draw the radial lines indefinitely and number them as shown, *B*, 1, 2, 3, *A*, 3, 2, 1 and *B*. Then using *S, E,* Fig. 4, as a radius and point *S* of the pattern as a center, cut the radial lines *S, B* at *E, A* and *E, A*. Continue this way, using *S*, 1^A, *S, F, S*, 3^A and *S*, 2^A, Fig. 4,



PATTERN FOR SMALL CONE.

as radii until the several points in the pattern are located. Then by joining these points as shown you complete the pattern for the small cone.

To develop the pattern for the large cone, including the opening, proceed as follows: First draw the outline of the large cone *U, V* and *X, Y*, and erect the center line *W*, F^V, as shown in Fig. 6. Then from the intersections *E*, 1^X, 2^X, 3^X and *F*, Fig. 4, draw lines at right angles to the axis, cutting the side of the cone at points E^3, 1^3, 2^3, 3^3 and F^3. Then, in the plan view, Fig. 3, with the straight edge resting on points *W'* and 2°, cut the base line at 2^V. Do the same with points 1° and 3°, locating points 1^V and 3^V. Then, with a thin strip or



PATTERN FOR LARGE CONE.

batten, lift the spaces in plan view *O* 3^V, *O* 1^V and *O* 2^V, and transfer to the pattern on both sides of the center line *W*, F^V, as shown, F^V, 3^V, 1^V and 2^V, etc. Through these points draw radial lines to the apex *W*. Now, with the radius equal to the distance from apex *W*, Fig. 4, to the points E^3, 1^3, 2^3, 3^3 and F^3, and using point *W*, Fig. 6, as a center, draw the several arcs intersecting the radial lines with similar numbers by joining the points so found with an irregular curve, completing the opening in the large cone.

STAYING CROWN SHEETS.

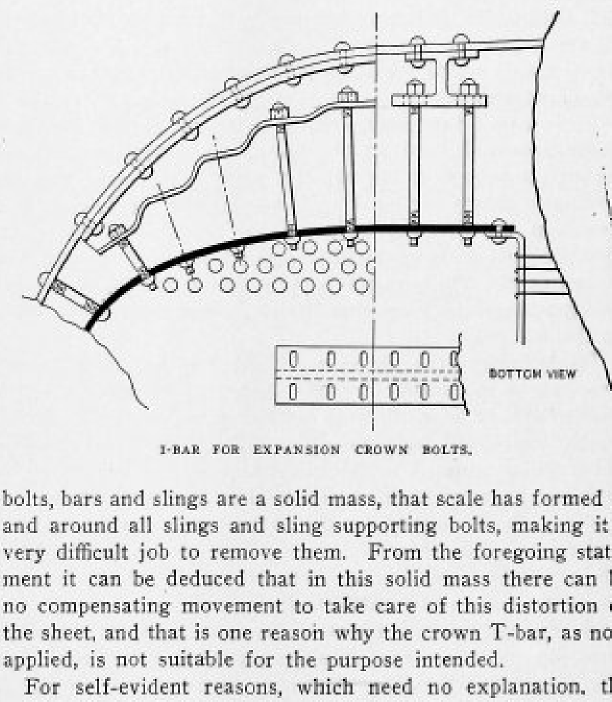
BY N. H. AHSIUOHL.

The cause of defects arising in top flue sheet flanges, and also the distortion of crown sheets under the ends of crown T-bars in radial stayed boilers, has been the subject of much discussion and diversity of opinion in the last few years. Many have been the remedies suggested to overcome these defects, but, as the matter stands to-day, we are still patching top flue sheet flanges and removing flue sheets solely on account of defective top flanges.

In this article the writer will endeavor to show the cause of these defects, and also suggest a form of expansion crown bolt which will positively eliminate cracked flanges and distortion of crown sheets at, and under, the ends of crown T-bars, as now almost universally applied to radial stayed boilers.

We know that the top flange of the flue sheet moves in a vertical direction, and carries a portion of the crown sheet with it; therefore, to properly stay this part of the crown sheet there must be a design of bolt which will adjust itself to this movement.

It is a fact, well known by all boiler makers who have ever removed crown T-bars and slings from crown sheets, that the



T-BAR FOR EXPANSION CROWN BOLTS.

bolts, bars and slings are a solid mass, that scale has formed in and around all slings and sling supporting bolts, making it a very difficult job to remove them. From the foregoing statement it can be deduced that in this solid mass there can be no compensating movement to take care of this distortion of the sheet, and that is one reason why the crown T-bar, as now applied, is not suitable for the purpose intended.

For self-evident reasons, which need no explanation, the highest point in the radius of top flue sheet flange, which would be along the vertical center line, is where the first and most of the travel or distortion of the sheet takes place.

By rigidly fastening a crown T-bar to and at all points in its length, equidistant from crown sheet, we secure the sheet, so that, theoretically, no vertical movement of sheet can take place in the center of same, unless a corresponding movement takes place along under the entire distance of the crown T-bar.

When a new firebox is applied the crown sheet bolts are tapped at a right-angle with the crown sheet. Now, when the flue sheet distortion begins the crown sheet is carried up at an angle of from 5 to 15 degrees with the horizontal. The crown bolts in the row next to the flue sheet flange naturally will move accordingly; that is, move back from the vertical from 5 to 15 degrees. The result is then evident: the top of the bolts move back as far as the holes in crown T-bar will allow; then, as the sheet moves further, the strain is increased, which moves the front web of the T-bar up, throwing the top of the vertical web of T-bar back. This stress upon the T-bar in the center of the radius of same would naturally cause an opposite stress in the ends of the bar, causing a twist, so to speak, this twist resulting in throwing the ends of T-bar down.

The foregoing assertion of the movement and this twisting of T-bars can be verified any time by taking a short straight-edge and placing against vertical web of T-bar in a boiler with a bad top flue sheet flange and noting the deflection of same towards the back of boiler.

Another, and more than likely the real, reason for crown sheets coming down at, and under, the ends of T-bars, is the fact that the T-bar is an independent factor, hung in the boiler, the expansion and contraction in length of which is not controlled by and has no connection with the relative expansion and contraction of the casing and firebox sheets.

The casing and firebox sheets being rigidly stayed do not relatively change position due to expansion of the boiler. The T-bar does not change, vertically, position relative to the firebox and casing sheets; horizontally, not being stayed in any manner to prevent, it does expand and gets longer.

The T-bar, being bent to a radius, this expansion will follow the line of curvature, and the resultant lengthening of the bar will bring the ends closer to crown sheet.

With each repeated firing of the boiler the bar lengthens out, until at last it having traveled until hard against the side of the top of the end bolts, it then starts to push bolts and sheet down, causing end bolts to loosen in the thread in crown sheet, and also causes a bulge in crown sheet.

In proof of this statement, we will find that in fitting a T-bar removed from an old firebox to a new firebox, the exact counterpart of the old one when it was new, that the end holes do not line up at right angles with the holes in firebox, and also that the radius of bar has changed in so far that the ends must be raised to make T-bar parallel with new crown sheet. This situation clearly shows that the T-bar has become longer and also that the ends have come down while in the old box.

Having shown that the crown T-bar does not allow enough freedom of movement of crown sheet, it is evident that the defects arising in the heel of top flue sheet flanges are caused by the stresses to the metal, resulting from the upward movement being confined to the space between the center of the first row of crown bolts and the heel of flue sheet flange.

When these stresses are distributed over a wider area of the crown sheet, then this deterioration of the metal in flue sheet flanges is not evident, there being no cracks out from flue holes and no horizontal cracks in flanges.

By this statement it is not meant that the crown sheet will have to stretch or bend to a much greater extent than with the T-bars, as while these stresses are great they are not great enough to overcome the ductile strength of the metal.

The addition of a second crown T-bar to stay the crown sheet is entirely superfluous, as it does not take a very great stretch of imagination to note that there can be no movement of crown sheet that far back from flue sheet unless the sheet stretches at the side roll.

The designing of supporting slings with oblong holes will in itself condemn the crown T-bars as unfit for the purpose intended, as these holes are made oblong under the misapprehension that the bar travels upward when the boiler is fired, and flue sheet is at its greatest point of expansion. Now this is the time when all bracing of the boiler, no matter of what character, should be taut, and what is the use of applying a style of bracing to a boiler sheet which will not be taut when the steam pressure is on the sheet?

The writer was, for a period of nine years, employed in various capacities in the boiler shops of a large Eastern railroad system having upwards of 200 radial boilers. Never in his experience on this road had he heard of or seen any defects in any of the top flanges of these flue sheets or crown sheets; he never applied a patch nor put in a new sunflower plug, nor removed a flue sheet due to these defects.

The flanges of flue sheets in these boilers were far more distorted in shape than any he has seen in the last few years since coming West; yet they never cracked out, nor did the metal deteriorate in any manner. These flanges were turned to a ¾-inch inside radius, and flue holes were so close to heel of flange that it was a very difficult job to roll and bead same after distortion had taken place.

The reason these flue sheets did not crack was because of the difference in the method of bracing; there being two rows of crown bolts next the flange, these bolts going through a series of crowfeet hung from the wagon top. This style was a great improvement upon the crown T-bar, inasmuch as every bolt carried its share of the load and also distortion independently of the others.

In the center the bolts were about 20 inches long, and as this was where the greatest backward strain came as flue sheet traveled up, this is where the bolts were found to be bent back in the middle. This style of bolt was effective as far as reducing the cracked flanges, but was defective in so far that when after distortion of flange had taken place, and bolts were bent back, then they were not in tension when boiler was fired and full steam pressure was on.

Internal inspection of Belpaire boilers will bear out these theories as to the backward movement of crown bolts. Upon making inspection of Belpaire boilers in which the top flue sheet flange has become distorted, it will be noted that the top end of the crown bolt in roof sheet is hard back against the sleeve, and in aggravated cases the bolts in the center of the first row have been bent back in the middle as much as ⅜ inch.

This backward movement produces an unequal longitudinal strain upon the roof sheet and causes expansion sleeve holes to crack out across the sheet, and also causes connection seams at neck sheet to crack through rivet holes.

Now, as a result of the foregoing statements, we have a theory which shows that the flue sheet moves in a vertical direction. The crown sheet, being at right angles to flue sheet, will move up in a backward curve line, and the end of any bolt tapped at right angle to crown sheet must, of course, move at a right angle to that curve; that is, backward and downward. It will now be evident that in providing a style of bracing that allows for a vertical movement only we are wrong; we must provide a style of bolt and hanger in which the upper end of the bolt will move in this backward and downward direction, and still be in tension when pressure is on boiler.

Attached is a sketch of a cast steel I-bar, cast to conform with inside radius of wagon top sheet. This bar has oblong holes opposite holes in crown sheet, to allow the backward movement of crown bolts. The inside faces of the bottom web are inclined downward toward the back of the boiler, so that as bolts move back and downward they will always be in tension. This form of I-bar, if placed in radial boilers, will eliminate all cracked flanges and distorted crown sheets, and when cast to suit roof sheet of Belpaire boilers, and applied therein, will eliminate all cracks from expansion holes (which will then not be necessary), and also will remove the unequal longitudinal stresses now carried by neck sheet at connection seams, thereby removing the only remaining argument that can be used against Belpaire boilers in general.

Although the heating surface of the firebox of a large locomotive boiler may not be over 10 percent of the total heating surface, yet it is frequently assumed that 40 percent of the steam generated is generated around the firebox.

NOTES ON A BOILER EXPLOSION.*

BY C. J. MAGGS.

In dealing with the above subject it is not my intention to go scientifically into the subject or to propound any new theory, but it struck me that the plain facts recorded may be of some use to to those in charge of steam boilers.

DESCRIPTION OF BOILER.

The boiler was in use on a launch, 60 feet long, 10 feet beam, single-cylinder, high-pressure engine, the boiler single-ended marine return tube, 6 feet in length over front and back plates, 3 feet 8 inches external diameter, single plain furnace tube, 4 feet 9 inches over all in length and 22 inches internal diameter, with return tubes 2 inches external diameter and 4 feet long. The boiler was formed by a single steel plate 5/16 inch thick, and jointed by one longitudinal double-riveted lap seam, rivets ⅝ inch diameter, 2¼ pitch placed zigzag. The front and back plates were braced by two stays 1⅞ inches diameter, the combustion chamber was secured to the shell in the ordinary way by screwed stays. The working pressure was 100 pounds per square inch, and the fuel used was wood.

On examining the boiler I found the interior in first-class condition, no corrosion worth mentioning was to be seen, so it was evident that the explosion was not due to wasting of the plate.

The shell plate was rent from front to back, and likewise in the two circumferential joints, throwing back the shell plate outwards and downwards, at the same time forcing the boiler off its seat and turning it about a quarter around.

From examining the edge of the plate I concluded that the direct cause of this explosion was a fracture in the shell plate along the longitudinal lap seam, because the edge of the plate showed two distinct forms of fracture, the inner part clean cut and the outer ragged, which pointed at once to grooving or nicking. The plate was not wasted, the full thickness measuring up to the fractured edge, caused no doubt by the indirect straining that exists at lap joints, owing to the tendency of the internal pressure to make the boiler assume a perfectly cylindrical form and the variations of pressure to cause the groove or crack to develop more or less rapidly.

The detection of a defect of this kind would be extremely difficult, as the size of this boiler was too small to allow any visual examination to be made. In this particular case there is a probability that in the first instance the calking tool hastened the grooving by nicking the plate.

In the middle of the longitudinal fracture the groove had penetrated through the plate save 1/16 inch, gradually narrowing towards both ends, the middle of the rupture being bulged outwards.

Taking the longitudinal seam as a girder supported at each end with a load evenly distributed, naturally any movement caused by internal pressure would be greatest at the center, which would account for the ruptured edge being bulged and likewise causing it to be the first point to give way. Once that part of the shell plate had been separated, it is easy to conceive how the initial fracture was continued through the other parts of the shell by a pressure that would be insufficient to start the rent. The expansion of a volume of steam at a high pressure from a large body of water at a high temperature would force the plate forward with great force, flattening out the shell plate, causing the rupture to pass through front and back plates, shearing plate, rivets and rivet holes according to the position of the line of least resistance.

There is much contention as to the value of the hammer test and the hydraulic test, the majority leaning towards the hydraulic. I should be pleased to hear the opinion of readers on this. I contend it is quite possible to pass a fracture of this sort, relying on the sound given out by a blow of the hammer; if the crack is not quite through it will scarcely affect the sound given out.

I have about thirty land and marine boilers under my care, and in the workshops, which we claim to be the largest in this part of the world, we undertake repairs to boilers, machinery, etc. It happened that two boilers of a well-known watertube make belonging to an outside company were placed in our hands for repairs. Grooving was suspected in the upper or steam drum; this was discovered by the engineer in charge, when attending to some valve at the top, having felt a leak of steam blowing against his leg. The boiler was shut off, orders were placed with us to calk the leak, the hydraulic pump was applied to locate the spot. When full pressure was applied not a sign of leak showed itself; the engineer in charge then struck the plate with his hammer. Immediately a thin sheet of water escaped through the plate at the edge of the lap joint and disclosed the groove or crack; this sounds very peculiar, but it is true. This was repaired by a double butt strap after cutting away the fractured lap edge.

In the case of the second boiler (they were side by side) the same defect was found and treated in a similar manner; both boilers are working at the present day.

In consequence of these occurrences I submit that individually the hammer or the hydraulic is not a reliable test, but should be applied together, rapping the plate with a hammer at intervals as the pressure is increased. This applies more to small boilers where the dimensions are not sufficiently large for a man to get inside to inspect them.

This explosion referred to was the third of a series which took place in this colony within a short period, the first being a vertical boiler used in a rice mill, the second a locomotive boiler. The age of the boiler was eleven years.

*Abstract of a paper read before the Institute of Marine Engineers.

Bolt Circle Problem.

BY E. N. PERCY.

Given number and pitch of bolts what is diameter of circle?

$$D = \frac{P}{\text{Sin}\ \frac{180^\circ}{N}}$$

$D =$ diameter.
$P =$ pitch.
$N =$ number of bolts.

Given diameter and number of bolts to find pitch, meaning straight line distance between bolts?

$$P = \frac{R\ \text{Sin}\ A}{\text{Sin}\ C}$$

$P =$ pitch.
$R =$ radius.

$$A = \text{angle at center} = \frac{360^\circ}{N}$$

$$C = \text{angle with chord} = \frac{180 - A}{2}$$

A Question for Readers to Answer in the Next Issue.

What are the causes for the buckling or bulging of back flue sheets in locomotive boilers? The boilers I have reference to are using the very best clear boiler water, but still some of the sheets are bulged in spots. Could these sheets be straightened by heating and pounding back to place while the flue sheet was in place? What effect would the straightening have on the flue holes? FLUE SHEET.

The Boiler Maker

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In our August issue we showed an arrangement for drilling out stay-bolts, to take the place of the usual drilling knee, or "old man." The saving which can be gained by its use is great, but it is astonishing to find that men in charge of boiler shops are so often short sighted, and do not allow their foremen to provide such handy contrivances, thus largely nullifying the value of electric or air-driven tools. A workman has a right to feel annoyed if he is expected to get out his work rapidly and in good shape with apparatus which is not in good working condition or without necessary rigs.

Every man who reads this, who has ever had a practical shop experience, can remember how, time and time again, he has had his entire backing fall apart because the thread on the holding bolt had been so bruised that he could not run a nut up on it with his fingers, or that the nut went entirely too tight and the bolt turned and he could not reach the head to hold it. Such little annoyances are not confined to the man himself and to the unlucky apprentice who happens to be helping, but the irritation is very apt to run through the entire shop. And who has not seen all hands upset and "grouchy" because the force pump would let go every once in a while in a hydraulic test when the pressure was almost up to the required point, or just when a hurried repair is wanted the tap is found to be broken or worn out and a special bolt has to be made to make a tight job? To-day portable boiler makers' tools are on the market which are admirably designed. They not only cut down the time of the work but they improve it. The fundamental idea is to be able at a moment's notice to put these tools in use and not to have half the shop looking around for some lost, mislaid or worthless appliance. We know that many boiler-making establishments can, with very great advantage to themselves, overhaul their present assortment of junk in the shape of old and worn taps, and wrenches which do not fit anything—"old men" that are bruised and banged so that their use is almost impossible, screw jacks that are dangerous, differential pulley blocks whose chains are stretched and whose sheaves are worn to a knife edge. A well-equipped shop is talked about by the men and the men like to work in it, and the fact of being well equipped is passed on, and a good reputation draws customers. Keep your tools and appliances in working order and your product will go up. Give your workmen a chance to get out your work at the smallest cost by having what they need ready at hand and do not let them do apprentice boys' work, hunting about the shop when they should be working at their trade.

On the other hand, there is very just cause for complaint on the part of proprietors and foreman in the treatment which appliances and tools far too often receive at the hands of the men. A foreman commonly complains that there is no use in providing anything for the boiler maker that needs the slightest care. It is almost impossible to have them return tools or rigs with all their parts and in proper shape. Of course, tools do get broken, and no foreman can expect that this will not take place to a certain extent; but he has a right to complain when a tool is injured that the man who injured it does not report it and it is handed into the tool room in a condition which makes it useless for the next man to use. This is a common state of affairs, and boiler makers in general are very apt to misuse tools, which, of course, results in a disposition on the part of those in charge to care little about providing good tools. It is true that there is an amount of physical effort which has to be performed on the part of the boiler maker and that his arms tire, consequently he often throws a tool from the top of a boiler or from a platform onto the floor or into a box of bolts and nuts without thinking of the injury that is likely to be done; and this carelessness has become really a habit in boiler shops.

The thing to be done is for the men, foremen and proprietors to work together to keep the tools in the shop up to a high standard of efficiency. The foreman's supervision should not lag and the proprietor should be ready to supply him with the means to keep the tools and appliances in proper condition, and, finally, the boiler makers should be taught not to misuse their tools and given the opportunity to apply their own ideas in special appliances for efficient work.

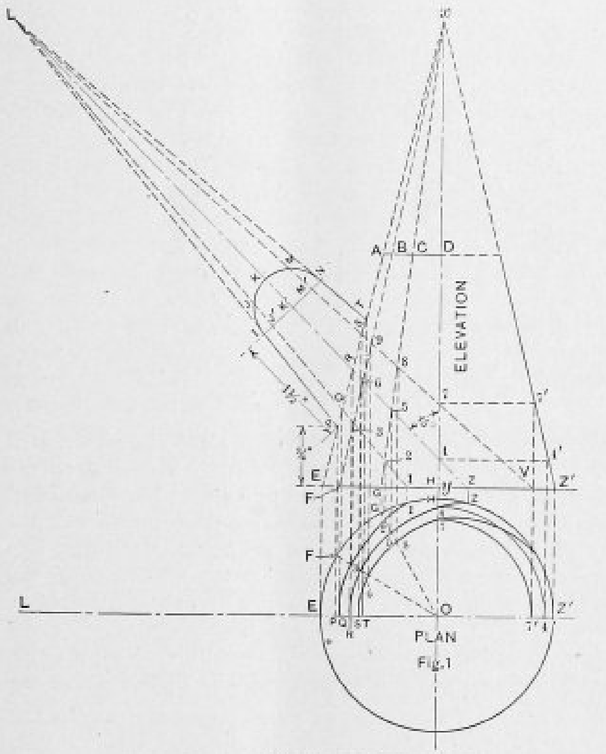
COMMUNICATIONS.

To Lay Out an Intersecting Cone.

EDITOR THE BOILER MAKER:

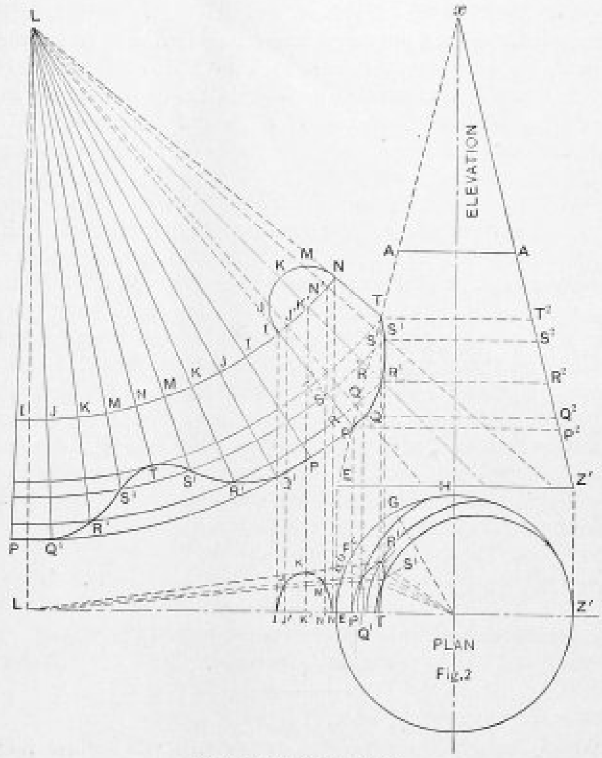
In the May issue of THE BOILER MAKER, on page 145, a correspondent wishes to know how to lay out an interesting cone. Here is one which I shall explain as best I can. I have drawn this problem 1 inch equal to a foot. I wish to call his attention to the dimensions given in the base of the intersecting cone, which is shown to be 18 inches. I would ask that he erase the line drawn at an angle of 45 degrees and then bisect the angle. He will then find that his center line is other than 45 degrees.

In Fig. 1 the intersection between two right cones is shown. The problem should be drawn making the base *E Z′* in plan



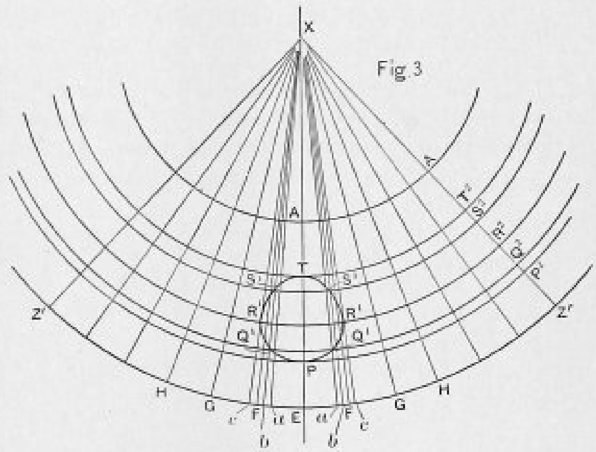
INTERSECTION BETWEEN TWO RIGHT CONES.

3 inches in diameter, and the height of cone in elevation *y D* 3 inches, the distance from *A* to *D* should be ¾ inch. Bisect the line *E A*, locating *R*, from which draw the axis of the smaller cone at an angle of 45 degrees to the axis of the larger cone, as *L Z*. From *E* to *P* measure ¾ inch, and from *P* to *I* measure 1½ inches, locating *K′*. At right angles to *L Z* draw *I N*. Now, using *K′* as center and *K′ I* equal ½ inch, draw arc *I K N*, which is a half plan of small cone. Now, using points *P* and *I* draw a line until it cuts the center line at the apex *L*. From apex *L* and point *N* draw a line until it cuts *E A* at *T* in the elevation, which gives the outline of the small cone. Now divide the arc *I K N* into four equal spaces, as *I J K M N*. From points *J* and *M* draw lines parallel to *K K′* and locate the points *J′* and *N′*. From the apex of the smaller cone draw lines, as *L J′* and *L N′*, extending them to the base of elevation, as 1 and *v*. We have now located *P Q R S T*, which are the imaginary intersecting lines of the smaller cone. Now divide *E H* in the plan into three equal spaces, as *E F G H*. From these points draw radial lines to *o* at the center of the plan. Now, starting again in the plan at points *E F G H* and project them to *E Z′* in the elevation, as *E F G H*. Now from the points *E F G H* in the elevation



PATTERN OF SMALL CONE.

draw the lines to the apex *X*, cutting *A B C D*. Project the points *P Q R S T* in the elevation to similar points in the plan corresponding to the letters *P Q R S T*. Do the same with the numbers 3, 6, 9 and 2, 5, 8 in the elevation, and make them coincide with the numbers 3, 6, 9 and 2, 5, 8 in the plan. From points 7 and 4 in the elevation draw horizontal lines, cutting *X Z′* at 7′ 4′, and projecting these points to 7′ 4′ in the plan.



PATTERN OF LARGE CONE.

Using *o* as a center and *o* 7′ and *o* 4′ as radii, draw the arcs 7′ 7 and 4′ 4 in the plan. We have now located a lot of points in the plan, as 7, 8, 9, *S* and 4, 5, 6, *R* and 1, 2, 3, *Q*. Through these points trace the curves 7, 8, 9, *s*, which is the half horizontal section of *v*, 7, 8, 9, *s* in the elevation. To avoid possible confusion of lines we will reproduce the outlines of the intersecting cone in Fig. 1 to that of Fig. 2. Projecting all points in the elevation of the small cone as *L I J′ K′ N′ N* to the plan, and transferring the height of *J J′* and *K K′* and *M N′* in the elevation to similar letters in the plan. Draw lines from the apex *L* in the plan through *J K M*, and extending them to Q^1 R^1 S^1 in the plan, we get the true points of intersection. Projecting the points *P* Q^1 R^1 S^1 *T* in plan to

$P\ Q^4\ R^4\ S^4\ T$ in the elevation, and tracing a line through these points, we get the true line of intersection between the large and small cone. Draw lines from $T\ S^4\ R^4\ Q^4\ P$ to $T^2\ S^2\ R^2\ Q^2$ and P^2 and parallel to $E\ Z'$ in the elevation. Draw lines from $T\ S^4\ R^4\ Q^4\ P$ to $T^3\ S^3\ R^3\ Q^3$ and P parallel to $I\ N$ in the elevation, Fig. 2, we obtain the true lengths of the small cone. We are now prepared to lay out the cones. Starting with the small cone we proceed as follows: From apex L as a center and the different radii as $L\ I$, $L\ T^3$, $L\ S^3$, etc., draw arcs the length of twice $I\ J\ K\ M\ N$ the circumference. Now, tracing a line through the points $P\ Q^4\ R^4\ S^4\ T$ completes the layout of the small cone. To lay out a large cone take x as a center and $X\ A$, $X\ T^2$, etc., as radii from the elevation, Fig. 2, and draw arcs, as in Fig. 3, from A to Z'. Now, starting at E of the plan, Fig. 2, and taking the stretch out of $E\ a\ b\ F\ C\ G\ H$ to Z', and place them upon Fig. 3 from E to Z', respectively. Drawing radial lines to the apex gives the layout of the cone. To find the opening in the cone take the points $P\ Q^4\ R^4\ S^4\ T$ of the elevation, Fig. 2, and place them at corresponding points in Fig. 3, which will complete the layout of both cones.

E. EATON.

West Hoboken, N. J.

Development of a Cone Intersected by a Cone Obliquely Inclined.

EDITOR THE BOILER MAKER:

Complying with the request of "California" for information concerning a method for finding the line of intersection between two cones, as appeared in March's issue of THE BOILER MAKER, the writer offers the following explanation and drawings on the subject which may prove of interest:

CONSTRUCTION—The three Figs. 1, 2 and 3 represent three distinct operations necessary in order to secure the correct patterns for the two cones. Referring to Fig. 1, this view will be considered first. The plan and elevation are drawn in their relative positions and according to the required dimensions. The small intersecting cone is to be considered as extended into the large cone, as indicated by the dotted portion in the elevation. With the center of the base line of the small cone as an apex, draw a semi-circle which represents one-half of the profile of the base of the small cone. Divide each quarter of the semi-circle into a number of equal spaces. For convenience in showing the construction as clear as possible, each quarter is divided into two equal parts. The points on the semi-circle are then projected to the base of the small cone. Radial lines are then drawn connecting these points with the apex A. Next divide one-half of the circle in the plan into twice as many spaces as contained in the semi-circle of the small cone, as indicated on the drawing from 1 to 9, inclusive. Connect points 1, 2, 3, 4, 5, etc., with the apex B'.

Now, in order to produce the correct line of intersection between the two cones it is first essential to find where the

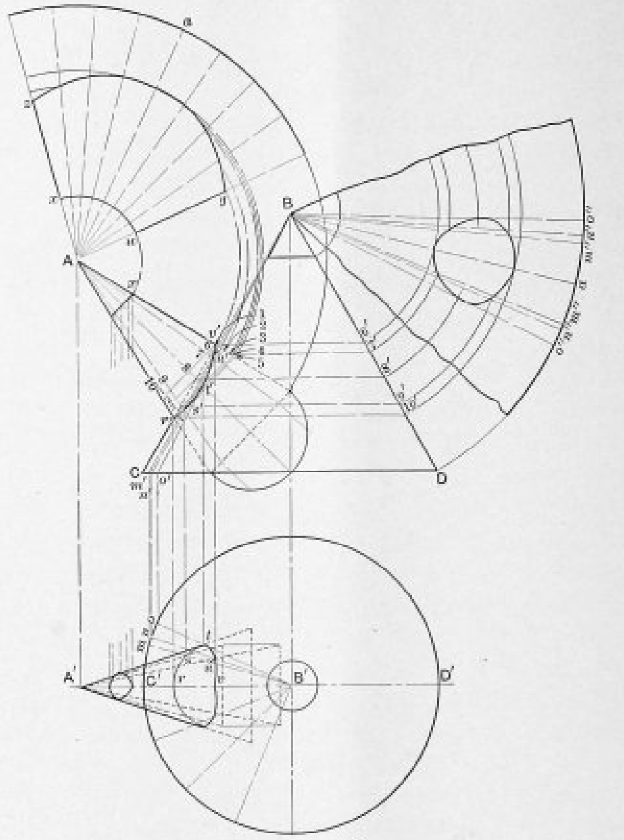
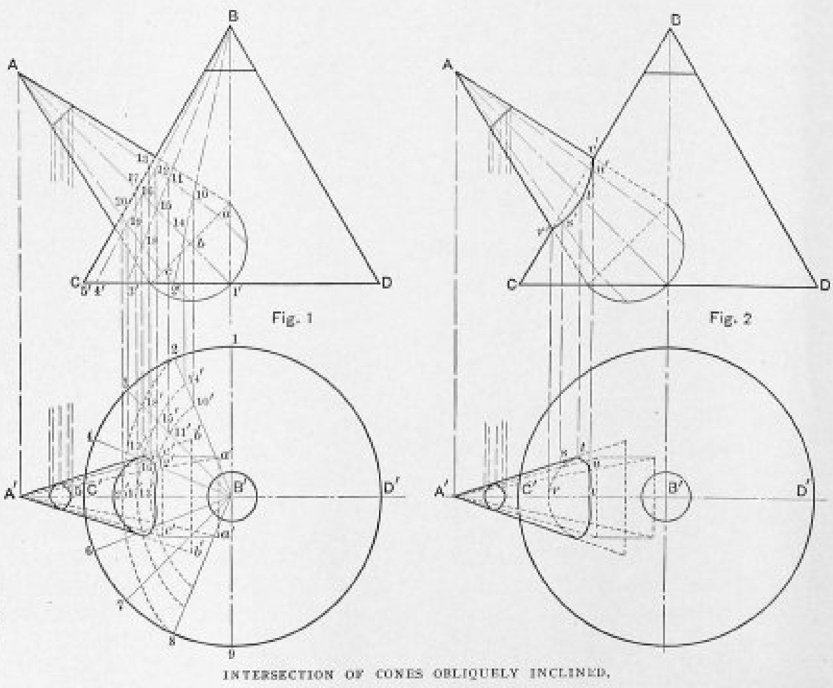


FIG. 3.—PATTERNS OF CONES.



INTERSECTION OF CONES OBLIQUELY INCLINED.

elements of the small cone intersect planes through the large cone; therefore, the planes which are intersected must be found first, and in the following manner:

The elements *B'*-2, *B'*-3, etc., are located in the elevation by projecting from the points 1, 2, 3, 4, 5, etc., to the base of the elevation, radial lines are then drawn through the points on the base connecting with apex *B*. These radial lines correspond to those shown in the plan. Referring to the elevation, the elements *Aa*, *Ab* and *Ac* and their corresponding opposite sides are to be considered as planes which are passed into the large cone. Where these planes cut the large cone, produce sections of an irregular shape. The plan view in this case shows how they appear when viewed from above. The outer elements of the small cone at top and bottom are in the same plane, and their true positions are shown in the elevation where they intersect the outer element *B C* of the large cone.

To secure the irregular sections, first reproduce sections of the small cone shown in the elevation. A section through *A a* of the elevation will appear in the plan as *A' a'*; section through *A b* will appear as at *A' b' b'*; section through *A c* as at *A' c' c'*. Where the elements of the small cone in elevation intersect the elements of the large cone at 10, 11, 12, 13, 14, 15, etc., determines the points from which the corresponding ones in the plan are to be located. This is accomplished by projecting points 10, 11, 12, etc., to the plan until they intersect their corresponding elements, as shown at 10', 11', 12', 13', 14', etc. Through 10', 11', 12', 13', 14', 15', 16', 17', etc., draw the irregular curves, as shown. Where the elements of the cone in the plan intersect the irregular curves, draw the outline of the hole. This view is foreshortened owing to the curvature of the cones' surface.

In order to avoid confusion, which is likely to occur with so many construction lines drawn on the views, it was considered advisable to draw extra views, as shown in Figs. 2 and 3.

It is not necessary to draw these extra views in laying out the object, as the layerout would have little trouble in working from the one plan and elevation. It will be noted in Fig. 2 that the plan is the same as in Fig. 1, with the exception that the irregular curves and radial lines are omitted. The plan and elevation are reproduced in Fig. 2 equivalent to Fig. 1, with the exception of the lines mentioned.

The points *r s t u* and *v* are projected to the elevation until they intersect the elements as shown at *r' s' t' u'* and *v'*. The irregular line drawn through these points gives the required line of intersection or miter line between the two cones.

DEVELOPMENT OF PATTERNS—Fig. 3 shows the proper method for laying off the required patterns of both the small and large cones. It also shows how the hole in the pattern of the large cone is developed. The plan and elevation of this figure are reproduced drawings of Fig. 2. To obtain the patterns proceed as follows:

Considering the small cone, its pattern will be developed first. With *A* as center, draw an arc of an indefinite length. The radius of the arc is equal to one of the outside elements of the cone. Locate any convenient line in the pattern, as *A-a*, and on either side lay off the same number of equal spaces as contained in the semi-circle. Then draw the radial lines to point *A*. At right angles to the axis of the small cone, draw the line 1-1, 2-2, 3-3, 4-4, etc., through the points *r' s' t' u'*. With *A* as a center, draw arcs from the points 1, 2, 3, 4, 5 through the pattern; where these arcs intersect the corresponding elements in the pattern determines the points through which the curve is to be drawn. With *A-x* as a radius, draw the arc for the top of the cone. The full lines *W X Y Z* is the outline for the complete pattern.

In order to connect the small cone to the larger one properly it will be necessary to cut out a hole to suit the shape of the base of the connecting small cone. The view to the right of the elevation shows the shape of the required opening, but in order to develop it it will require a little preliminary drawing. Its construction is as follows:

Through the points *S t u* of the plan, draw the radial lines until they intersect the base of the cone at *M N O*. At right angles to *C' D'* of the plan, and through the points *m n o*, locate the points *m' n' o'* in the elevation. Connect *m' n' o'* with the apex *B* with radial lines as shown. If the work has been accurately constructed the line *m' B*, line *n' B*, and the line *O' B* will pass through the points *S' t' u'*. The height of the hole in the pattern will equal the slant height 6' to 10' of the elevation, and its extreme width will equal twice the distance *C' O* of the plan. With *B* as a center, and with a radius equal to the element *B D*, describe the arc as shown. In this case the full pattern is not shown, as it was desired only to show the correct shape of the hole in its true position. Proceeding with the development, draw any line as *B a* as a center line, and on either side locate the points *M' N' O'*, which are equal to the arc distance between *C M*, *C' N* and *C' O*. Connect *M" N" O"* with the apex *B*. With *B* as a center draw arcs from 6', 7', 8', 9', 10', indefinite in length. Through the intersection of the arcs with the corresponding radial lines draw the outline of the hole, thus completing the layout.

C. B. LINSTROM.

Beveled Plates and Calking.

EDITOR THE BOILER MAKER:

In relation to beveled plates for calking I note your invitation to readers of THE BOILER MAKER to express opinions in the matter.

It seems to me that as to whether the edges of plates should be beveled for calking will depend in a measure upon the thickness of plate used, and also upon which the seam is considered—the longitudinal or the girth. With thin plates, say up to and including ½ inch, a better job will undoubtedly be made by beveling the edges of both longitudinal and girth seams. But for thick plates, those above ½ inch, there is really no reason to bevel the edges except for appearance and finish.

Considering the breathing action of a steam boiler under steam, the bevel-edge calked joint will be more flexible and respond to that breathing better than if the edges were not beveled.

In the girth seam there will not be so much need for bevel edges as far as the breathing action is concerned. I believe all these points are worthy of consideration in connection with the subject to be discussed, and I trust that you will have a goodly number of letters setting forth various opinions from which a summation may be made that will be of value to all interested.

CHARLES G. MASON,
Scranton, Pa.

EDITOR THE BOILER MAKER:

In answer to the question, Is beveling necessary? I would say: Yes, by all means, for with a beveled edge the calker has his work in sight at all times, which is not the case with a straight shear edge. Can you do a successful job of calking without beveling or chipping? I would say no, for nearly all square-edge sheared plates have a little overhang which must be chipped off before calking, so that the calking edge must be quite square; then with the ordinary flatter and splitting tools a careful man can do a good job. But in this method of calking there is always a tendency to work the sheets apart, especially so if you have a laminated plate to deal with, as the splitting tool acts like a wedge.

The cost of the work is in favor of the bevel sheared plate, for the rotary beveled shears, being a continuous cut, does three times the work of the straight shear with its 6 or 8-inch cut. Having had some years' experience calking straight-edge plates, I find there is nothing to be said in its favor, for this kind of calking does not stand in the fireboxes of any of our large locomotives, and all can be said in favor of the thin and beveled edge. G. H. HARRISON.

Pittsburg, Pa.

EDITOR THE BOILER MAKER:

Is beveling of sheets for calking necessary? At first thought one may be led to answer that question by another, Is calking necessary? But as the question is asked in good faith it should be answered fairly and impartially. The writer is speaking from the standpoint of nineteen years' experience in locomotive work, principally back shop work, and in that length of time, with all classes of engines under various conditions of service, one can form a fair idea of what is necessary to good work.

We will take up the case of back flue sheet and door sheet flanges. Until a very short time ago it was the custom to leave these flanges full thickness to the edge of the flange. The result was that on account of so much material being exposed to the fire the material became crystalized, cracks developed from the edge of the sheet to the line of rivet holes. The result was leaky seams, which gave no end of trouble, and were a constant source of expense. To overcome this

Fig. 1

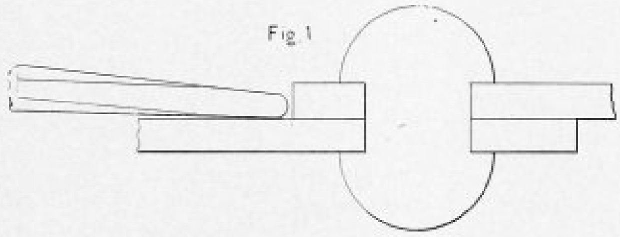
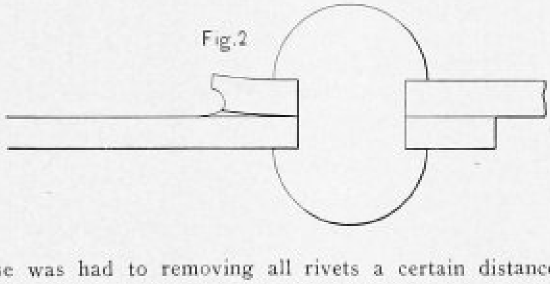


Fig. 2



recourse was had to removing all rivets a certain distance above the grates; the flange was then chipped to a tapered surface from the edge of the sheet to back of the rivet holes. The holes were then countersunk, and where cracks extended into the rivet holes the material was cut away in V shape. Rivets were then applied. Where flues had not been removed patch bolts were installed. The edge of the sheet was then chipped level and calked, thus insuring a tight joint. In nine cases out of ten no further trouble was experienced, proof enough in the case of firebox sheets that the beveling of sheets for calking is necessary.

By leaving the sheet the full thickness for calking the tool has to be held as shown in Fig. 1. Should leakage ensue, and there are a thousand chances to one that it will, more calking is necessary, with a tendency to raise the sheet, as shown in Fig. 2. When you reach that stage you must take out the rivets, lay up the sheets well before riveting, and then you take the step that should have been taken in the first place; that is, chip the sheet bevel for calking. The first cost in this case is insignificant as compared to the cost of riveting the seam. The best tools for calking are, in the writer's opinion, the round-nose fuller with a thickness at the extreme end of two-thirds the thickness of the material to be calked, with a width of half an inch. For finishing a lighter fuller should be used, with a thickness of one-quarter the thickness of the material. This tool should be run very lightly along the edge of the calking. J. SMITH.

Lorain, Ohio.

EDITOR THE BOILER MAKER:

About calking. The sound name for calking work that is not beveled is "splitting and calking," not "split calking." This is a greenhorn's name for it, and the other is the professional name for it—and I am a professional calker.

Splitting and calking will make tight work for water if the lap is small and the rivets fairly close and the plates well put together, but it takes an experienced and good calker to make it tight. Plates that are beveled take good calkers a great deal of time to make tight. Splitting and calking can be made tight, but upon looking closely into the work one can see openings all over the seams. They are small, but they are openings all the same. They are caused by the edges of the plates being scaley.

To make good, sure splitting and calking takes longer than to do the work with beveled plates, and if the plates are to be beveled bevel them well; that is, 130 degrees or 125 degrees. Short beveling means poor work. For fuller calking 120 degrees is O. K., but give me the square tool and the beveling at 130 degrees and I will give you a welded job of calking, practically, and it would only want light calking at that, because of the good beveling; and this can be made just as quickly as the poor one can. Under any circumstances, however, really bevel it, and do not merely chop it off, as this makes poor work, because a calker is not allowed time to fool over a job. He has got to get so much work done. It is up to the foreman to see that the man bevels the plates properly, and if they are out of shape he will get poor calking. Let any one go inside of a job that is split and calked, and he will see that the plates are fractured all along the seams, and mostly on the longitudinal ones, especially if the plates are 3/16 inch, ¼ inch and 5/16 inch thick. If the shop has some way of beveling plates by machinery, it is cheaper to calk them than it is to split and calk them, but then the calking is genuine; but if you want to calk a job in and outside, split and calk the inside, then chip and calk it on the outside; that is, I mean bevel it on the outside. HENRY MELLON.

Boston, Mass.

New Boiler Shop Plant.

EDITOR THE BOILER MAKER:

Two or three years ago I was left by my father a boiler works and considerable means, and I took a look over the plant and made up my mind that some new machinery was needed. From THE BOILER MAKER I got a great many addresses of boiler tool builders, and wrote them. Now I am not the one who expects to have anyone give me anything or to get something for nothing, but I must say I was surprised to find so many who had tools to offer me for some reason or other, always very plausible, was anxious to make this particular sale, and particularly to me, and, in order to make it, they would all make special prices.

I suppose selling tools is an art, and part of the art is to make a customer feel he has got a bargain. No doubt that desire of getting something for nothing is in all of us to a certain extent. I am wondering if my experience in tool buying is the same as others'. I got bids which varied about 40 percent. This did not seem to me possible, so I began to note in a tabulated form just what was offered. In the final work out I found I was getting just what I paid for. If the price was small I got less. Some bidders went very strong on weight, which in two cases was clearly added to the machines, where the weight could not possibly do any good except to give the impression when quoting the weight of solidity, where, in fact, no solidity was gained in working strength, and in one case the weight was entirely in a bedplate to stand a machine on, which plate was entirely unnecessary. I want to say, however, right here, that every tool offered was a thoroughly practical article, usually very well designed, fairly well made, but in the furnishing means for handling material it seemed to me they were all woefully lacking. When I called the attention of salesmen to this, they all argued that the handling of the material was a point to be settled by the surroundings of the machine itself. I do not think this is quite true. Take, for instance, a large punching shear, such as shown on page 24 of your April issue, I think a properly designed crane, or, perhaps, two of them, made a part of this machine would increase its value very much and not increase its cost very much. I am quite sure that such cranes would not increase the cost of the machine as much as would the money that is expended in the usual makeshifts for overhead hoisting apparatus in shops.

Looking at the old tools bought by my father, I was struck most forcibly with the wonderful advance in some directions and the seemingly no advance in others. In heating appliances and welding appliances what can be obtained to-day is, I might guess, fifty times as economical and one hundred times as handy as what was obtainable even ten years ago.

When it came to the small tools I certainly got bewildered by the conflicting statements of the makers of tools, but after a while I managed to get a very good equipment, making some mistakes, however, I think in choice, and I was more than surprised to have a foreman, who is a man advanced in years, tell me after a month's use of the new machinery that my investment was paying me a tremendous percent a month by increasing the output of the shop, bettering its equipment and, above all, elevating the ideas of the men in the shop. He said that the men were taking more interest in the work, and were proud of being employed in an establishment so thoroughly up to date. This, from an elderly man, pleased me and surprised me. But then there are some old men that never get old.

It is not an easy job for a man to pick out tools for the proper equipment of his shop, and it seems to me there is a great big business waiting an engineer who has actually done boiler work and knows just what is wanted, and knows just what is in the market to undertake the purchase and thorough equipping of boiler shops, or even if a single tool is wanted I believe that the small consultation fees that would be asked for such work would pay the purchaser manyfold. I certainly know now that had I known where to go for advice I would have saved myself money and got a better plant.

Worcester. Up-to-Date.

Working Pressure on Concave and Convex Boiler Heads.

Editor The Boiler Maker:

Noting the article in last month's issue on concave and convex boiler heads and their working pressure, I desire to state that a short time ago I had occasion to go into detail quite deeply in this matter, and in looking up rules and formulas on this subject I think that I find the rules prescribed by the Board of Supervising Inspectors of Steam Vessels the simplest and easiest to memorize. I give the following rules for concave and convex heads:

Let P = Working pressure.
T = Thickness of head in inches.
R = Radius to which head is bumped.
S = Tensile strength of material.
A = Area of head in square inches.

When the head is convex and single riveted to the shell the formula is

$$P = \frac{T \times S}{3 \times R}$$

When the head is double riveted it is

$$P = \frac{T \times S}{2.5 \times R}$$

When the head is concaved and single riveted to the shell the formula is

$$P = \frac{T \times S}{5 \times R}$$

When a head is concave and double riveted to the shell the formula stands

$$P = \frac{T \times S}{4\frac{1}{2} \times R}$$

When a flat head is used they prescribe the following:

$$P = \frac{T \times S}{.54 \times A}$$

By a close inspection of these rules it will be readily seen that it is most economical to use the bumped or convex head, since with a given thickness and tensile strength it will be allowed a greater working pressure than any other. Conversely, for a given working pressure a thinner head may be used.

J. H. Brooks.

Marshall, Tex.

PERSONAL.

Mr. George W. Bennett, general foreman of the boiler department of the West Albany shops of the New York Central & Hudson River and president of the Master Boiler Makers' Association, has been appointed a district boiler inspector of the Inter-State Commerce Commission.

Mr. James Crombie, foreman of the boiler department of the Sawyer & Masey Company, Hamilton, Ont., Can., and a member of the executive board of the Master Boiler Makers' Association, has accepted the position of general foreman of the Oil City Boiler Works, Oil City, Pa.

Mr. S. Severance, who has been president and manager of the S. Severance Manufacturing Company, Glassport, Pa., since its formation, severed his connections with that company on September 1.

Mr. John Butler, boss flanger of the Kelly Road Roller Company, Springfield, Ohio, sailed from New York August 19 on the *Olympic* for England, to be absent about thirty days. Mr. Butler was erecting engineer for W. H. Wood for fourteen years.

Mr. J. N. Heltzel, formerly superintendent of prominent Eastern boiler shops, has been interested for the past year with the W. B. Jones Streator Boiler Works, Streator, Ill. The present firm name is Jones & Heltzel Streator Boiler Company. Besides manufacturing tubular boilers, tanks, stacks, breechings, etc., the company has added to its line the manufacture of a system of steel forms invented and patented by Mr. Heltzel. Mr. Heltzel exhibited his forms at the International Cement Exhibition, held in New York last December, and also at the Chicago Exhibition of last February. In addition to Mr. Heltzel being an expert layerout and boiler shop superintendent, he has proved himself a successful salesman, having sold his new system of forms in all parts of the United States and in some foreign countries. Mr. Heltzel will exhibit at the coming cement exhibitions at New York City, Chicago, and Kansas City.

A. ANDERSON, general boiler inspector for N. de M. of Mexico, is now general foreman boiler maker at Aguascalientes for N. de M.

ED. R. BOCK is now foreman boiler maker at San Luis Potosi for the N. de M. of Mexico.

ENGINEERING SPECIALTIES.

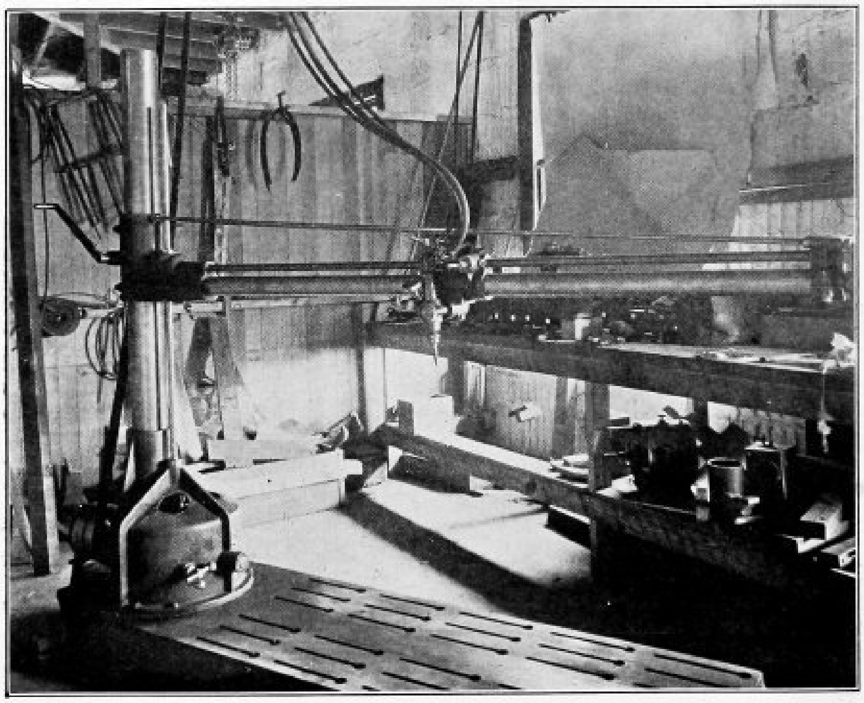
Acetylene Welding and Cutting Machine.

A machine for welding and cutting material by means of an acetylene torch has been brought out by the Davis-Bournonville Company, 90 West street, New York.

The illustration shows the tool set. It is in appearance very much like a radial drill of light construction, but it lacks the radial movement. At the base of the upright clamp there is fitted a tight and loose pulley, and a shaft fitted thereon, imparting rotary motion to a vertical shaft, which can be seen in front of the clamp. It is driven by friction discs. The vertical shaft carries a beveled gear, which meshes with one on a horizontal shaft which is inside the cylindrical hollow arm. The gear on the vertical shaft is fitted with a feather or key, which engages in a keyway in the vertical shaft, which transmits motion through this key to the beveled gear, and through its mate to the horizontal shaft referred to. On the outboard end of this shaft is a spur gear, which meshes with a second spur gear on the horizontal screw which shows just above the arm in the illustration.

A rack on the vertical post is engaged by a pinion which is suitably mounted on the sliding sleeve which carries the arm, and this pinion is actuated by a crank to raise or lower the protecting arm. On this arm there is a sliding sleeve, or saddle, through which the horizontal screw passes, engaging with a nut. This sleeve carries the torch to which the oxygen and acetylene is brought through flexible tubes. The tip of the torch is of the ordinary form. The belt being moved over, the tight pulley drives the friction discs on the horizontal and vertical shafts and the screw, which in revolving will, of course, move the saddle or sleeve in either direction as may be required.

The work to be operated upon is set on a table and properly secured, and the torch can then be run over it and a perfect welding job made. The speed of the moving torch and saddle can be varied from 3 inches to 24 inches per minute. Of course, this speed will be somewhat determined by the thickness of the metal to be welded, but on moderate thickness even as great a speed as 28 inches per minute can be obtained. It is evident that this machine can be used for cutting by simply changing the jet. The post is about 7 feet high, and the arm extends out about 6 feet. It would seem to us that a machine of this description would produce work of high class, and while at first sight the arm may look very light it has to be remembered that we have to disabuse ourselves of any great strength being needed, as the torch simply has to be suspended and carried in a direct line. There is no upward thrust as there is in a drill press.



ACETYLENE WELDING AND CUTTING MACHINE.

Copper Lining for Commercial Pipe.

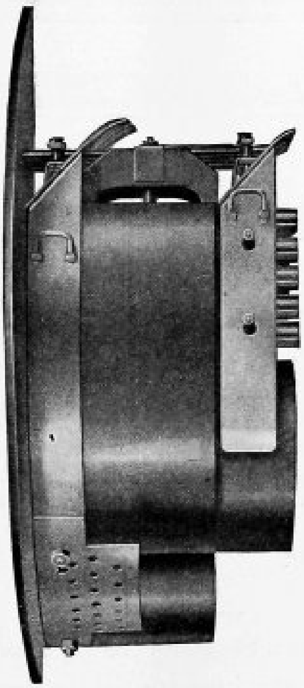
There are numerous places where it is advantageous to use a non-corrosive metal in tubing, but its first cost is often prohibitory, and then, again, commercial brass tubing is apt to split, and it is quite difficult to get the joints tight, and if left unguarded in many places it is stolen.

To overcome these difficulties, Mr. J. P. Materne, president of the Materne Manufacturing Company, of Eighteenth and Gratiot streets, St. Louis, Mo., got up a system of lining commercial pipe with copper, and this produces an article which is open to none of the objections of brass pipe, and has great advantages. It is, of course, considerably stronger than brass pipe, and the only possible objection that can be raised to it is that to a very small degree it encroaches on the internal diameter of the pipe. Its price is such as to allow its use, and it can be obtained in all sizes. The New York representative is W. E. Voltz, 126 Liberty street.

The Ross Schofield Marine Boiler Circulator.

Many attempts have been made to promote circulation of water in marine boilers. The Ross Schofield Circulator, manufactured by the Ross Schofield Company, 39 Cortlandt street, New York, is the latest device to be put on the market for this purpose. Our illustration shows the furnace and combustion chamber of a Scotch marine boiler equipped with this system, in the installation of which no part of the boiler is drilled or otherwise damaged.

It consists of a steel plate, supported on the short stays,

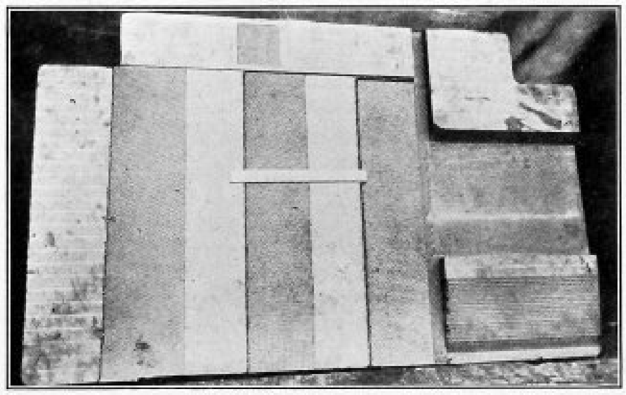


completely enclosing the water space back of the combustion chambers, except at the top and between the furnaces at the bottom; steel plates, supported by the tubes, placed in front of the combustion chambers and on each side of each furnace or bank of tubes; a back hood and a front hood. Two spaces are thus provided, which operate in parallel, their superimposed curved hoods promoting longitudinal and elliptical circulation of the water by utilizing the natural force of the steam bubbles. These bubbles, passing up through the guiding compartments and issuing from the curved hoods, throw the ascending streams of water in a horizontal direction, eliminating the vertical mechanical projection of water particles, and promoting a flow which continuously draws the water from the lower and colder part of the boiler up between the guiding plates, thence propelling it longitudinally toward the front, rapidly establishing constant and effective circulation, which is maintained. The mammoth *Titanic,* among other transatlantic ships, is equipped with this circulator. One company alone has ordered fourteen equipments.

Reversing Motor Drive.

There is little doubt but what the planer has pretty nearly reached its maximum size if driven with belts. The difficulty arises in the fact that in order to get the enormous power required for the quick return of a very heavy platen high speed of belt drive is not alone necessary, but width of belt is also demanded, and this got so cumbersome that to shift a wide belt became practically uncommercial. Four belts were resorted to, which helped matters some, but when the introduction of the electric motor began, and finally was selected as the means of an individual drive for various machines, it was not to be wondered at that the motor drive was first used in connection with belts, but of late, both abroad and in the United States, a great deal of money has been expended and a tremendous amount of experimenting done with the reversing motor drive.

The illustration which we give is a slab, which was worked up on a 76-inch Pond planer, driven by a 30-horsepower reversing motor. The load on the table was 17,000 pounds. The 12-inch scale, which lies on a piece, gives a fair idea of the dimensions of the piece planed. The extreme left portion, which is shown as being smooth with a very wide cross feed, is in a higher plane than any of the other parts, numbered 1, 2, 3, 4 and 5. It is, therefore, to be noticed that in

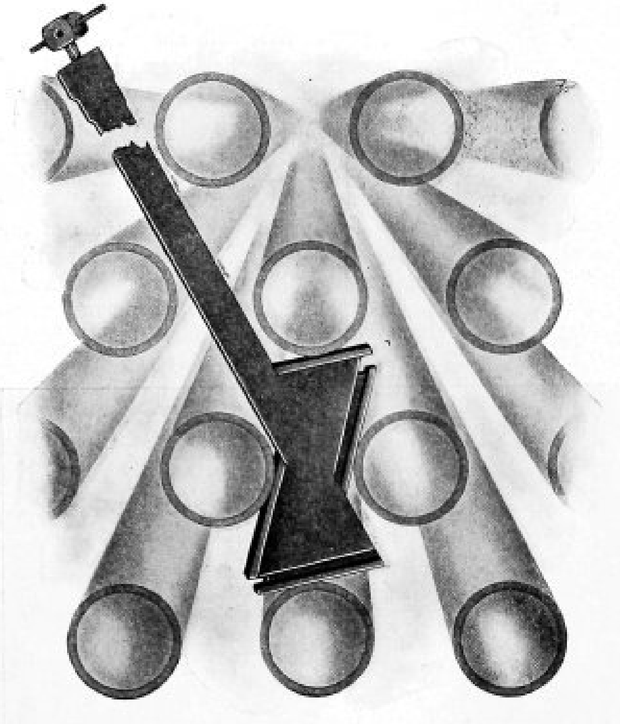


planing No. 5 the tool dropped into the clearance space and planed up to an absolute stop, which is the point at which part No. 4 started. It is to be noticed that this line is practically straight. The next step, No. 4, was taken with a different feed, and it in turn brought up against a shoulder which forced the right-hand edge of No. 3, and so on. The part marked No. 6, of course, had ample room to the right for the tool to start in its work, and it ran out in the clearance space at the end of the cut, but it is to be noted that the feed of this plane portion, No. 6, varied. This was done while the planer was in motion. The square part, marked No. 7, is a depression, the tool digging in at one end and running up against a shoulder at the other. This, of course, is not an operation that would often be required and would hardly be looked upon as commercial, but it is illustrative of the control which this reversing motor drive places in the hands of the operator.

The whole secret of the matter is that at the instant of reversal, when the leading or pilot switch comes in contact with the shifting dogs on the table, the controller short circuits the armature, creating therefore considerable resistance, which causes the motor to become a generator, consequently a most powerful electric brake. The cutting speed is shifted at any time the operator desires by merely moving a little contact button, while the feed can be varied in the same way and under the same conditions, and the control of the motor is such that there is practically no overload and no wide fluctuation of the amount of current to be supplied from the line. The Niles-Bement-Pond Company, New York, handles these tools.

Tool for Spreading Boiler Tubes.

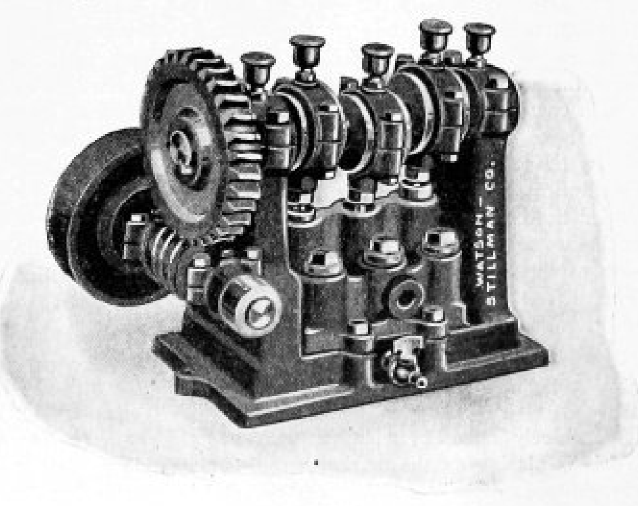
The Heely Tube Spreader Company, at 346 Broadway, New York, is placing on the market a tool for spreading tubes in certain types of boilers. It is a useful article in replacing the fire brick between the tubes which form the baffle walls. The difficulty of spreading the tubes has frequently forced people to neglect repairs. With the Heely spreader the work becomes an easy job. The tool is made with an adjustable spreader



head. The movable part is operated by a threaded stem that screws into a nut on the inside of the handle and is operated by the rod on the end. The working ends of the spreader are provided with large faces, which prevent any possible injury to the tubes.

A High-Pressure Test Pump.

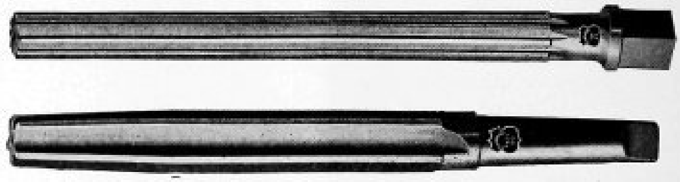
The Watson-Stillman Company, 50 Church street, New York, is putting on the market the three-plunger hydraulic testing pump, which we herewith illustrate. The idea is quite common that the efficiency of a worm and wheel is extremely low; and, while this is true in a badly designed wheel, Escher of Zurich, by a set of experiments, has shown that an efficiency as high as 95 is obtainable with the worm and wheel. Part of the drive is shown in the illustration. This pump will give pressures up to a thousand pounds. It is most compact, weighing 300 pounds, and when it is to be used in various parts of the establishment it can be coupled up with a



motor. The plungers are 7/8 inch in diameter, with a stroke of 1/2 inch.

Reamers and Taps for Boiler Work.

It is admitted that there is no harder usage for a reamer than that it gets in reaming out holes in boilers. The bearing is very short, the power is generally applied vigorously, and little or no attention is given to keeping the reamer nicely

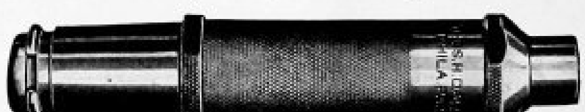


in line with the punched or drilled sides of the hole, consequently material of the best must be employed in any tool of this kind. These reamers also are tapered about 1/16 inch, or perhaps 3/32 inch per foot, and this gives them a pretty good gripping power; and, if the temper is not just right, the face of the flutes are broken. We illustrate a Standard Tool Company's (Cleveland, Ohio) taper reamer for locomotive work, fitted with a square head for a wrench, and also one specially designed for heavy iron work, where the shank is made taper to fit a ratchet.

The long experience of the Standard Tool Company has enabled it to make a selection of material which is tough and yet holds its edge; while, at the same time, it is not brittle. Experience has shown the number of flutes best adapted for work—and this is no small matter. The company also makes a staybolt tap of selected material, which has all the features above described for the reamer.

Dallet Pneumatic Boiler Scaler.

The Dallett pneumatic boiler scaler is a pneumatic hammer, striking rapid, light, uniform blows (some 3,000 per minute). Air is admitted through the inlet at the upper end of the tool, and the work produced by the piston striking the chisel which is inserted at the lower end. This tool removes the hardest scale down to the sheet, as the scale is not cut or chipped off, but the light, rapid blows of the piston against the chisel, combined with the vibration caused thereby, crack the scale from the shell. These blows are sufficiently strong to cause this action, yet not powerful enough to cut or other-



wise injure the sheet, and as compared with the hand-hammering method will enable the work to be done in a fraction of the time. By simply holding the tool against the sheet with one hand it strikes over 3,000 blows per minute, while a man using a hammer would strike 50. It weighs only 27 ounces, requires no attention except a few drops of oil at intervals, can be easily taken apart by anyone, and should repairs be necessary after years of service it can be made as good as new. With each tool are furnished two chisels suitable for this work, the chisels being blunt on the end to prevent cutting or injuring the sheet, but pointed enough to effectively crack the scale. This tool is made by Thos. H. Dallett Company, Philadelphia, Pa.

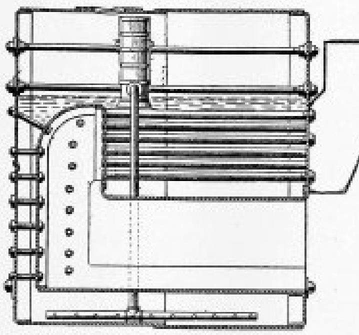
SELECTED BOILER PATENTS.

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

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

993,566. BOILER CIRCULATOR. CHARLES STEWART, OF BROOKLYN, N. Y.

Claim 1.—A boiler circulator having an upwardly tapered collector adapted to stand with its open lower end submerged but near the surface of the water, a chamber above the collector, the chamber extend-



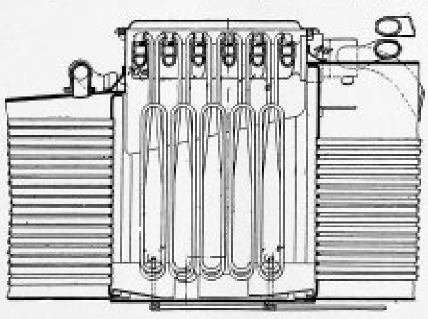
ing above the water level in the boiler, a tube communicating with the open upper end of the collector and extending vertically in the chamber, said tube having a vertically disposed water outlet along its length and having its upper end open for the escape of steam, and a connection extending above the water line downward to the lower part of the boiler. Seven claims.

993,628. FEED WATER REGULATOR. ORBERT E. WILLIAMS, OF SCRANTON, PA.

Claim 2.—The combination with the main feed line of a boiler, and an inlet valve therein, of a diaphragm to operate said valve, connections for a constantly flowing stream of fluid acting on said diaphragm, and means to restrict the flow of such fluid and thereby build up pressure on said diaphragm. Twenty claims.

994,045. STEAM BOILER SUPERHEATER. HENRY H. VAUGHAN, OF MONTREAL, QUEBEC, CANADA, ASSIGNOR OF ONE-HALF TO LOCOMOTIVE SUPERHEATER COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW JERSEY.

Claim 1.—The combination, with a locomotive boiler, of a superheater comprising a saturated steam header having a plurality of horizontally extending lateral branches, a superheated steam header having



a plurality of similar extending branches, alternated in position with those of the saturated steam header, said headers and branches being located entirely above the boiler tubes, and a plurality of looped or return bend superheating pipes, connected at their ends to the header branches and depending therefrom in vertical rows in the path of the gases of combustion from the tubes. Ten claims.

993,929. APPARATUS FOR FEEDING FINE FUEL. JOHN A. WELTON, OF CANAL DOVER, OHIO.

Claim 1.—In apparatus for feeding fine fuel, the combination of a steam boiler furnace; a fuel receiver; a fuel conduit leading from the receiver to the firebox of the furnace; fuel reducing elements arranged to operate on the fuel as it passes through said conduit; means for supplying air to the furnace with the fuel; a pressure regulator exposed to boiler pressure and operable thereby; a pair of connected dampers movable toward and from each other controlling the outlet from the fuel receiver; and connections between the pressure regulator and said dampers whereby the dampers are opened and closed automatically in response to variations in boiler pressure, said connections including a cam shaft and means connecting the same with the pair of dampers. Twelve claims.

994,063. FURNACE GRATE. ALFRED F. DAWSON, OF MILMONT, RIDLEY TOWNSHIP, DELAWARE COUNTY, PENNSYLVANIA.

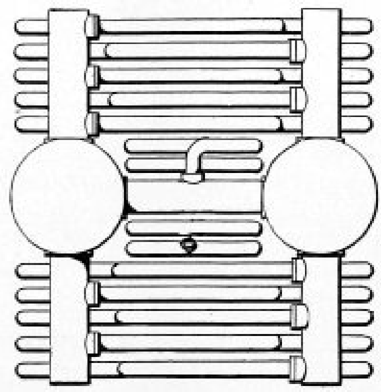
Claim 2.—A grate bar comprising a cylindrical rib having formed integral therewith transversely extending staggered leaves and a one piece reinforcing element of relatively large cross section embedded in its entirety within said rib and extending throughout the length thereof.

994,656. BOILER. THOMAS T. PARKER, OF HACKENSACK, N. J.

Claim 1.—In a boiler, the combination of a separating chamber, means tending to prevent the circulation of water from the boiler proper to said chamber, means for feeding water from said chamber to the boiler proper, and means for providing a tortuous course for the water in said separating chamber. Fifteen claims.

994,403. STEAM BOILER. ERA C. JACOBSON, OF LOUISVILLE, KY.

Claim 1.—In a steam boiler, a plurality of approximately vertically disposed shells, connecting pipes establishing communication between the upper and lower portions of said shells, pairs of oppositely extending pipe arms connected with the upper and lower portions of said



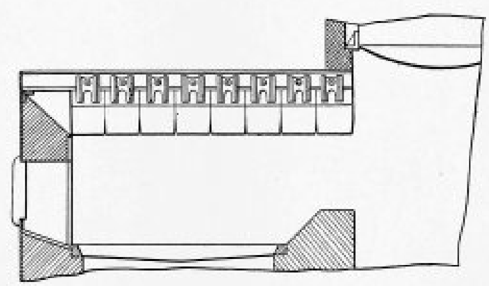
shells, steam-generating coils having connections with said pairs of pipe arms, and a superheating coil disposed between said shells and steam-generating coils, said superheating coil having its end connected with the upper connecting pipe. Seven claims.

994,387. SPARK ARRESTER. WILLIAM H. GYER, OF SIEGFRIED, AND EDWIN B. ELDRIDGE, OF ALLENTOWN, PA.

Abstract.—A spark arrester comprising a smoke stack with an upper frusto-conical hood, and a lower inverted frusto-conical hood thereon, a frusto-conical shaped deflecting member situated within the upper hood and spaced from the walls thereof, bars extending from said upper hood for supporting said member, a circular damper having a conical lower surface revolubly mounted in said member, an annular downwardly inclined deflecting flange supported within the upper portion of said lower hood and spaced from the lower end of said member, a draft-regulating sleeve slidably mounted on said stack, a vertically adjustable lever pivoted to the sleeve, said lever extending through the lower hood and pivoted thereto, and an adjustable rod connected to said lever.

994,383. FURNACE ROOF. MILFORD T. GOSS, OF CHICAGO, ILL.

Abstract.—In a flat furnace roof, an overhead girder consisting of an I-beam; combined with a series of blocks disposed end to end beneath said girder and each having its sides tapered downward and a



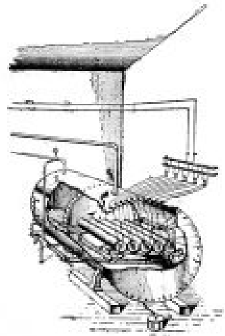
laterally reduced head at its upper end with the sides thereof rounded and undercut, and for every block a pair of clamps whereof each comprises a plate shaped to fit the web of the I-beam and provided with depending fingers at its edges hooked to conform with the base of the beam and the shape of said head, and strengthening ribs extending longitudinally of the fingers and upward across the plate; and a bolt through both plates and the interposed beam.

995,349. FEED-WATER HEATER. JOHN J. HOPPES, OF SPRINGFIELD, OHIO, ASSIGNOR TO THE HOPPES MANUFACTURING COMPANY, OF SPRINGFIELD, OHIO, A CORPORATION OF OHIO.

Claim 1.—In a feed-water heater, a main casing, an exhaust steam supply, an oil separator located in said supply, and a dam for the feed-water in proximity to said supply, said dam forming an unobstructed open space or chamber beneath said supply to receive the over-flow oil from said supply. Six claims.

995,132. ELECTRIC STEAM-GENERATOR. CHARLES E. GRIFFING, OF SALT LAKE CITY, UTAH, ASSIGNOR TO THE GRIFFING ELECTRICAL STEAM BOILER CO., OF BIRMINGHAM, ALA.

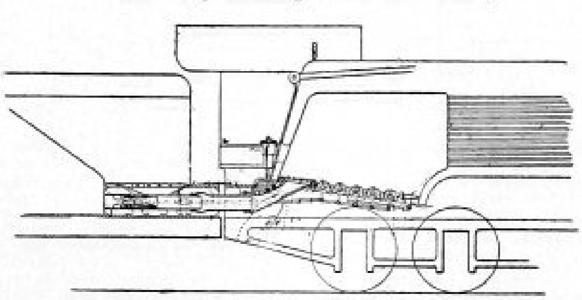
Claim 1.—In a generator of the class described a tank provided with a diaphragm dividing the tank into compartments, one of which con-



stitutes a reservoir for air and water under pressure, and the other a generating tank, separate valved means for controlling the escape of air and water respectively into the generating tank to produce a spray, and electric heaters in the generating tank in the path of spray thrown thereinto. Four claims.

996,031. LOCOMOTIVE. GEORGE B. RAIT, OF MINNEAPOLIS, MINN.

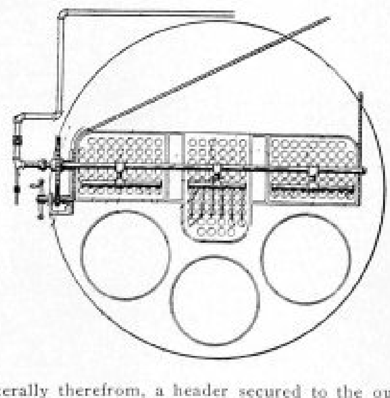
Claim 2.—In combination with a locomotive and its fire box and tender, underfeed mechanism extending from said tender up into the front of said fire box having a coking duct at its upper end, a twyer in the form of a rearwardly declining hollow annular ring detachably



secured to said coking duct about its discharge end in said fire box, a grate back of the outlet of said underfeed mechanism onto which the fuel is advanced by said mechanism, said grate being composed of a number of crowned rocker elements adapted to advance the fuel in the fire box after it is received from said underfeed mechanism and means for simultaneously operating said underfeed mechanism and rocker elements. Seven claims.

995,931. BLOWER FOR BOILERS. THOMAS S. WALLER, OF DETROIT, MICH., ASSIGNOR TO DIAMOND POWER SPECIALTY COMPANY, OF DETROIT, MICH., A COPARTNERSHIP.

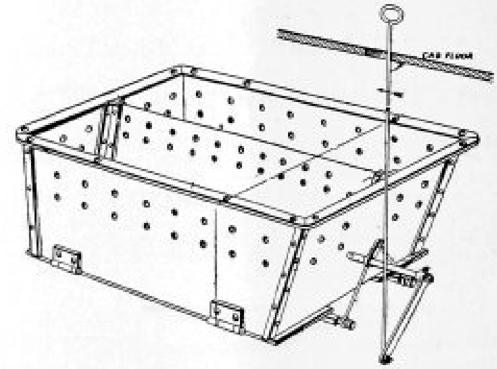
Claim 1.—A device of the character described comprising a horizontal steam main rotatably supported adjacent the tubes of a boiler, a branch



extending laterally therefrom, a header secured to the outer end of the branch parallel to the rotatable main, a series of jet nozzles on the header, a series of jet fingers extending from the header transversely to the branch, and means for rotating the horizontal main. Four claims.

995,698. LOCOMOTIVE ASH-PAN. GEORGE MAURER, OF TERRE HAUTE, IND., ASSIGNOR TO GEORGE MAURER, WILLIAM A. REDDY, AND JOHN C. TWOHIG, OF TERRE HAUTE, IND., A FIRM.

Claim.—In a locomotive ash-pan, the combination with the side and end plates secured together to form the outline of the pan, an inverted V-shaped partition held within said pan and running lengthwise of the same, angle irons secured in the end plates of said pan and to said inverted partition extending from the bottom to the top of the pan, bottom gates hinged along their outer longitudinal edges to the side walls of the pan, bearing members secured to the under side of said inverted V-shaped partition, a shaft in said bearing members, a lever on said shaft, connecting rods between said lever and said bottom gates,



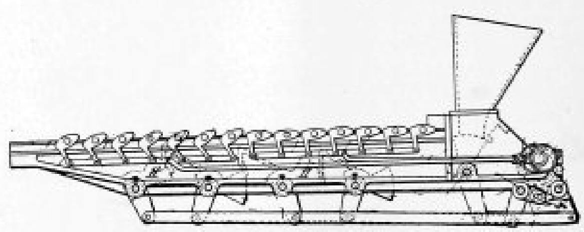
and an operating rod connected to said lever through the medium of which said bottom gates may be opened, said bottom gates opening toward one another.

995,523. WATER-TUBE BOILER. WILFRED D. CHESTER AND HENRY B. RUST, OF PITTSBURG, PA., ASSIGNORS TO THE BABCOCK & WILCOX COMPANY, OF BAYONNE, N. J., A CORPORATION OF NEW JERSEY.

Claim 1.—In a water-tube boiler having horizontal water and steam and water drums, a group of straight tubes adjacent to a vertical plane passing through the center line of the two drums, groups of bent tubes on either side of said group of straight tubes placed at a distance from the said group of straight tubes a sufficient distance to allow a man to enter the said space, a wall between the straight tubes and supported by them, said wall resting on the water drum and extending from side wall to side wall, and horizontal baffles supported by said vertical wall and the straight tubes and extending from the group of straight tubes toward the group of bent tubes, and inclined baffles extending from the front and rear walls to the bent tubes. Two claims.

997,019. UNDERFED STOKER. WALTER F. SMITH, OF BALTIMORE, MD., ASSIGNOR TO THE SMOKELESS STOKER COMPANY, A CORPORATION OF DELAWARE.

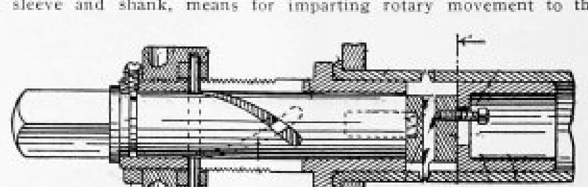
Claim 1.—An automatic stoker comprising a magazine having a throat, a laterally movable conveyor at the front end of the throat for forcing fuel rearwardly therethrough, a hopper located to deliver fuel



behind the conveyor when the latter is in its forward position, a second conveyor located at the rear portion of the throat and having a fuel-feeding portion movable to a receiving position below the bottom of the throat, a flat horizontal stationary plate forming the bottom of the throat between the said conveyers, and a mechanism for moving the conveyers simultaneously in opposite directions. Six claims.

996,310. FLUE-CUTTER. JOHN CASAGRANDE, OF DENVER, COL., ASSIGNOR OF ONE-HALF TO HERMANN J. GAMMETER, OF DENVER, COL.

Claim 1.—A flue cutter composed of a sleeve, a shank within the sleeve, the sleeve having slots parallel with the axis of the tool, the shank having a spirally arranged slot pin passed through the slots of the sleeve and shank, means for imparting rotary movement to the



tool as a whole, means for moving the pin in the slots of the two members for imparting independent movement to one member, a cutter device carried by one member, and a connection between the cutter device of the other member whereby as the independent movement is imparted to one member the cutter device is moved laterally. Six claims.

996,302. BOILER AND SUPERHEATER. GEORGE W. WADE, OF CHICAGO, ILL., ASSIGNOR TO BECKER & WADE COMPANY, OF CHICAGO, ILL., A CORPORATION OF ILLINOIS.

Claim 1.—An apparatus comprising a boiler, heating means, a flue passing through said boiler, and a steam pipe passing from said boiler through said flue and in open communication with said heating means, and a feed-water heater mounted above said boiler likewise in open communication with said heating means through said flue. Three claims.

THE BOILER MAKER

OCTOBER, 1911

REGULAR AND IRREGULAR Y-PIPE CONNECTIONS.

BY I. J. HADDON.

In the first place I would like to impress it upon the readers that it should be the aim when laying out any problem to try to have true straight lines in the plan, elevation and development, and these straight lines to be rolling lines, so that after the plate is rolled to its correct shape a straight-edge may be put on the line and lie evenly, because if there are straight lines in the plan and elevation, and assumed to be straight lines in the development, and after the plate is rolled a straight-edge does not lie evenly, the development is sure to be inaccurate. I would not go so far as to say it would be a long way out, but still I do say it would not be as accurate as if the straight-edge did lie evenly.

FIRST METHOD.

Fig. 1 represents a so-called elliptical-based Y-pipe connection. Draw the elevation as shown; produce the line *A a* and *B b* until they meet at the point *C*, also produce the line *B d* and *E e* until they meet in the point *F;* draw a line through *F C*, producing it well toward *G*. On this line draw the plan; of course the plan could have been drawn higher up or lower down, but on this line, you will see, is a very convenient position. I have drawn the whole plan and elevation, whereas you will see it is only necessary to draw one-half. Divide one-half the large circle into six equal parts, as shown at 1, 2, 3, 4, 5. This may be done accurately by using the same radius as the circle and stepping from A' to 2, 3 to 1, 3 to 5 and E' to 4. Draw lines from 1, 2 and 3 to *C*, and from 3, 4 and 5 to *F;* these will be the plan of the rolling or straight lines. Now to obtain their true lengths, and also the true length as to where they cross the line 3 B', proceed as follows: With *C* as center and radii *C* 1, *C* 2 and *C* 3 draw arcs up to the line *G F*, and then project up to the line *A E* in $1'$, $2'$, $3'$; connect $1'$, $2'$ and $3'$ to *C*, these lines will then be the true lengths of the lines 1 *C*, 2 *C* and 3 *C* shown in the plan. From *F*, with radii *F* 3, *F* 4, *F* 5, draw arcs as before, and project up to the line *A E* in $3''$, $4'$, $5'$; connect $3''$, $4'$, $5'$ to *F*, these will then be true lengths of the lines shown in the plan, they will also be rolling lines when developed. Now, as you will see by the plan, the lines *C* 1 and *C* 2 cross the line B' 3; now we must mark these points onto the lines in the elevation, so from *C* with radii *C* $2''$ and *C* $1''$ draw the arcs as shown, and project up to their respective lines in *H K*.

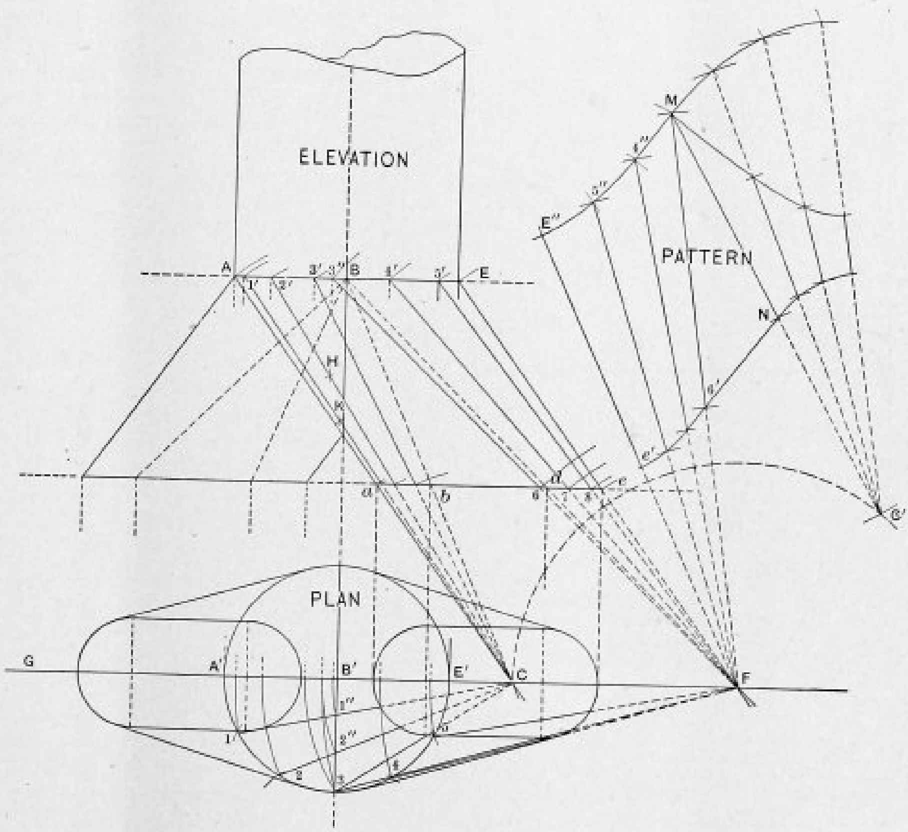


FIG. 1.

DEVELOPMENT.

From F, with radii $F\,E$, $F\,5'$, $F\,4'$, $F\,3''$, draw arcs as shown, and from F, with radii $F\,e$, $F\,8$, $F\,7$, $F\,6$, draw arcs as shown. Draw the line $E''\,F$, cutting the other arc in e'. Now multiply one-half the diameter of the large circle shown in the plan by 3.1416, or say 3 1/7, as this is sufficiently accurate for most purposes, and divide by six, and mark these divisions on a thin lath, then lay one of the marks on the lath onto the point E'', and allow three of the other points to cross on the arcs, as at $5''$, $4''$, M, and draw a fair curve through them as shown. Draw lines from these points to F, cutting the arcs drawn from e, 8, 7, 6, and draw a fair curve through them as shown. From F, with radius $F\,C$, draw the arc $C\,C'$, and from M, with radius $C\,3'$, cut the arc in C' as shown. Now from C', with radii $C\,2'$, C', $C\,A$, $C\,H$ and $C\,K$, draw arcs as shown. Now place the thin lath on the curved line $E''\,M$, with the marks in their correct positions, and allow the other marks to cross the other arcs as before, and draw a fair curve, completing the curve at the top. From the points obtained draw lines to C', cutting the other arcs as shown. Draw straight line from 6' to N and fair curves through the others to complete half the pattern.

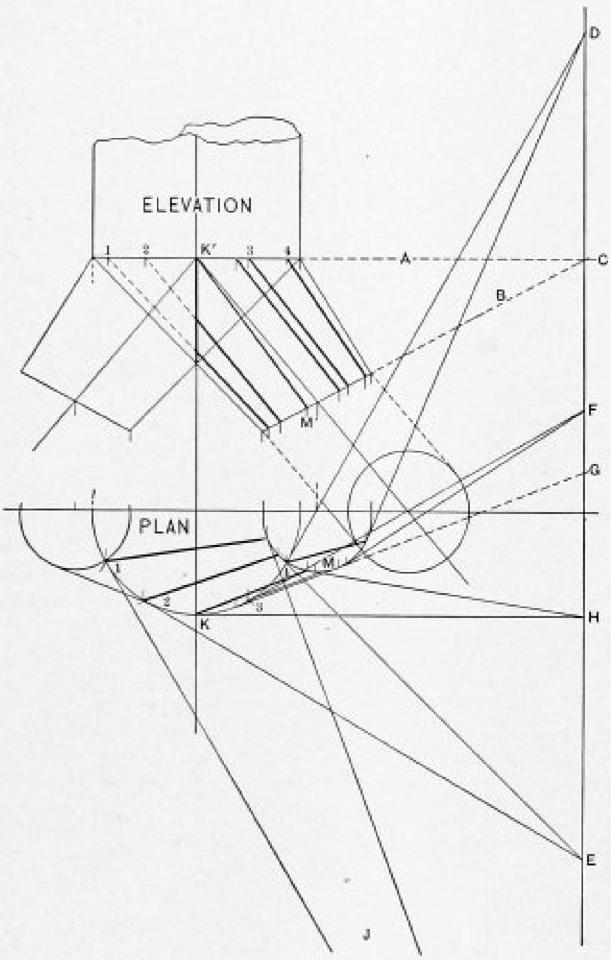


FIG. 2.

The lines in the development are rolling lines, and a straightedge should lie evenly on them after the plate has been rolled up to shape. You will see I took no notice of the plan or elevation of the bottom of this problem, because the ends were semi-circles, and the top and bottom of the figure were parallel; had the bottom not been parallel with the top or bottom, say, ellipses, the problem would have been more difficult.

SECOND METHOD.

Fig. 2 is a Y-pipe connection having elliptical bases with a circular top, and the bases are at an angle with the top.

The most practical method of developing this problem is by triangulation, but even then it would not be wise to divide the top into, say, twelve *equal* parts and the bottom into twelve *equal* parts, as they *would not* represent rolling lines; they would be straight lines in your plan, elevation and development, but would become curved lines after rolling your plate to shape. Now my reason for drawing this figure is not to explain triangulation, as I think you all know sufficient as regards that, but to show how to get the true straight lines in your plan and elevation, after which you may form them into triangles and develop by triangulation, and you will then be more accurate than if you had not got these known straight lines, because they will be rolling lines and also straight lines after the plate is rolled to shape; that is, as near as can be got, allowing for the slight inaccuracies of triangulation.

Now I want the reader to imagine the lines $A\,B$ to be two flat surfaces, like the covers of a book open to an angle with the hinge at C. The plan of this hinge point C is the indefinite straight line $D\,E$. Now looking from the point C you can see the whole face of the top and bottom of the figure requiring developing. Now the plan of point C may be anywhere along the line $D\,E$, so we will take, say, the point H; draw $H\,K$ tangent to the large circle and $H\,M$ tangent to the ellipse; connect $K\,M$. This will be the plan of a true straight line, a rolling line, also a straight line after the plate is rolled to shape. Project this line up to the elevation as $K'\,M'$; connect $K'\,M'$; do the same from any point along the line $D\,E$ as from F, G, J, then the heavy lines shown in the plan and elevation are the true straight rolling lines, after which you may form these into triangles (not shown) so as to develop by triangulation.

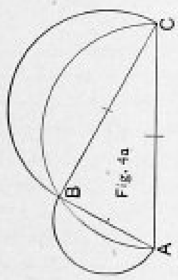
You will see by the drawing that the top is divided into twelve equal parts, as at 1, 2, K, 3, 4, but the ellipse does *not* divide into twelve *equal* parts.

Had the angle been such that the point C became closer along the line A to K', then $K'\,M'$ would have been farther from the center line than is shown here.

THIRD METHOD.

The problem of Fig. 3, having two pipes as A and B and a larger pipe as C to make the connection between as D and E, also showing the line of interpenetration made by a smaller pipe F entering $D\,E$.

On the center line of the pipes A, B, C, and in any convenient position, draw the circles *equal in diameter* to the diameter of the pipes respectively as shown, then draw tangents to these circles as shown. Now where these tangents cut the parallel lines representing the pipes A, B, C, such as at $G\,H$, $N\,O$, J, K and $L\,M$, draw lines (marked heavy) as $G\,H$, etc., etc. These are the miter lines (straight lines). Now it will be noticed that the lines $J\,K$ and $L\,M$ cross at P, so draw $P\,R$ to represent the intersections of the two cones D and E. Take notice the interpenetration lines do not cross on the point where the centers of the pipes and cones cross. Now to find the line of interpenetration of the smaller pipe and the cones $D\,E$. From the center of the large circle draw arcs (it is not necessary to draw the whole of the circles), cutting the cones and small pipe; now where they cut the cones draw lines, and where the same arc cuts the pipe draw a line; now where these lines intersect will give a point on the line of interpenetration. The whole of the interpenetration may be drawn, as shown, by obtaining sufficient number of points and drawing fair curves through them, meeting on the line $P\,R$, as shown in heavy lines.


C
B
Fig. 4a
A

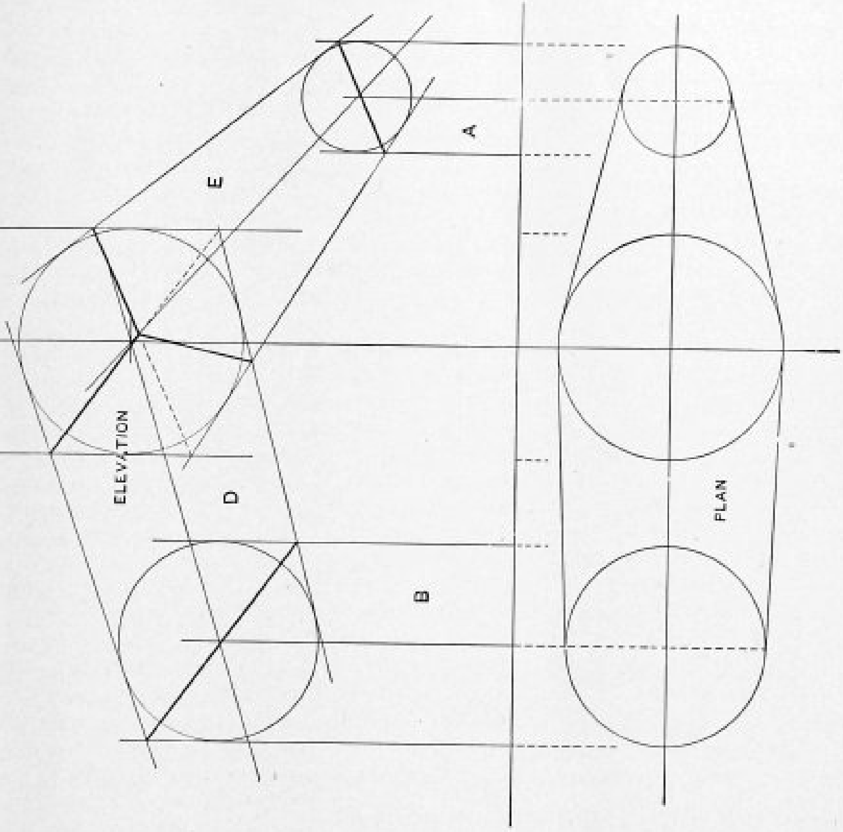

A
E
C
ELEVATION
D
B
PLAN

FIG. 4.

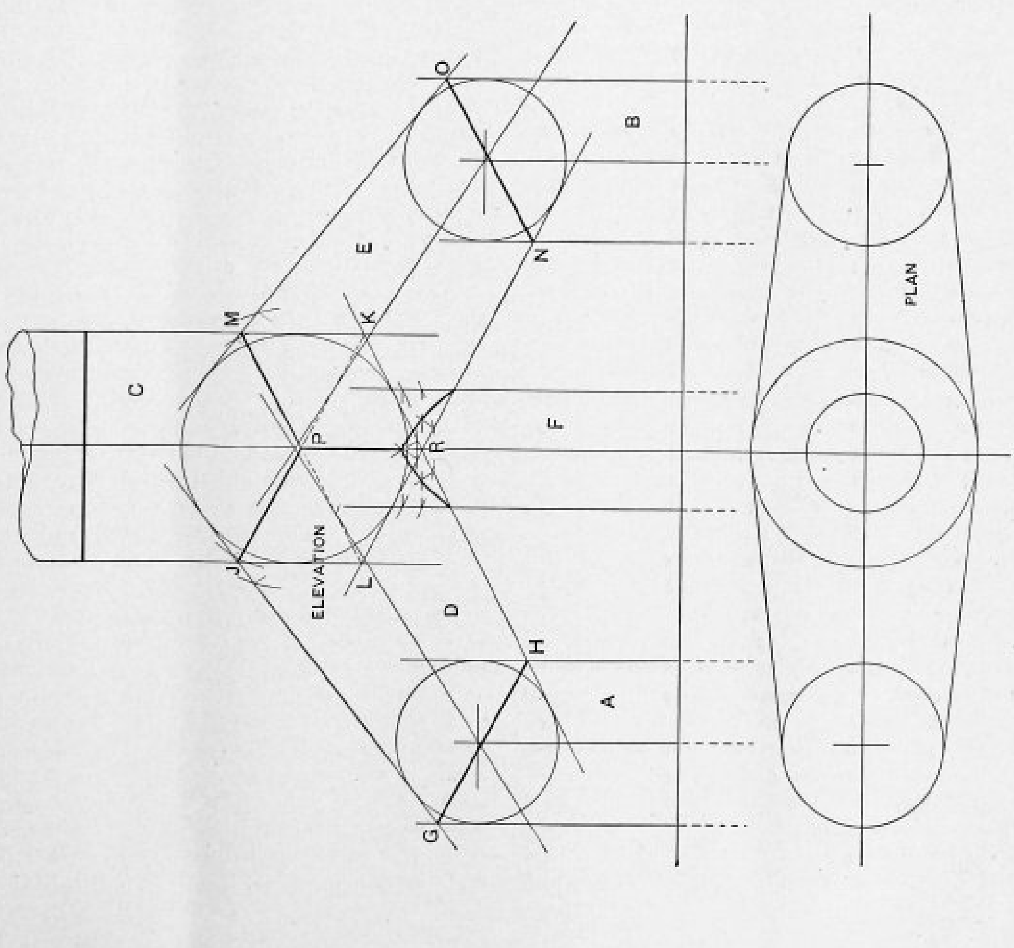

O
B
N
E
M
K
C
P
R
F
PLAN
J
L
ELEVATION
D
H
A
G

FIG. 3.

If the reader could imagine all these arcs and the circles as shown to be globes you would easily see that these interpenetrations are perfectly accurate.

Now in this figure I have drawn the pipes *A, B, C* similar to those shown by Mr. Linstrom in the December, 1910, issue, but showing that the connections *D* and *E* must be cones if the pipes *A, B* are circular and of a different diameter to the circular pipe *C*.

Now as regards Fig. 4. We will suppose it is required to make a connection between two pipes of different diameters to enter into a pipe of a diameter equal in area to the two added together, also imagine there be a shed or something in the way, so that these pipes cannot be made as in Fig. 3, but must have a connection as in Fig. 4.

Upon the sides of a right-angled triangle, as *A B, B C*, Fig. 4a, draw half circles, as shown, equal in diameter to the two pipes *A* and *B*, respectively, Fig. 4. Then if a circle be drawn equal in diameter to *A C*, Fig. 4a, it will be equal to the other two added together. This rule is generally applied when it is required to lead two pipes from two boilers into one large pipe, such as two donkey funnels into one. The development of the pipes *A, B, C* and *F*, Fig. 3, should be done by projection; it hardly needs any explanation from me how to do this.

To develop the pipes (cones) *D* and *E*, I would refer the reader to an article in the July issue of THE BOILER MAKER, 1911, viz.: "Development of a Cone Cut at an Angle when the Apex is Unattainable." I may point out that the problem by Mr. Linstrom, Fig. 4, page 367, in the December, 1910, issue, should have been done by the same method which I have just shown.

FURTHER NOTES ON THE HIGH-SPEED BOILER.

[FROM A CORRESPONDENT.]

The most recent expert views of British engineers on the high-speed boiler introduced to public notice within the last two years, some details of which have already been given in these columns, are as follows: The inventor, Prof. Nicholson, of Manchester, England, is firmly convinced that boilers of the ordinary type are designed on faulty principles and are worked at a disadvantage. Allowing for the radical nature of the changes in high-speed boiler designs, which he so strongly advocates, it is noteworthy that a large proportion of British boiler experts have not been impressed with his proposals, and can scarcely be said to have given them the serious consideration which they undoubtedly deserve. There can be no doubt whatever, if we except boilers of the watertube type, that no innovation in boiler design principles during the last generation has been so remarkable as that of Prof. Nicholson, who boldly proposes that the heating surface should be reduced by one-half or more of the allowances now generally considered necesary, and that the required evaporation and efficiency should be assured by the introduction of extremely high gas speeds and water speeds. It may be admitted that boiler makers throughout the world have reached a high level of excellence in the work they turn out, and have every reason to be satisfied with the practical results achieved by the boilers they design; both in Great Britain and the United States deaths and accidents due to boiler explosions and defects are extremely few in proportion to the number of boilers at work, a strong point in favor of the boilers as now made. It should also be noted that the general simplicity and good working qualities are further points to their credit. But all these advantages form no reason for ignoring suggested improvements, providing that they are real advances and that the good points already achieved are maintained.

It has been suggested by an expert that if we turn to a consideration of the principles in accordance with which boilers are at present designed, it appears that in the vast majority of cases the proportioning of furnace grates and capacities and the calculation and arrangement of heating surface are done in Great Britain upon what may be described as an empirical basis. Such a want of sound system is only excusable where either there is a check by scientific reasoning and when science cannot furnish material assistance. It may be admitted that it is only comparatively recently that science has been able to check the empirical formulas employed by boiler designers in Great Britain; scientists with novel ideas and new principles do not therefore command the attention in this branch of engineering they may receive in others.

Three English scientists are responsible for an important point in practical boiler making—Prof. Osborne Reynolds, Prof. Perry and Dr. Stanton. In 1874 they first established the important principle of heat transmission of water flowing on both sides of a metal dividing wall. Dr. Stanton experimentally verified the theory about 1897; Prof. Perry also wrote on the subject, and more recently these researches were experimentally verified in the United States. It is this theory which Prof. Nicholson has quite recently developed and applied to the practical improvement of boilers, and which a large section of the engineering world hesitate to approve of. Expressed more fully the principle laid down by these scientists is that the rate of heat transmission across a boiler plate is proportional to the temperature difference between water and gases; to the density of the gases and to the speed at which the gases are traveling. This velocity theory is a most useful conception; whether the attempts Prof. Nicholson has made in his speed boilers stand the test of time or not, and are a right or wrong application of the theory, both opponents and others can only benefit by discussion. It may be described as put into practice by the inventor as follows: The problem was to find out how far it would pay to increase the gas speed through the flue of a boiler, and whether the design of the steam generator could be improved by the use of a powerful draft, a high gas speed and a smaller heating surface. There was a fundamental difference between this proposal and all other forced or induced draft systems, the difference being that the high drafts employed did not necessarily involve high rates of combustion on the grate. No matter how great the difference of air pressure between the furnace and funnel, that between furnace and ashpit need not and should not be greater than that commonly employed when firing under natural draft. The object was to show that the return to moderate draft for, say, marine work, and even of natural or chimney draft for land work, was a retrograde step, and that the design of a steam generating plant on rational lines would lead not only to a return to the high drafts which were formerly in vogue, but even to drafts three or four times as great as had ever yet been attempted. The distinguishing features of the proposed designs were means for producing secondary combustion in a hot chamber of the unburnt gas and coal dust, the use of a relatively high draft whereby the products of combustion were compelled to pass through narrow flues at a high speed, giving with greatly enhanced rates of evaporation a much reduced area of heating surface, and the use of a counterflow economizer whereby the gas temperatures were lowered to about 220 degrees F. and the steam spent upon the fan plant more than recovered. The main problem which had to be solved was the most economical value for the draft pressure. Test experiments had also been made by other experts, who reported that no other boiler had given so high an evaporative efficiency combined with so high a rate of evaporation per square foot of heating surface. It might confidently be expected that a high-speed counterflow boiler to give a net efficiency of 80 percent, when evaporating at the rate of 20 pounds of steam per square foot of heating surface per hour, would shortly be constructed. The application of a high-speed boiler of this type to, say, the *Mauretania*, would result in a saving in space of 37 percent, and a net evaporation of 11 pounds of cold water could easily be guaranteed per pound of coal, with a rate of firing as low as 25 pounds per square foot of grate per hour. The estimated annual saving with the new boiler in ordinary practice was $1,536 per annum per 1,000 indicated horsepower installed.

Experiments have been made the results of which directed attention to the furnace as a source of possibly serious losses (thereby confirming experience with locomotive boilers), due to a considerable quantity of unburnt coal being ejected from the boiler by the excessive rate of combustion. An English expert has propounded a formula, based on the results obtained from a number of experiments, showing that the loss by incomplete combustion increases uniformly with the rate of combustion on the grate. At 20 pounds per square foot of grate the loss is about 12 percent, while at 50 pounds the loss is proportionately less, only 40 percent. These figures are certainly large and may not hold good for all descriptions of coal burnt, but they emphasize the importance of a moderate rate of firing. An expert suggests that in order to recover to some extent the loss by incomplete combustion in the furnace a firebrick combustion chamber would probably be an advantage. Prof. Nicholson in his experimental boiler actually tried one, but it is said not to have proved the success that was expected, which may possibly be due to the following causes: It has been ascertained that dilute mixtures of combustible gases will not burn, and probably the same tendency to incombustibility is even more marked with coal dust and cinder. It is quite conceivable that the fine unburnt fuel blown from the grate, being greatly diluted with a large supply of air and a still larger quantity of inactive gases, cannot burn because the conditions are unfavorable. Additional experiments are necessary, and should it be found that a combustion chamber after the furnace does not work as expected experts will have to work out an effective substitute.

Another point to be discussed is radiation; very little is really known, experts accept the conclusions laid down by Stefan and Boltzmann, who have formulated a law as follows: That the radiation is proportional to the fourth power of the absolute temperature of the fire surface. It is from this basis that Prof. Nicholson works out the temperature of the fire and the radiation. Both, he states, increase up to a rate of about 70 pounds of coal burnt per square foot of grate per hour; but resulting from the loss due to incomplete combustion in practice the maximum radiation is calculated to occur between 30 pounds and 40 pounds rate of combustion, and then it amounts to 20 percent of the total heat in the coal, that is about 30 percent of the heat received by the boiler. It follows from the above that radiation from the fire to the boiler tubes and plates should be permitted to the fullest extent, which, however, prevents the use of a firebrick-lined furnace. An expert states that, summing up the furnace and chimney losses in boilers of ordinary design, the best efficiency is obtained when burning from 25 pounds to 30 pounds of coal per square foot of grate, and it is then 73 percent. This theoretical figure and actual results are practically identical.

With the new boilers which incorporate the high gas and water speeds principle, investigations have been made into the most economical speed and other working conditions; a comparison can then be made between the new type and the present accepted types on the practical basis of the total costs per annum. Briefly stated, for evaporating 10,000 pounds per hour for 3,000 hours per year, with coal at $1.92 per ton, the inventor, Prof. Nicholson, calculated that the new boiler costs $3,336 per annum, as against $4,104 for a watertube boiler and economizer. Many experts doubt the reliability of such estimates; they suggest that a good many assumptions have to be included, and in the case of an installation of two or three boilers only, the increased complication of the high-speed boiler, with its turbo-fan and force pumps, would be an item for which due allowance does not appear to have been made. No doubt with a large battery of boilers this complication would be of less importance. and in the case of steamers the saving of space and reduction of weight would be advantageous. It must, of course, be assumed that no difficulties would arise from sediment in the gas and water spaces, corrosion and leakage. The inventor alleges that the tests have shown that at high gas and water speeds sediment cannot be deposited to any serious extent. It may be pointed out, however, that in practice even steam turbine blades become furred up. An expert pointed out "that this action is analogous to the 'bird nesting' in marine boiler tubes, the sediment being caught in the eddy formed whenever a fast-flowing stream enters a cylindrical tube or strikes obliquely across a division wall. The same action would occur in the tubes of a high-speed boiler, and might easily lead to the furring up of the ends of both water and gas channels. The evidence on these points and upon the important one of corrosion is unconclusive, and further experiments are necessary to determine them."

Rolling Boiler Tubes.

The following are the ideas of a correspondent of *Power* on rolling boiler tubes:

In my estimation there is a proper time to roll boiler tubes, and proper persons should be set to do the rolling. Speaking of tubular boilers, it is my opinion that if the boiler maker, who is really the proper person to do the work, will look over the boiler as soon as the furnace and combustion chamber have become sufficiently cool and before the boiler is emptied, he will get a more intelligent idea of the necessary work to be done and will be able to determine without question just which tubes are leaking and roll them. In tubular boilers, with the rows of tubes arranged vertically, a tube in one of the top rows only may leak, and the water and dirt from it may run down over the lower tubes. To the inexperienced and not thoroughly practical man there will appear to be an immense amount of trouble, especially if the boiler has been emptied. A great many men cannot start rolling at the topmost leaks and work downward, carefully noting the effect of their work. According to my observation it very often happens that many tubes that never have leaked are rolled unnecessarily, as a result of this inexperience, or the fact that the one who did the rolling did not make note of the work before the boiler was emptied, or after it had been washed out and refilled. I am not advocating work on boilers under pressure when I speak of working on them before being emptied.

Men often make the mistake of not having the inner surface of the tube perfectly clean. Others do not have their expander set so that the rolls will not protrude too far into the tube. Others use a too heavy hammer and slam the pin in entirely too hard the first time. It is easy to ruin a tube in just this way if they only knew it. It is very nice if a boilermaker has a correct idea of the thickness of the tube sheet or head upon which he is working in order that he may set his expander collar properly.

Rolling tubes in any kind of boiler should never be done by guesswork. Carefully note your leaks, roll the tubes just enough to stop them and remember to leave enough material to work on in case a leak should occur in the same place at some future time.

RECOMMENDED METHOD OF APPLYING TUBES AND PREPARING HOLES IN TUBE SHEETS AND CARING FOR TUBES IN ENGINE HOUSES.*

BY JOHN GERMAN, SUPERVISOR OF BOILERS, L. S. & M. S. RAILWAY.

PREPARING TUBE SHEETS.

The holes in the firebox tube sheet should be 1⅞ inches in diameter, as per Fig. 3. The holes in the front tube sheet to be 1/32 inch larger in diameter than outside diameter of tubes. This for new boilers and new tube sheets in old boilers.

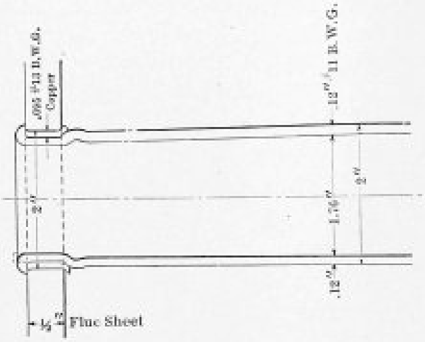


FIG. 1.

The material around the tube holes must be rounded slightly both inside and outside to remove the sharp edges.

Before placing tubes in old sheets, the sheets must be examined for sharp edges at the tube holes, and any sharp edges must be removed. Sheets should be examined for tube holes out of round, and holes that are a thirty-second or more out of round should be reamed.

*From the proceedings of the Master Boiler Makers' Association, 1911.

COPPER FERRULES.

Copper ferrules are to be used only in the firebox sheet. The ferrules should be equal in width to thickness of the sheet, and No. 13 B. W. G. .095 copper to be used.

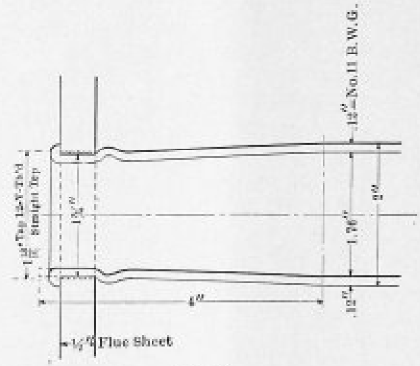


FIG. 2.

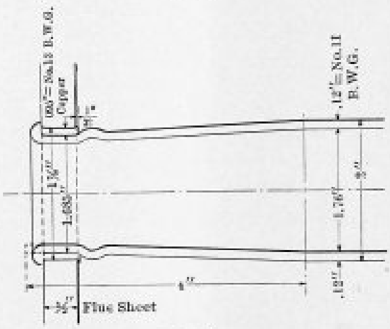


FIG. 3.

They should be placed so that the edge of the ferrule shall be 1/32 inch from the fire side of the sheet. Gage shown in Fig. 5 to be used for this purpose, then expanded so as not to be displaced when the tubes are being inserted.

	Engine No.	New Tubes Applied	Size of Tubes	Size of Hole in Tube Sheet	Size of Copper Ferrules	Cost of Application, Preparing Tube Holes Included	Tube Mileage	To	Date	No. of Tubes Prossered and Rebeaded per Engine	Average No. of Tubes Prossered and Rebeaded per Eng.	Average No. of Tubes Prossered and Rebeaded per 1000 Miles	Labor Cost per 1000 Miles for Repairs	Remarks
L. S. & M. S. RY.	4682	4-19-07	2″	2″	⅝″ x .095	$25.00	45729	7-1-08	3287	4547	8.68	$1.08	
	4691	3-2-07	2″	2″	⅝″ x .095	25.00	58894	7-1-08	5807				
	5840	5-26-07	2″	2″	⅝″ x .095	25.00	16522	7-1-08	1490	2592	101.4	1.27	
	5860	5-31-07	2″	2″	⅝″ x .095	25.00	34619	7-1-08	3695				
	4683	8-13-07	2″	1⅞″	⅝″ x .095	29.88	32366	7-1-08	1400	1400	43.2	.54	
	4680	8-17-08	2″	1⅞″	⅝″ x .095	29.88	2127	7-1-08	100	100	47.	.59	
	5823	5-11-07	2″	1⅞″	⅝″ x .095	29.88	31101	7-1-08	1590	1590	51.4	.64	
	5834	2-19-08	2″	1⅞″	⅝″ x .095	29.88	18532	7-1-08	1360	1360	73.3	.92	
	5818	5-11-07	2″	1⅞″	⅝″ x .095	29.88	37967	7-1-08	3613	3613	95.1	1.18	
	5817	4-12-07	2″	1¾″	None	28.20	42472	7-1-08	1840	1840	43.3	.54	Threaded Holes
L. E. & W. R. R.	5520	10-24-07	2″	1⅞″	⅝″ x .095	30.10	15355	5-1-08	2518	2418	17.07	.26	
	5522	11-20-07	2″	1⅞″	⅝″ x .095	30.10	12972	5-1-08	2318				
	5535	9-10-07	2″	2″	⅝″ x .095	28.65	14199	5-1-08	3577	3677	24.26	.39	
	5524	10-19-07	2″	2″	⅝″ x .095	28.65	16070	5-1-08	3777				
M. C. RY.	7704	4- -07	2″	1¾″	None	18.25	44535	5-1-08	1569	1569	89.	1.34	Threaded Holes
	7711	5- -07	2″	2″	⅝″ x .095	18.25	43924	5-1-08	1375	1375	93.	1.39	
	7953	6- -07	2″	1⅞″	⅝″ x .095	19.70	66435	5-1-08	3322	3322	56.	.84	
	7965	5- -07	2″	2″	⅝″ x .095	19.70	60365	5-1-08	3618	3618	63.	.95	
BIG FOUR	6949	6-12-07	2″	2″	⅝″ x .095	24.37	39030	5-1-08	14241	11946	334.	1.83	
	6917	6-14-07	2″	2″	⅝″ x .095	23.03	37301	5-1-08	9651				
	6636	6-29-07	2″	2″	⅝″ x .095	25.48	23190	5-1-08	9735	10230	451.	2.48	
	6668	6-6-07	2″	2″	⅝″ x .095	28.86	22096	5-1-08	10725				
	6922	6-21-07	2″	1⅞″	⅝″ x .095	23.03	32957	5-1-08	11023	11560	323.	1.77	
	6900	8-27-07	2″	1⅞″	⅝″ x .095	25.74	38573	5-1-08	12097				
	6527	10-21-07	2″	1⅞″	⅝″ x .095	20.28	15114	5-1-08	7280	5347	540.	2.97	
	6559	2-28-08	2″	1⅞″	⅝″ x .095	24.44	4684	5-1-08	3415				

FIG. 4.

When so arranged the copper will be expanded out to be approximately flush with the fire side of the sheet when the tubes are being finished. If the ferrules project beyond the fire side of the tube sheet, the ferrule is bent around between

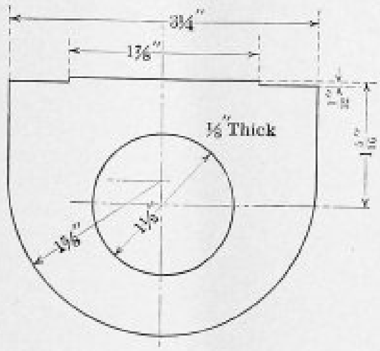


FIG. 5.

the bead of the tube and the sheet, and such conditions should not exist.

There should be nothing there but the bead of the tube and the sheet.

PREPARING TUBES.

Tubes should be swedged to 1 11/16 inches at the firebox end for new tube sheets, and for old sheets with enlarged

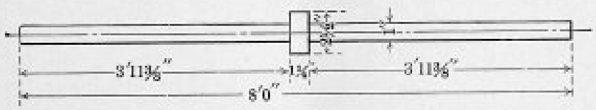


FIG. 6.

holes they should be swedged just enough to enter the copper ferrules.

All scale should be removed from swedged end of tubes before they are applied.

The front end of the tube should be opened on a mandrel to 1/32 inch less in diameter than the diameter of the hole in front tube sheet.

This expanding of tubes can be done when they are annealed, and is done much cheaper than the cost at which liners can be applied.

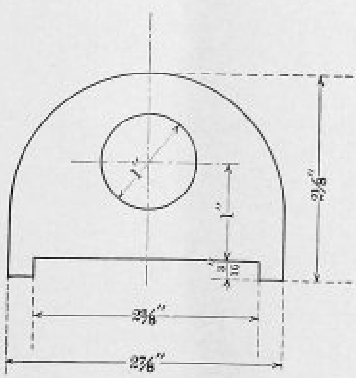


FIG. 7.

If the tube holes in front tube sheet are more than ⅛ inch greater in diameter than the outside diameter of the tubes, liners should be placed between tubes and tube sheet, so that it will not be necessary to expand the tubes to such an extent as to endanger splitting them rolling.

PLACING TUBES IN BOILERS.

All tubes should be placed in position in the holes before any of them are fastened, so that the extra help required to handle them may be dispensed with as promptly as possible.

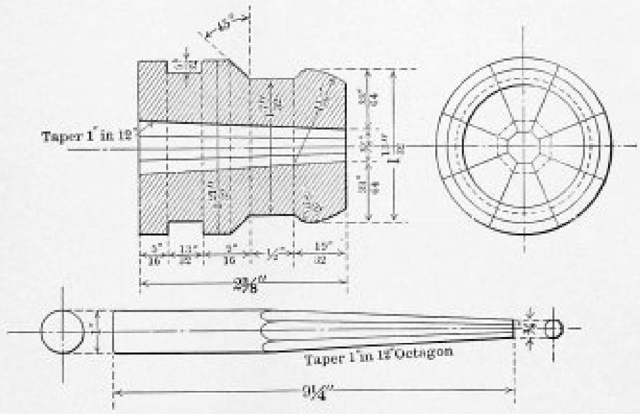


FIG. 8.

FASTENING TUBES IN TUBE SHEET.

Tubes should be driven into back sheet with a bar, shown in Fig. 6. The long shank which enters the tube is provided so that the bar can be readily rammed back and forth to drive the tube into position.

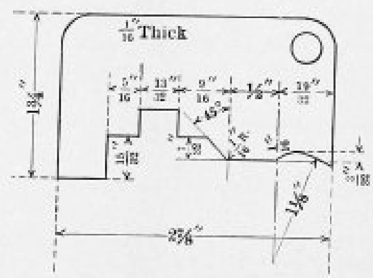


FIG. 9.

The ends of the tubes should project into the firebox to suit gage shown in Fig. 7. This provides sufficient stock for beading. After the tube is driven into position the bar remains in the tube, and a man places his weight on the outer end so as to hold the tube while it is being fastened at the

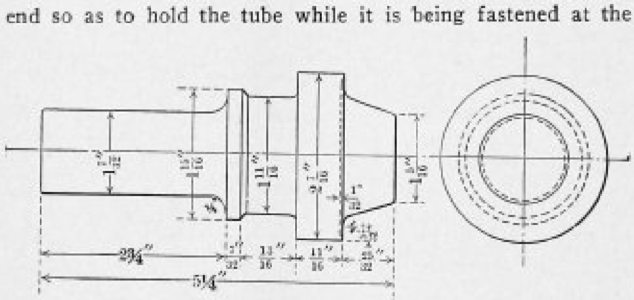


FIG. 10.

back end. The fastening should be done by driving in with a few blows a sectional expander, which has no shoulder on the inner end of the sections, the outer shoulder having taper toward the end of the tube and not abrupt. See Fig. 9. *Sectional expander must be used.*

Having fastened tubes as indicated above the assistant the front end is available for other work.

Master gages for expanders should be used. See Fig. 9.

When expanding tubes, commence in the center of tube sheet. The two center rows vertically should be expanded first to the top of sheet. Then the same rows from the center down to the bottom of sheet, then from center two rows horizontally to right of sheet. Then same two rows from center to left of sheet. This applies to both ends.

Tubes should be flared before they are expanded. This can be done very rapidly with long-stroke riveting hammer and tool for this purpose. See Fig. 10.

EXPANDING TUBES WITH SECTIONAL EXPANDER.

This can be done with jam riveter, long-stroke hammer, or by hand, preference given in the order mentioned.

Care should be taken to have sectional expander conform to master gage. The pin should be driven into expander until tube is expanded solid against tube hole. This should be repeated three times and expander turned slightly before the last two operations.

All tubes should be carefully inspected after expanding, to be sure that recess in tube is the full depth of recess in expander, and the recess even all around the tube.

Roller expanders must not be used in firebox.

BEADING TUBES.

Standard beading tool must be made from master gage. See Fig. 11. (Also tool.)

Small air hammer should be used for beading; the No. 2 Boyer, or one of similar dimensions. Ten percent of tubes may be flared at front end.

CARE OF TUBES IN ENGINE HOUSE.

All tubes should be expanded in each boiler once per month at firebox end, whether they leak or not. This should be done with water out of the boiler, and the sectional expander shown in Fig. 12 used to do the work.

All tubes that are poor or thin should be removed at this time.

In no case should leaky tubes be stopped with roller expander or beading tool.

If in the judgment of the foreman boiler maker beads are slightly away from the tube sheet, beading tools should be used after leaks have been stopped by methods referred to above.

When it is necessary to expand tubes in engine houses, they should be cleaned out so that they will be free from dirt as possible.

Care should be taken to have sectional expander at engine house gaged to know that they conform with the tools that tubes were originally set with. Great care must also be taken to gage beading tools to know that they are not used when spread out of gage. Tools must not be altered in any manner. They must conform to the master gage at all times. Gaging of sectional expander and beading tools should be done at least twice per week.

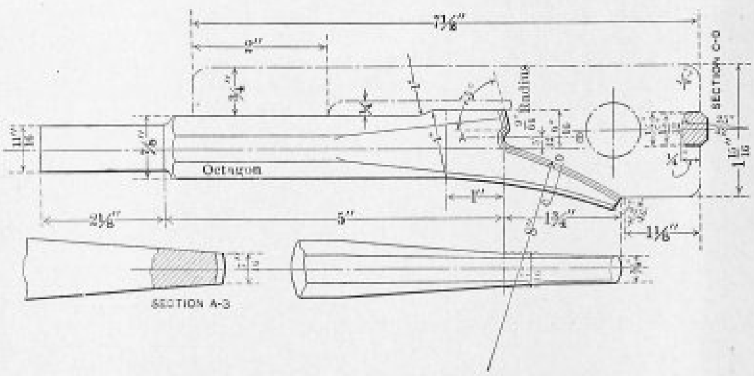


FIG. 11.

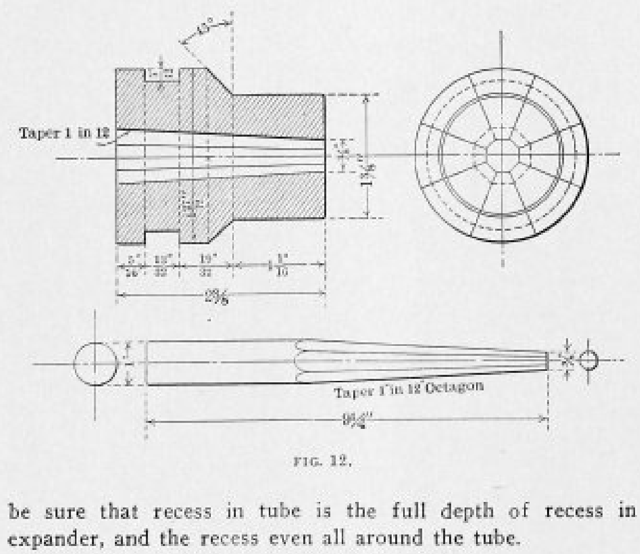


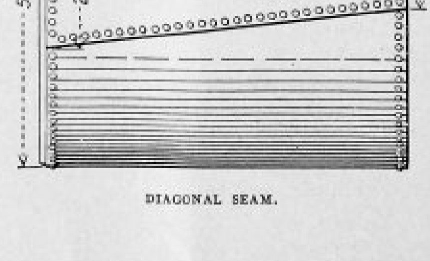
FIG. 12.

Efficiency of Diagonal Seam.

A correspondent asked the following question of the editor of *Power*: A 60-inch shell, built of 5/16-inch plate, having a tensile strength of 60,000 pounds per square inch, has a single-riveted patch for its entire length. The patch is 20 inches wide at one end and 6 at the other. The rivet holes are 11/16 inch in diameter and the pitch is 2 inches. Assuming the rivets to be of steel and the efficiency of the joint to be 41 percent, what increase in efficiency is obtained by the patch seam being slightly diagonal to the axis of the shell?

To this the editor replies:

To find this in a simple manner multiply the length of the



DIAGONAL SEAM.

patch seam in inches by 41, the efficiency of the joint, and divide the product by 60, which is the length in inches measured along a line parallel to the axis of the cylinder. Thus, as the patch seam measured along the rivet centers of the diagonal seam is 60.4 inches $\frac{60.4 \times 41}{60} = 41.27$ percent, the efficiency of the diagonal seam. There is a gain of 0.27 percent in efficiency.

NOTES ON BOILER COVERING.*

While there is no lack of attention on the part of engineers to secure the highest economy in steam-engine machinery, there has been a corresponding lack of appreciation of the importance of the highest economy in connection with the steam generator. Whenever boilers are under steam there is a continual loss of heat, whereas nothing is debited to engines when not turning round.

Although much has been written on this subject, one cannot help noticing the haphazard way many of us regard the serious losses that occur from boiler to engine, brought about by so-called radiation of heat energy. I venture to think that if we could picture more clearly what actually takes place, we should more readily realize the advantages to be gained by the most efficient non-conducting laggings. I appreciate that I am speaking to "live," practical engineers, and will therefore endeavor to present data, of whatever value, in as practical a way as possible. First, let us consider how the losses are brought about. These losses are generally termed losses by radiation. By radiation is meant the transference of heat from one body to another, through a medium which may not in itself be heated.

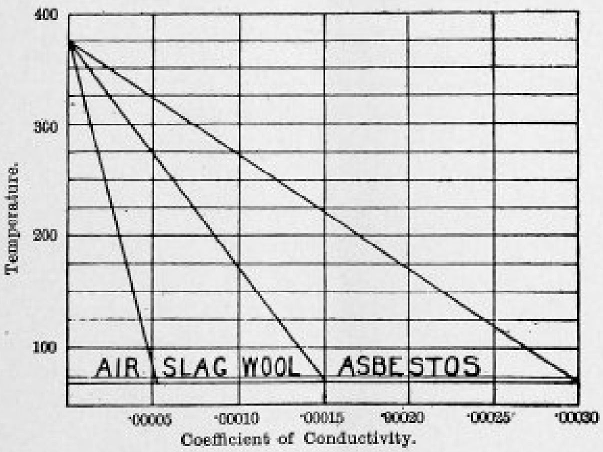


FIG. 1.

I think we may safely assume that the losses through direct radiation from conveyors carrying heat energy in the form of steam are exceedingly small. From an uncovered boiler or pipe the losses are undoubtedly primarily due to conduction and convection. Convection is merely the hustling of heated particles, due to a difference in the specific weight or volume. When the vessel carrying heat energy is lagged, convection is minimized, but in my opinion conduction is increased in the way I will endeavor to show you. My methods of deduction may possibly, to a scientist, appear crude, but an acceptance of the conception will aid the solution of some otherwise unexplainable phenomena met with when investigating the properties of commercial laggings.

Fig. 1 diagrammatically illustrates the path of heat energy through different materials, supposing one end of the material to be heated to a temperature of some 400 degrees F., and a drop through the material, so that the other end is at the temperature of the atmosphere. On the base line I have plotted the coefficients of conductivity. The figures for the materials chosen have been taken from standard works on the subject. You will see that air has a coefficient of conductivity of 0.00005, slag wool 0.00015, and asbestos 0.00030.

If no heat could pass from a column of air otherwise than by conduction along its length, we may diagrammatically illustrate the length of path necessary to obtain a certain drop in temperature, as shown. The same applies to the other materials plotted. It will thus be seen that slag wool and asbestos offer a lower resistance for heat than air, and to obtain the same drop in temperature longer lengths are necessary. An analogy could be taken, and this may appeal to electrical engineers, to the path offered and taken by a current of electricity. If we have two wires of equal cross-sectional area, but of unequal electrical conductivity, in parallel with a difference of potential at their jointed extremities, then to obtain an equal current density in both wires, the wire with the higher electrical conductivity, or lower electrical resistance, must be longer by an amount varying with the relation of the coefficient of conductivity or resistance the one wire bears to the other. Applying this to our materials to be used for heat laggings, in order that the potential difference, or in other words the temperature difference, shall be the same for air as for, say, asbestos, it will be necessary to increase the length of asbestos by an amount equivalent to the difference in conductivity.

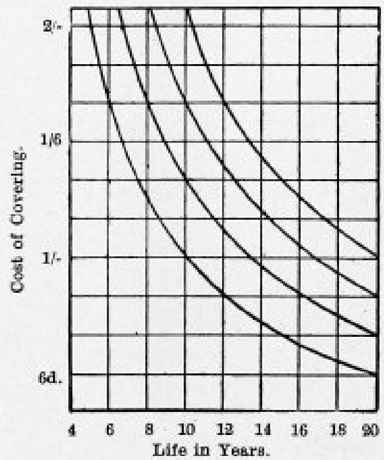


FIG. 2.

It is generally stated that the more air cells present in a covering the more efficient will be the covering. Although this is true, I wish to make it clear that it is not because of the air cells, but because of the longer path, and therefore increased resistance of the material we are using. The total sectional area of the material considerably exceeds the total sectional area of the air cells. If the losses in British thermal units for a particular material be plotted against varying temperature differences, it will be found that most materials give a curve with a gradient decreasing as we approach extreme temperature differences; that is to say, the material is a more efficient non-conducting covering when used at higher temperature differences. This improvement is generally explained by stating that the excess of air is expelled as the temperature rises. Possibly this may be so to some limited extent, but I venture to suggest that it is chiefly due to an increase of resistance or a decrease in conductivity of the

* A paper by A. P. Strohmenger, read at the Institute of Marine Engineers, November last.

material used. Surely the path of least resistance is the governing factor in losses by conduction.

The choice of a covering is not an easy matter. There are many things to be taken into consideration. Life generally governs cost, cost generally governs efficiency, but it does not follow that a covering with a short life and low efficiency is cheaper than a covering with a long life and high efficiency, or even of a covering with a short life and high efficiency. As far as life and cost go we can, with the help of a similar diagram to that shown in Fig. 2, clearly illustrate how a covering low in first cost, but with a short life, may, over a term of years, cost most to maintain than a higher-priced covering with a long life. Assuming the term to be twenty years, and that a covering costing 2s. will last for the whole of this time, we have merely to follow the curve plotted for lower values to the point of intersection to obtain the number of years the cheaper covering will have to last before it can compete with that having a higher value, not taking into consideration any saving which may have been made in plant economy.

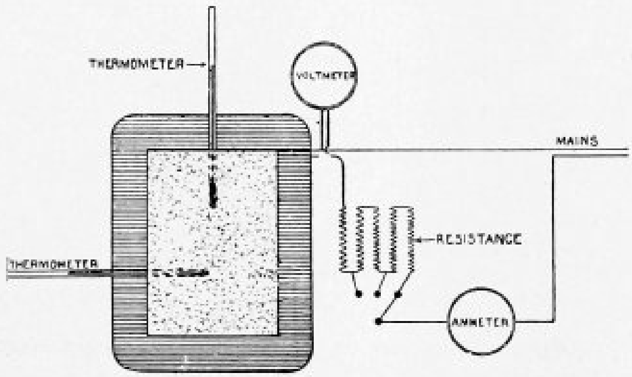


FIG. 3.—ELECTRICAL CONNECTION FOR TESTING EFFICIENCY OF COVERINGS.

This brings us to what should be the principal consideration in the choice of a covering, namely, efficiency. Of late years there have been devised various methods for testing the efficiency of non-conducting properties of commercial coverings. It has been my pleasure during the last ten years to test and report on coverings of every description, and I have found no more reliable method than that of using electrical energy as the source of heat. This method presents many disadvantages over the use of dry steam at constant pressure, weighing the water condensed over a definite period. It is exceedingly difficult to procure perfectly dry steam, and the determinations being somewhat expensive, are not checked to the same extent as they can be by the use of a less costly and quicker method. I personally adopt the method suggested by Mr. Darling in his book on *Heat for Engineers,* and described by me in a report dated a few years previously. The apparatus consists of a piece of steam pipe 12 inches long and 6 inches diameter, the external surface being completely lagged by the covering under test. Mr. Darling suggests an electric lamp with carbon filament for the heater. I prefer to use a long length of wire evenly distributed over the whole internal space. A current of electricity is passed, and can be varied at will by means of the variable resistance shown on the diagram, Fig. 3. The energy necessary to maintain a definite temperature difference between the interior of the lagged vessel and the atmosphere, and therefore the energy lost, is calculated from a knowledge of the current passing in amperes and the potential difference across the terminals of the heater in volts. The drop in voltage, multiplied by the current in amperes, multiplied by the factor 3.42, will give the loss in British thermal units per hour. This, divided by the surface area of the vessel in square feet, will give the loss in British thermal units per hour per square foot covered for the particular covering under test. It is a simple matter to vary the external resistance until any temperature difference desired is obtained. This method enables us to rapidly compare the non-conducting properties of any coverings at any temperature difference. The curves in Fig. 4 show the variation in the heat escaping per square foot of lagged surface per hour, with varying temperature differences. The results were obtained from coverings all 2 inches thick. You will notice the marked improvement in the more efficient coverings with higher temperature differences. I do not propose to cite every covering at present supplied or applied for the prevention of loss from conveyors of heat energy, as such, if possible, would be rather outside the scope of this paper. I have therefore confined my results to a few typical samples. It will be noticed that the figures obtained for magnesia sectional covering and for blue asbestos mattresses are practically identical, and one wonders why good long-fiber white asbestos mattresses are not such good insulators of heat when applied. An examination of

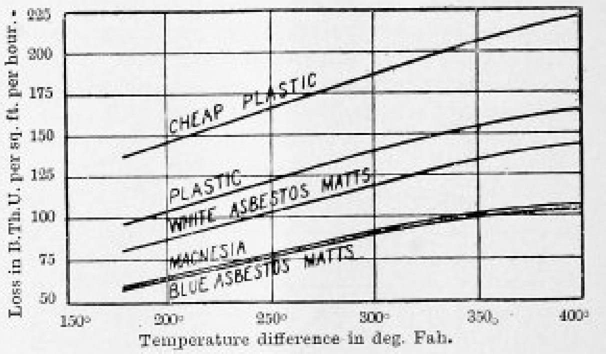


FIG. 4.

the fiber will make this fairly clear. Take a sample of good long-fiber blue asbestos and a sample of pure long-fiber white asbestos. You will notice that the blue fibers are considerably more resilient than the white, and that after compression there is a far greater tendency for the blue fibers to spring apart. If it were possible to give to the white fiber an equal power of resiliency I do not think any appreciable difference in the non-conducting properties of the two materials would be found.

As I understand, magnesia composition is a mixture of carbonate of magnesia and white asbestos; if carefully examined with the aid of a microscope it will be seen in the best samples to consist of small threads of white asbestos entirely enveloped with fine crystals of magnesium carbonate. These crystals prevent the close contact of the asbestos, and therefore the path of least resistance is lengthened.

Laggings in practical use are made up and applied in many different forms. Broadly, they may be divided into four different classes. In the sectional form they are shaped before applying and bound in place, generally by strips of metal. Another class is the mattress form, which consists of a cover, preferably woven from pure asbestos, containing the material which is to function as the heat insulator. Unfortunately, this very convenient form of covering allows of a considerable amount of unfair competition. The cover should consist of a strong, pliable woven asbestos. One often meets with covers containing as much as 25 percent of combustible material. A common practice is to use a vegetable fiber in order to assist in spinning short-fiber asbestos. This is undoubtedly a bad practice, and should be condemned, for sooner or later the cover will go to pieces, owing to the decomposition of the organic matter present. Pure long-fiber asbestos, sufficiently strong to allow rough handling and of being walked upon, appears to me to be absolutely necessary. The material used for filling the mattress, if of asbestos, should also be of long fiber, in order to obtain the highest efficiency. On the table are varying grades of fiber, and it can be readily seen that a material more in the form of powder cannot hope to compete with the fibers of greater length. Rope covering, really an offspring of the mattress type, appears to be exceedingly convenient for pipe covering. It is very important in this form to have the plaiting as loose as possible. It is again the question of the path of least resistance. The more the material is consolidated the greater the cross-sectional area of the pathway for heat. Bends are exceedingly simple to cover with rope covering, and for pipes of small diameter there is probably no more efficient mode.

The plastic form of covering is doubtless the cheapest variety, and can be, and often is, very bad. On the other hand, there are plastics which are very good. As a class, plastics are not such efficient heat insulators as sectional coverings and mattresses, although many of the good plastics are better non-conducting coverings than poor sectionals and mattresses. For permanent work a plastic is often economical owing to its cheap first cost, but as its removal entails the destruction of the covering the economical consideration is governed by the permanency of the job. It is necessary, for the correct appli-

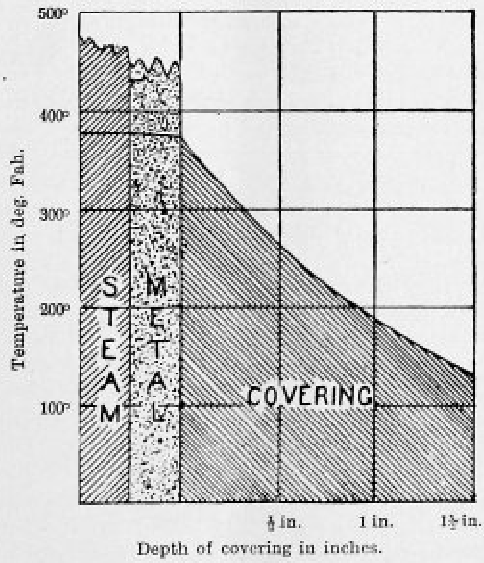


FIG. 5.

cation of the plastic form of covering, to have the metal surface to be lagged perfectly clean and at a moderate temperature. I need hardly remind you that there is a lot of rubbish at present sold as such and such a plastic, and which, to apply, is absolutely false economy. Coverings composed of clay mixed with straw, hay, dung and other objectionable substances are not worthy the cost of fixing.

The temperature of the outside of a covering is not an indication of the efficiency of the covering. Fig. 5 illustrates the fall in temperature through a covering when the temperature of the pipe surface is at about 400 degrees F. It will be noticed that the temperature falls to about 100 degrees F. with the particular covering tested. If the temperature of the pipe surface were some other figure, the gradient of the curve would alter, but the surface temperature of the covering would be little altered. The only correct method for ascertaining the outside surface temperature of a covering is to take the temperature at various known depths and plot a curve. The general shape of the curve will probably be the same for all coverings of equal efficiency, although the end of the curve for temperature near the outside of the covering will vary according to whether the surface is rough or smooth. A thermometer applied to the outside gives quite an erroneous result as a guide to the efficiency of the covering. The rougher the outside surface the quicker will the heat disperse. It is

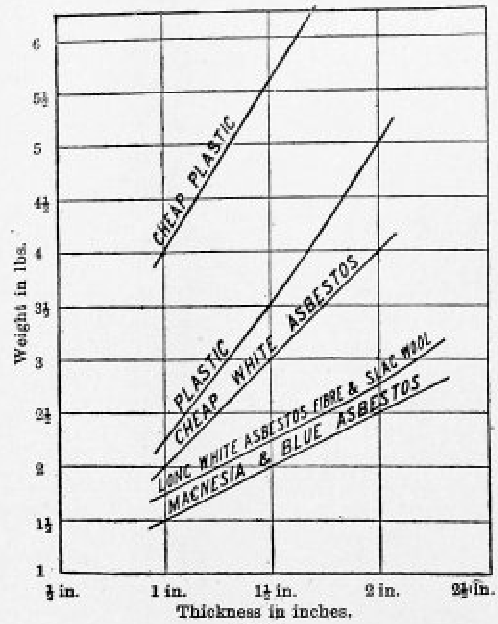


FIG. 6.

therefore advantageous to have all surfaces finished smoothly, although they may then feel hotter to the hand. The curves in Fig. 6 illustrate the variation in weight of some typical coverings for different thicknesses. It is always desirable to have a light covering, as heavy coverings often put strains on pipes altogether unallowed for by the designer of the plant.

Summarized, the properties of a desirable covering may be as follows:

It should offer a high resistance to the passage of heat.

It should be capable of being easily removed.

Its efficiency should not be impaired by variations of temperature, the action of steam or water, vibration, rough handling or physical and chemical changes over a term of years.

Its specific weight should not be so high as to place an undue strain on the steam pipes.

It should have no action on the metal surface lagged, even with the presence of steam and water.

It should be non-inflammable.

Its specific heat should be as low as possible, so that the covering may arrive at its full efficiency as soon as possible after starting cold, and absorb the minimum amount of heat.

A lagging possessing all these qualifications to a maximum degree, if such were possible, would, of course, be desirable. I will not venture to suggest that any covering is perfect, and think I should serve no useful purpose in dwelling further on the subject. If I have in any may kindled a spark in a new channel of thought, however improbable it may be deemed, I shall have succeeded in my endeavor to call the attention of engineers to the fact that there really are British thermal units to be saved, and economically saved, by the adoption of more efficient coverings for boilers and steam pipes. Once this is realized I feel certain that some of the ridiculous specifications of to-day will soon be a thing of the past.

UNUSUAL LAYOUT FOR AN IRREGULAR ELBOW.

BY PHILLIP A. ROSS.

The following is a description of the methods used in developing patterns for an irregular elbow. The elbow, as shown, is a section of a large pipe order received by our works, and the elbow is a transition piece connecting the oblong portion of the pipe with the round. The drawings as received by the layerout gave no radius for the center line of the elbow, so it was decided to hold the figures for the off-sets and the over-all length of the elbow exact and find arcs for the center line of the elbow so as to make the ogee as gradual as possible. An angle-iron joint was needed at a point about 7 feet from the oblong end of the elbow, and it was decided to make the pipe round at that point. The transformer part of the elbow was made in three courses, as shown in the elevation, and in order to simplify the layout the seams were placed horizontally where it was possible to do so.

To lay out the different courses in this piece of work it is necessary to draw a side and end elevation, full size if possible, and locate the circumferential seams so as to make the job as uniform as possible. In this case the transformer section of the elbow has been divided into three courses, the cylindrical section in four courses, with one course of oblong pipe at the bottom.

To lay out section A draw the plan view as shown in Fig. 1. Draw center line *R-R*, and on this line draw an oblong 18½ inches by 48 inches, also draw center line *N-N* parallel to *R-R*, and at a distance from *R-R* equal to distance *R* in the end elevation also draw center line *S-S* bisecting the oblong. At a distance from *S-S*, equal to distance *O* in the side elevation, draw center line *M-M*. The intersection of center line *M-M* and *N-N* will be the center of the upper end of course *A*. From this point as a center draw an oblong whose major axis is equal to distance *C* (Fig. A, side elevation) and minor axis equal to distance *F* (Fig. B, end elevation). Note that the outline of the upper end of course *A* was assumed to be a true oblong, and the half circles were described with a radius equal to half the distance *B* (Fig. B, end elevation). This was done to avoid a lot of unnecessary developing to find the true outline, and it answered the purpose just as well.

Divide the semi-circles, Fig. 1, into the same number of equal spaces, and connect points thus located with full lines, as 1-1′, 2-2′, 3-3′, etc. Also draw dotted lines from 1-2′ to 2 to 3′, 3 to 4′, etc. Also draw full lines from *A* to *A′*, *B* to *B′*, *C* to *C′*, etc., and dotted lines from 1′ to *A*, *A′* to *B*, *B′* to *C*, etc. Then take distances 1-1′, 2-2′, 3-3′, etc., and set off to the right of the vertical line *O-O′* in Fig. 2. Also take the lengths of dotted lines 1-2′, 2-3′, 3-4′, 4-5′, and set them off to the left as shown in Fig. 2. Draw lines from these points to the apex *O*. The height *H* is made equal to distance *H* (Fig. A, side elevation). This gives the true lengths of triangles.

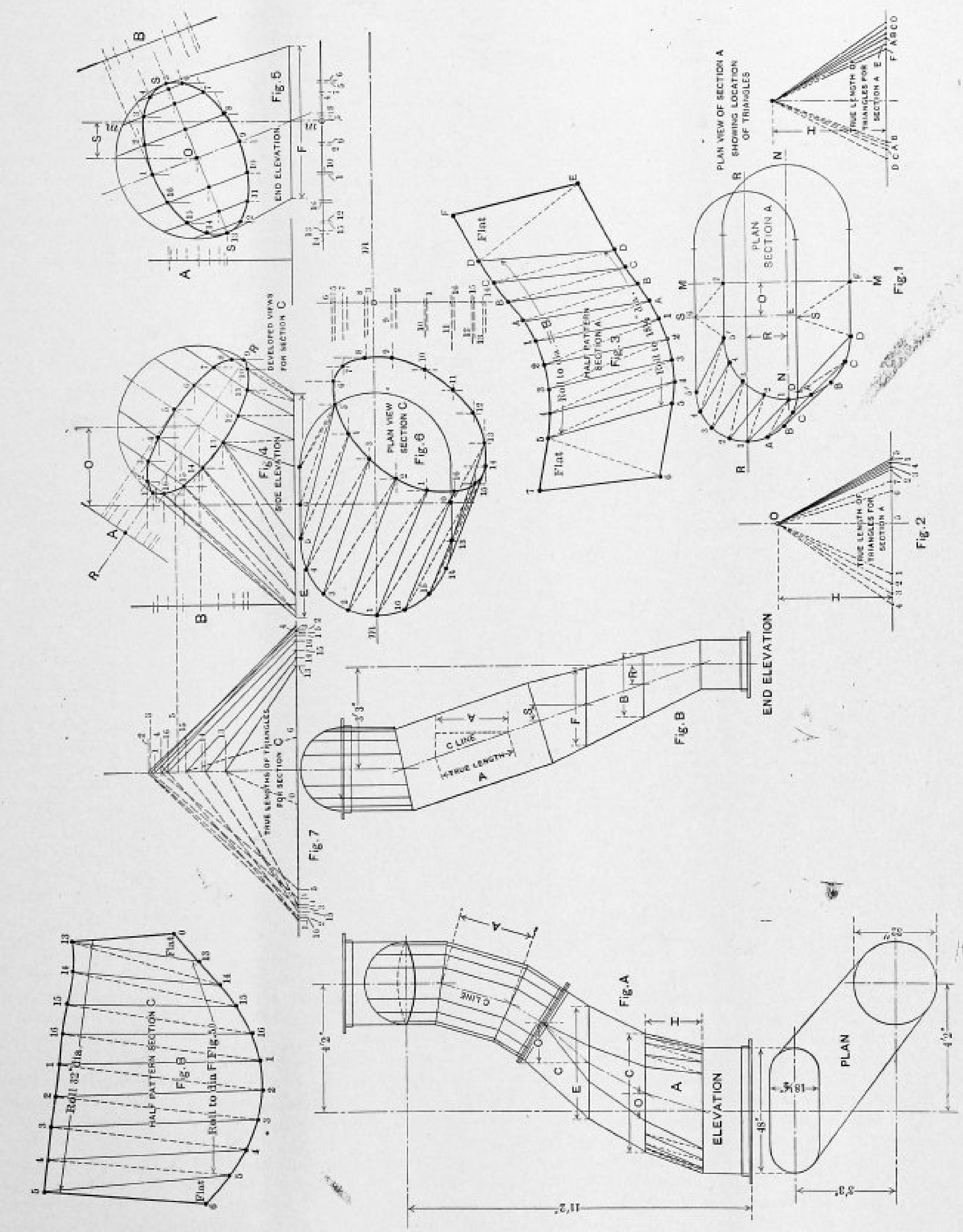
To lay out the pattern, set trams to the distance 1-*O*, Fig. 2, and strike an arc from any point 1 on a straight line, locating point 1′, then with dividers set to the distance 1′-2′ on the semi-circle, Fig. 1, and with 1′ as a center strike an arc, then with trams set to distance 1-*O*, Fig. 2, and with point 1 as a center strike an arc, intersecting the first arc and locating point 2′. Next, with trams set to the distance 2-*O*, Fig. 2, and with 2′ as a center strike an arc; then with dividers set to the distance *A*-1, and with 1 as a center strike an arc intersecting the previous arc, locating point 2. The other points are located in the same manner, taking the numbers in rotation until we come to points 5-5′. Then with distance 5-6, Fig. 1, as radius, and point 5, Fig. 3, as a center strike an arc, then with the trams set to distance 6-*O*, Fig. 2, and with point 5′, Fig. 3, as a center, strike an arc intersecting the previous arc and locating point 6. Next set the trams to the distance 5-7, Fig. 1, and with point 5′, Fig. 3, as a center, strike an arc. Then with trams set to distance 7-*O*, Fig. 2, and with 6, Fig. 3, as a center, strike an arc intersecting the previous arc, locating point 7. Connect 5′-7′-6-7′ and 5-6 with straight lines, also connect points 1′-2′-3′-4′-5′, drawing the lines with a steel flexible strip, bending it to the proper curvature. Points 1-2-3, etc., are found in the same manner, and the other half of the pattern is developed in the same manner. Note that the points are marked with letters instead of figures. This was done to avoid confusion. This completes the pattern for one-half of course *A*. The other is developed in the same manner. It should be remembered that the pattern is developed to rivet lines, and that the lap must be added for ¾-inch rivets. The upper part of the pattern is rolled to a diameter equal to *B*, end elevation. The lower part is rolled to 18½ inches diameter.

The next course, *B*, is developed in the same manner, so no further description is needed. To lay out the pattern for course *C* it is necessary to develop three different views before working lines can be obtained. The lower end is an oblong, whose major axis is equal to distance *E* in the side elevation, and the minor axis is equal to distance *F* in the end elevation. At the upper end a 3-inch by 3-inch by ½-inch angle-ring, 32 inches diameter, is wanted, and the upper end of course *C* must be layed out so that the face of the angle-ring will be at right angles to the center line in the side elevation and also in the end elevation; in other words, the regular elbow comprising the four top courses must follow the center line, as shown in the side and end elevations.

It will be noted that the upper end of course *C*, as shown in side and end elevation, is not a true view, and it must be developed to obtain the true outline. Draw Fig. 4 exactly as shown at *C*, side elevation. Also draw Fig. 5 as shown at *C*, end elevation. Draw a semi-circle from centers *O* in Figs. 4 and 5, and divide into the same number of equal spaces, in this case eight. Project points thus located through center line *R-R*, Fig. 4, also project the points on the semi-circle through center line *S-S*, Fig. 5. This gives us points to develop the elliptical outline shown in both views. Project points from center line, Fig. 4, horizontally to vertical line, as at *B*. Project points from center line, Fig. 5, to vertical line *A*; then mark points on vertical line *A*, on a strip, and project these points as shown at *A*, Fig. 4, intersecting the parallel lines previously drawn, thus locating points for the ellipse in Fig. 4. Take the points from vertical line *B*, Fig. 4, and project in the same manner as shown at *B*, Fig. 5, thus locating points for ellipse in Fig. 5. Draw the ellipse as shown, and number the points as 1-2-3, etc., to 16, Fig. 4. Now it will be noted that course *C*, as shown in Fig. 5, is turned a quarter way around from its position as shown in Fig. 4, and the figures as 1-2-3, etc., remain in the same positions.

Now draw Fig. 6, which is a plan view, directly under Fig. 4. First draw the center line *m-m*, and on this center line draw an oblong with a major axis equal to distance *E* and minor axis equal to distance *F*. The semi-circles are drawn with a radius equal to half of distance *F*. Now project lines downward of indefinite length from points 1-2-3-4-5, etc., Fig. 4. Also project lines downward from points 1-2-3-4, etc., Fig. 5, to a horizontal line as shown in Fig. 5. Now transfer these points on a strip, and project horizontally as shown in Fig. 6, taking care that the intersecting point of the vertical center line *m-m*, Fig. 5, is placed on horizontal line *m-m*, Fig. 6. Now the intersection of these lines with the lines previously projected from Fig. 4 locates the points for the ellipse in Fig. 6, taking care that the corresponding lines intersect each other; that is, horizontal line 1 must intersect vertical line 1, horizontal line 2 must intersect vertical line 2, etc., until all points are located for the ellipse. Next divide the semi-circle into eight equal spaces and number as shown at Fig. 6, as 1′-2′-3′, etc. Connect points 1′-1, 2′-2, 3′-3, etc., with full lines and 2'-1, 3'-2, 4'-2, etc., with dotted lines. Also connect 16'-16, 15'-15, etc., with full lines and 1'-16, 16'-17, 17'-18 with dotted lines.

Take the lengths of dotted lines 2'-1, 3'-2, etc., and set them off to the left of the perpendicular line in Fig. 7, then project points on the ellipse, Fig. 4, to the perpendicular line, locating



VIEW OF AN IRREGULAR ELBOW, WITH DIAGRAMS, SHOWING LAYOUT OF THE COURSES.

Next erect a perpendicular line as shown in Fig. 7. Take the lengths of full lines 1'-1, 2'-2, etc., from the plan view, Fig. 6, and set them off to the right of the perpendicular line.

the heights of the different triangles, as shown at Fig. 7. Connect points 1'-1, 2'-2, 3'-3, etc., with full lines. The points 2'-3,-4', etc., on the left of Fig. 7 and points 1-2-3, etc., on the perpendicular line are connected with dotted lines, which form the true lengths of the third sides of the triangles.

To lay out the pattern, set the trams to the distance 1′-1, Fig. 7, and with any point 1′ on a straight line as a center strike an arc, locating point 1. With point 1 as a center, and with trams set to the length of the dotted line 2′-1, Fig. 7, scribe an arc near point 1′. Then with dividers set to equal spaces 1′-2′-3′, etc., Fig. 6, and with point 1′ as a center scribe an arc intersecting previous arc, locating point 2′.

With trams set to distance 2′-2 and point 2′ as a center scribe an arc near point 1, then with dividers set to equal spaces on the semi-circle, Fig. 4, and point 1 as a center, scribe an arc intersecting the previous arc, thus locating point 2. Locate the other points in the same manner until points 5′-5 are located, then with trams set to distance 6′-5, Fig. 7, and with point 5, Fig. 8, as a center scribe an arc near point 5′. Then with trams set to distance 5′-6′, Fig. 6, and point 5′ as a center scribe an arc intersecting the previous arc, thus locating point 6′. Draw straight lines connecting points 5′-6′-5; also draw lines with a flexible strip connecting points 1′-2′-3′, etc., at the bottom of the pattern and 1-2-3, etc., at the top of the pattern; this completes half of the pattern shown at Fig. 8 to rivet lines. Lap must be added for ¾-inch rivets. The other half of the pattern is developed in the same manner, so no further explanation is necessary.

The elbow in four sections, as shown in the side elevation, is 32 inches diameter and is layed out by parallel lines in the usual way. It will be noted that the view of the elbow at the side elevation is a foreshortened view, and it will be necessary to get the true length of the center line of each section. To find the true length, draw a vertical line from any point on the center line of the end elevation and let the distance A' equal the length of center line A. Square over as shown, and the hypotenuse of the triangle forms the true length of center line A.

SPOTTING HOLES IN A DOME LINER.

"If I only knew how to spot the holes in a dome liner, life would be easier with me," was the startling opening sentence of a letter received by the writer a short time ago from a young man who was employed as layerout by a boiler manufacturer. He sent a number of sketches of the methods he had tried, none of which, he said, had given satisfactory results, and wanted to know of a method, if one existed, to help him out. Such a method does exist, and the purpose of this article is to present it to the readers of THE BOILER MAKER.

In all work, regardless of the character, there are "short cuts," some of which are applicable at all times, and others are of a limited character. The "short cut" presented in this article is, as far as the writer has been able to observe, applicable to all types of boilers constructed with the flanged dome base, as shown in Fig. 1. The dome base, naturally, is

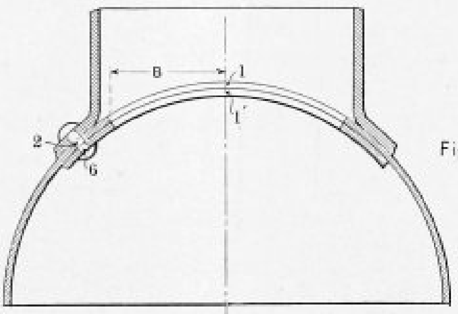
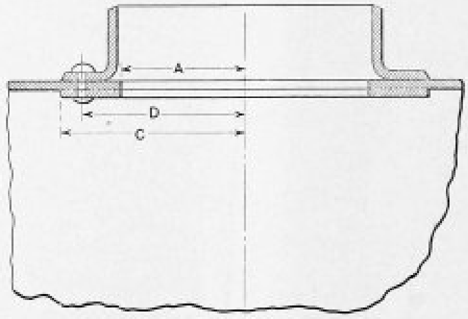


Fig. 1



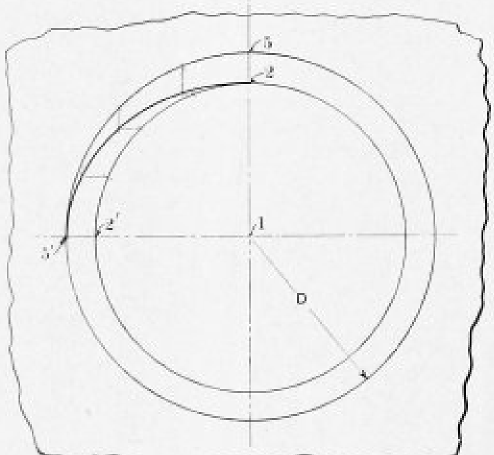


Fig. 4

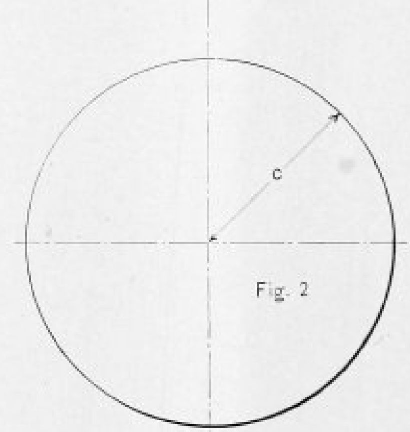


Fig. 2

attached to a curved surface, and by rolling the sheet to a circle, a perfectly round hole in the sheet when in the flat, will have a major and minor diameter, as indicated by the letters A and B, Fig. 1. If it is desired to have the diameters of the hole in the shell sheet the same in both the longitudinal and transverse planes, then the hole in the dome sheet or course must be made elliptical in shape when the sheet is laid out flat.

This was formerly done by many layerouts, and, in fact, is to-day, but the introduction of the detachable dome base, or collar, which is usually 1 inch or more in thickness, brought about a change. It is customary now to make the dome base round, as indicated in Fig. 2. This permits it to be beveled readily for calking purposes on a boring mill or similar machine. Incidentally it permits buying a sheet less in diameter for the dome base, this not being possible if the dome base is laid out elliptical in shape.

The laying out of the dome base to a true circle has necessitated the laying out of the rivet line in the dome course for the dome base other than on a circle as formerly. One plan used (in fact the plan used by my correspondent) was to lay out the dome base, Fig. 2, making the radius *C* equal to *C* of Fig. 1. This took care of the dome base itself, and now for the development of the hole in the dome course. First, he drew the outer circle of Fig. 3, making the distance *C* the same as the distance *C* of Figs. 1 and 2. This denoted the outline of the dome base sheet in the flat. Then the inner circle was drawn, making the distance *D* of Fig. 3 equal to the distance *D* of Fig. 1. This denoted the rivet line, or rather the supposed rivet line. The dome base having been laid out to a true circle and then to be flanged, would be the very nature of things requiring that the rivet line of the dome course be laid out elliptical in shape. Hence the practice of my correspondent was to ascertain the distance from points 1 to 2, Fig. 1, and lay this distance off as shown in Fig. 3. The distance between points 2 and 3, Fig. 3, is what my correspondent called the "draw-in," and then from points 2 to 4 he drew an irregular curve—usually free-handed. The irregular line is shown dotted in Fig. 3. This in a general way filled the bill, for the practice was to mark the holes in the dome base from the holes in the dome course. Naturally, the free-hand drawn curve of each quarter varied somewhat, but not sufficient to have any practical bearing.

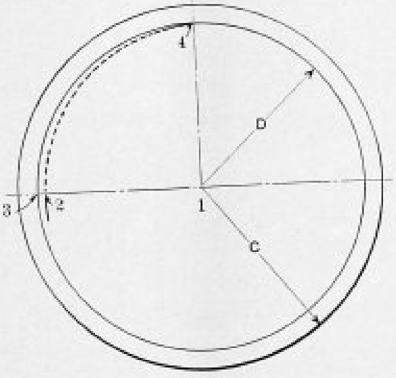


FIG. 3.

One of the difficulties my correspondent complained of was the fact that the size of the boilers and domes varied, and, accordingly, the "draw-in," the distance between points 2 and 3, Fig. 3, varied considerably. The greater the distance the more difficult it was to draw the irregular curve from points 2 to 4, Fig. 3, alike, or nearly so, on each quarter. Furthermore, many of the boilers had an inner liner, the same being indicated in Fig. 1, and the object sought was not only to lay out the holes in the dome course but also in the dome liner in the flat, so that when it was rolled to its correct shape the holes in the dome course and the dome liner would match, thus doing away with the marking off of each dome liner from the dome course, as was then their practice.

The solution to this matter was most simple, and is indicated in Fig. 4, the same being drawn out of scale for the purpose of illustration. First, let it be said that the method as used to develop the rivet line in the dome course is the same as to develop the rivet line in the dome liner. The circle by the distance *D* is first drawn, the distances *D*, Figs. 1 and 4, to be the same. Then the distance from 1 to 2, Fig. 1, is taken and transferred to Fig. 4, as shown. Then with trammels set equal to the distance 1 to 2, Fig. 4, draw the small circle as shown. The remarks will now be confined to one quarter, for what is true of one quarter in this problem is true of the balance. The distances from 2 to 2' of the inner circle and 5 to 5' of the outer circle are then divided into the same number of equal spaces—any amount—the more, the more accurate the layout. From the newly-found points on the outer circle project vertical lines, and from the newly-found points on the inner circle project horizontal lines, and where the respective lines intersect will be the points to locate the irregular lines from points 2 to 5', Fig. 4. The illustration, Fig. 4, is merely to indicate the method of developing the irregular line. When the dome liner rivet line is to be located, the distance from 1' to 6, Fig. 1, will be the minor measurement of the elliptical-shaped rivet line. In short, the minor measurement of the elliptical-shaped rivet line of the dome course will be the distance from 1 to 2, Fig. 1, and for the dome liner the distance from 1' to 6, all other measurements being the same in both cases. The holes are then stepped off equal spaces on the irregular line from points 2 to 5' in the dome course, and in a like manner on the dome liner (pattern not shown), the only difference between the pitch of the holes in the dome liner will be a fraction less. This method, if the irregular line is carefully developed and the holes spaced off equal spaces and properly punched, will make the holes as fair as the holes in the girth seam, etc.

THE GAS-STEAM BOILER.

BY JOHN JASHKY.

A number of Russian engineers have proposed to use the products of combustion of a boiler, turning them with steam into the engine, thereby obtaining some advantages. By so doing more steam is evaporated and the engine is worked by the use of steam mixed with these gases, thereby increasing its efficiency, as the steam is superheated by contact with the hot gases, consequently efficiency of engine will be better. As the heat will be transmitted more directly, therefore the boiler will be simpler in construction, easier to build, the effect of heating service becomes greater, and there is no formation of scale to cause uneasiness and at the same time very nearly the same pressures will be obtained in the boilers, and, further, hard water, and even sea water, may be fed into the boiler without being purified. Another important gain is that in vessels of war no smoke-stack will be required. Against these advantages, however, there are considerable disadvantages which might prevent the development and the final building of this peculiar type of boiler.

There is the difficulty of obtaining a perfect combustion, and the furnace has to be so constructed as to stand the same pressure as the boiler, and the fire can only be observed through peep holes. There is little difficulty in obtaining a fuel, as we now have both gas and liquid fuels, and this eliminates some of the difficulty. In order to burn coal a very complicated apparatus would have to be used, which would mitigate against the safety of the plant. In order to burn coal in the boiler it would be necessary to provide a compressor plant, thus adding to the cost of erecting and working, and the apparatus would demand complicated details in valves, etc., which are difficult to maintain under good working condition. These difficulties resulted in only one type of boiler being turned out in a Russian shop, and this was placed on a small vessel of war. Up to 1908 twenty-one patents had been issued to the patentee, who is Mr. R. Schmidt, engineer in St. Petersburg, and the patents are now being used by a company formed for the purpose of exploiting the boiler. A satisfactory working of the Schmidt boiler is only possible by the use of naptha and the employing of a good filter or purifier for the gas and steam mixtures.

On working the first boiler it was observed that much soot was found in the mixture—so much, in fact, that the engine could not be satisfactorily run. In Russia, naptha is a fuel that is made in large quantities and of very good quality, and it is cheap. Fig. 1 shows the Schmidt boiler.

The boiler is of the Cornish type, two domes *A* and *R*; the

The boiler is divided into compartments, which contain water, steam, gases and a mixture of steam and gas. The water cools the plates of the furnace of the receivers *C* and

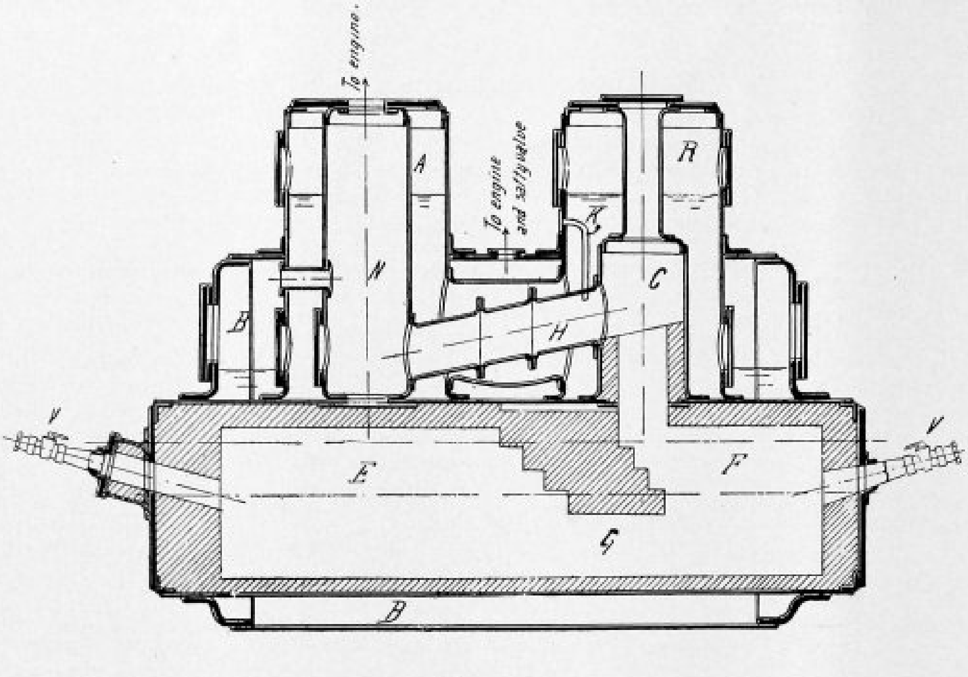


Fig. 1.

THE SCHMIDT GAS-STEAM BOILER.

firebox is in front and lined with the best firebrick or magnesia. In the front and back are the peep holes for observing the fire, and at the ends are placed the apparatus for feeding compressed air *V V*. The gases pass under the fire-bridge from the firebox, *E F*, and into the receiver *C*, and through the

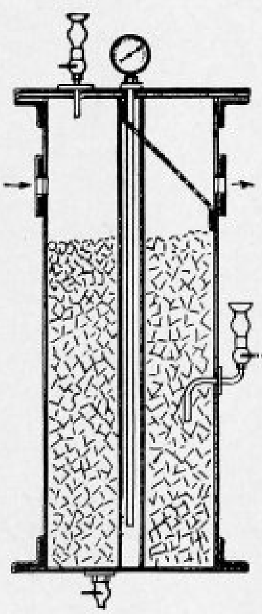


Fig. 2

GAS FILTER.

pipe *H*, and here the gases receive the liquid fuel through the pipe *K* and thence on to the receiver *N*. In passing the feed-water pipe they evaporate the feed-water superheating the rising steam and drive it into the receiver *N*.

N, and in the pipe *H* prevents these from becoming overheated. The compartment containing only steam can be connected directly with the steam pipe leading to the engine. By turning the naptha into the compressed air it is possible to perfect the combustion. The temperature of the gas is high. Mr. Schmidt claims the temperature in the receiver *C* rises to 2,200 F., and by feeding water into the dome *A*, 606-950 degrees F. are obtained.

Soot which is carried over with the gases is caught in the filter shown in Fig. 2. This is a cylinder divided into two parts by a plate, and partly filled with coke; the coke being oiled by an oiling device, and this oiled coke catches and retains the soot. At the same time the oil lubricates the steam on its way to the engine. When this filter is used at sea only metal plates are employed and no coke. In a test of this boiler on a boat for mine planting, the engine was driven by the gas and steam mixed, developing 68 horsepower; 32 horsepower was used for driving the compressors. The amount of fuel was 2.6 pounds for effective horsepower and 1.3 for the indicated horsepower. Another vessel, run with an ordinary boiler, required 2.6 to 3 pounds per indicated horsepower. The analyses of the burned gases were as follows: 81.1 percent C, 2.7 percent H, 7.2 percent H_2O, and 2 percent ash.

A Russian shipyard is undertaking to build five of these Schmidt boilers, delivering 500 to 700 indicated horsepower.

A committee on standard rules for care and construction of boilers has been appointed by the American Society of Mechanical Engineers, consisting of John A. Stevens, Lowell, Mass.; Edward F. Miller, Boston, Mass.; Charles L. Huston, Coatesville, Pa.; Herman C. Meinholtz, St. Louis, Mo.; R. C. Carpenter, Ithaca, N. Y.; William H. Boehm, New York, and Richard Hammond, Buffalo, N. Y. It is expected that the recommendations of such a committee for specifications, etc., will be recognized as a standard by legislatures and officials and that uniformity in legal provisions will thus be obtained.

THE BRICK ARCH.*

The brick arch has been in general use since bituminous coal was first used in locomotives, but unfortunately, until a few years ago, it did not keep pace with the progress made by other appliances. Since the brick arch was first tried in the coal-burning locomotives it is well known that the size of the locomotives has gradually increased. The demands of the operating department have also been of such a nature that at times it has been absolutely necessary to dispatch the power on the shortest possible notice, and with the old-style arch it was often impossible to meet the demands for power. For an illustration, should an engine arrive at a terminal with flues leaking, the entire arch had to be knocked out in order that access might be had to give the flues the necessary attention. Taking into consideration the time consumed and the expense of this operation, the advantages gained in the way of fuel economy were often lost sight of on account of the various disadvantages which were experienced from the use of the old-style arch that had received very little attention in the way of improvements for many years. Often serious delays were experienced; faulty design of arches being responsible for the delays. Many failures on the road have been charged to the old designs, resulting in the brick arch making enemies, and the advantages that were gained in fuel economy were often seriously doubted.

The design and construction of the brick arch to-day are the result of several years of close study, painstaking investigations and experiments by men of large experience in locomotive operation, resulting in eliminating the objections that have heretofore existed against the brick arch. The most noticeable improvement in brick arch construction is the sectional arch, the brick being made of small units, and so constructed that certain sections can be removed for flue work and stay-bolt inspection, without interfering with the other portions of the arch, resulting in saving of the arch, whereas with the old style the arch would be destroyed. A saving of time in connection with the installation of new arches is also effected.

The locomotive brick arch is a boiler accessory that has had the attention of railway motive power men for the last fifty years, yet it is only within the last five years that any decided steps have been made toward perfecting this efficient device so that its use could be extended and made practicable under all conditions of locomotive operation. It is apparent from a study of the history of the subject that there have been but few dissenters from the opinion that the locomotive brick arch is a device of considerable merit, yet in the past many, perhaps half, of the locomotive operators have considered it a complication to be avoided. A little light is thrown on this phase of the subject by a recent editorial in *Locomotive Engineering*, which reads as follows: "As long ago as 1885, James N. Lauder, master mechanic of the Old Colony Railroad, made a series of carefully conducted tests to find out the value of the brick arch in locomotive fire-boxes, and the conclusion arrived at was that the arch saved over 15 percent of coal. The Boston & Lowell Railroad people made tests of the brick arch about the same time, and concluded that the arch saved 20 percent of fuel. Yet neither of these railroads adopted the arch. The objection was that it was something extra to look after."

The above quotation mentions but two specific cases, but many other similar instances can be called to mind by any one who has given the subject any considerable study. The so-called complication has been avoided by many in years past simply because it was comparatively an easy matter to do so. But this is not the case at present, and for various reasons; but before giving these reasons it may be well to consider first the chief merits or virtues of the brick arch and the relation of these virtues to the present-day operation.

Other things being equal, the brick arch adds to the boiler capacity by making each square foot of heating surface count for more steam. This on account of the fact that the fire-box temperatures are always found to be increased by the installation of the brick arch.

The brick arch adds to the fire-box capacity and the fireman's capacity on account of the fact that the more complete combustion forces each pound of coal to yield a higher percentage of its total heat units.

The brick arch saves coal because of the better combustion and because of the baffling and retaining effect on the gases and on the fine and light combustible matter, which otherwise would be drawn through the flues in the form of sparks or partly-consumed coal.

The brick arch abates the smoke and cinder nuisance on account of the more thorough combustion, due (1) to the better mixing effect of the gases and oxygen of the air drawn into the furnace chamber, and (2) due to the fact that the longer flame travel gives more time for combustion to be completed before the gases pass into the tubes and are lost. The baffling effect on the cinders is a thing that can be determined, and numerous tests carefully conducted show a very marked decrease in cinder throwing due to the baffling effect of the arch.

The brick arch affords a protection to the flues. This statement can be verified by inquiring of almost any one responsible for the up-keep of flues, who has had opportunity to observe the difference in this respect between arch engines and no-arch engines. The result is due, no doubt, to the fact that wide and sudden variations in flue temperatures are prevented by the presence of the arch. The majority of present-day locomotive specifications include the brick arch. The reasons for this are many, the principal ones being as follows:

1. The growing demand for boiler capacity and fuel economy. This was met in years gone by with larger designs. There was plenty of room for growth in size and weight of boiler and plenty of margin in fireman capacity or endurance. Not so now. These limits are reached, hence the requirements such as brick arches, superheaters and other devices to further extend the capacity of the boiler.

2. The growing public sentiment and demand for economy in railroad operation. The consumers of transportation are putting forth arguments for properly enforced methods of economy, hence any accessory that will yield a net saving of even 5 percent of a railroad fuel bill cannot longer be ignored. A brick arch will give a net saving of from 5 to 15 percent, depending upon the conditions of operation.

3. The growing public sentiment against the smoke and cinder nuisance. The time is drawing near when the public will demand either the suppression of the smoke and cinder nuisance, or the suppression of the steam locomotive. We see this already about congested districts, and as congested districts are growing rapidly, the force of public sentiment on this has to be reckoned with, and brick arches are generally conceded to be a valuable aid in the suppression of smoke and stack cinders.

The brick arch is being used by the railroads in general, especially where there are strict city ordinances governing the emitting of black smoke from locomotives. The arch is recognized as one of the best smoke preventers and as one of the most efficient devices for reducing the quantity of sparks thrown from the stack, and on this account it becomes directly valuable as a fuel saver, by increasing the length of the flame

*A report presented before the Traveling Engineers' Association by a committee consisting of W. G. Towse, J. A. Cooper, J. J. Butler, S. D. Wright and V. C. Randolph.

or the flow of the gases, and the small pieces of fuel lifted from the grate are baffled by the arch and consumed instead of passing directly to the tubes and out of the stack. The use of the brick arch in abating smoke is considered indispensable by many of the large railway systems entering Chicago. It has been invariably shown that the roads using the brick arch have the lowest percentage of smoke. The elimination of smoke results from a more complete combustion of the gases liberated from the coal, which means that if a greater percentage of the gases is consumed from any given amount of coal the saving of coal is worthy of consideration.

The brick arch is recognized as one of the most efficient pieces of equipment in decreasing boiler troubles, and its value in locomotive operation in the latter period of the history of the modern locomotive boiler as a means of further increasing its capacity and fuel economy is recognized by motive power men.

The question arises: What changes are necessary on the draft appliances of locomotives when brick arches are applied to obtain the best results? The conditions to be encountered on the different lines, also the opinions from the members on this matter, are diversified. The quality of the coal, design of front end and boiler, grate area, and the service in which the locomotives are used, vary greatly. There does not seem to be any fixed rule that can be adhered to which will cover all conditions that will be satisfactory to all roads. It is quite evident that the nozzle tips can be increased in size with the application of the brick arch. This is accounted for by a greater percentage of the gases from the coal being consumed. As the function of the brick arch is that of a mixer it brings about a more complete mingling of the gases, thereby aiding combustion and resulting in higher temperatures in the fire-box. These claims have been fully sustained by many experiments made on different railroads. It is quite evident that the above advantages of better combustion will result in fuel economy, and if the nozzle can be opened up, which has been done, according to replies of the engineers, that will also result in fuel economy.

Many of the replies received from the members are very flattering on the benefits derived from the use of the brick arch where water conditions are considered bad, the steam failures having been reduced from 50 to 75 percent. Instances have been cited where locomotives arrived at terminals with flues leaking each trip without the arch, and since the arch has been applied the same locomotives are now making several trips before flues need attention. These favorable results are due to the uniform degree of heat maintained in the fire-box, and elimination of the cold air passing through the fire-box door, being deflected by striking the arch before reaching the flues. The adjustments to permit accessibility for cleaning flues on the sectional arch are made quite easily. The bricks are removed from the bars, and, due to their size, can be handled very easily, and do not have to be removed from the fire-box, the bricks having lost sufficient heat during fire cleaning and movement from pit to round-house to permit the arch being removed as outlined above. Engines equipped with superheaters, with the superheater flues at the top portion of the boiler, need only have the center row of bricks removed to permit of accessibility for cleaning the tubes.

Considerable discussion has taken place within the last few years in regard to whether the arch should extend all the way to the flue sheet, or whether an opening of a few inches should be maintained. As to this we believe no hard and fast rule can be laid down. We do believe that, theoretically, there should be no opening next to the flue sheet, and that all the gases should be made to pass over the rear of the arch. In actual practice, however, there are localities in which conditions are such as to require clearance at the front, and our only recommendation in this regard would be to experiment with the arch tight to the flue sheet, bringing the drafting of the smoke-box to favor it as much as possible, and if, after a thorough trial has been made, success is not met with, use a small spacer block on the tubes. A compromise may be effected by having the middle section tight to the sheet to protect the lower central flues, and the side courses set back to give clearance through which accumulations may be discharged to the grate.

The consensus of opinion is that a poorer grade of coal used with brick arches could not be recommended. As the quality of coal is governed by many conditions most suitable to the road on which it is used, the grade of coal used usually depends upon the point of supply. Many roads endeavor to foster the industries along their own line, and frequently inferior grades of coal are used on this account, when probably more economical results would be obtained if a better grade of coal had been used, which might cost more per ton; but considering car supply, as well as the benefits derived from building up the industries along the line of road, these conditions frequently more than offset the other improvements which might be made by getting a better grade of coal. It has been our experience that there are many instances where the percentage of slack runs very high, the sizes of coal often being separated by being placed on the tanks, increasing the amount of slack on some tanks, and under such conditions the brick arch will give better results than if no arch was applied, due to the many reasons that have already been stated.

A test was made on consolidation engine No. 1014 on the Central of Georgia Railroad. The engine has 21 by 32-inch cylinders, length of fire-box, 136 inches; width, 84 inches. A brick arch, 10 inches thick and 43 inches high, extends across the fire-box, and is 27½ inches from the flue sheet. There are five 3½-inch air ducts placed an equal distance apart, and extending perpendicularly from the bottom, and through this wall to a point near the top, where they open with a 5-inch flare in the back side of the wall toward the fire-door. To the lower end of each of these ducts is connected a 3½-inch pipe, ending just below the mud-ring with an elbow and a 6-inch funnel opening toward the front. The space between the brick wall and the flue sheet constitutes the combustion chamber, and is lined in the bottom with fireclay. It has a spark hopper, to be used for cleaning out if necessary. In running, the air enters the funnel under and in front of the fire-box, and in passing through the brick wall becomes heated and passes into the fire-box at such a height above the fire as to insure a complete mixing with the gases.

During this test the average pounds of coal consumed per 1,000 miles run was 101 and the average per hour 1,991. The water evaporated per pound of coal averaged 8.10 pounds, and the number of miles run to 1 ton of coal averaged 15.38.

From a test which was recently made with a wide fire-box type of boiler on the New York Central Lines to ascertain the efficiency of the brick arch and arch tubes, the following results were obtained:

With brick arch and water bars the equivalent evaporation per pound of dry coal showed a gain or increase of 14.9 percent over the arrangement without brick arch and without water bars, and a gain of 9.3 percent over that arrangement without brick arch but with water bars. Therefore, the increased circulation and heating surface due to the water bars cause a gain of one-third of the 14.9 percent increase, while the brick arch must be accredited with the remaining two-thirds of that increase.

With the brick arch and water bars the actual evaporation per pound of coal showed a gain of 13.1 percent over the arrangement without the brick arch and without water bars, and a gain of 8.4 percent over the arrangement without the brick arch, but with water bars.

With the brick arch and with water bars, the equivalent evaporation per pound of coal showed a gain of 12.9 percent over the arrangement with the brick arch and without water bars, and a gain of 8.8 percent over the arrangement without the brick arch but with water bars.

With the brick arch and with water bars the coal fired per square foot of grate surface per hour was 14.7 percent less than with the arrangement without the brick arch and without water bars, and 7.8 percent less than with the arrangement without the brick arch but with water bars. The boiler of this engine was equipped with four 3-inch arch tubes, had 458 2-inch flues 15 feet 6 inches in length. The fire-box was 75¼ by 105 inches, and the boiler carried a pressure of 200 pounds per square inch.

Progress in Return Tubular Boilers and Settings.

BY WILLIAM KAVANAGH.

Improvements in the design of horizontal tubular boilers and settings have been slow as compared with other types. Those improvements that have been made in late years, however, include dispensing with staggered tubes, leaving out the middle vertical row of tubes, placing manholes above and below the tubes, dispensing with the handhole in the rear head, the proper protection of the blow-off pipe against overheating,

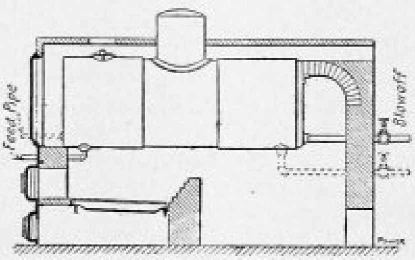


FIG. 1

omitting the steam dome and carrying the boiler on rollers or suspending it from girders.

Fig. 1 represents what may be termed an "old-time" setting in which the feed pipe is attached to the bottom sheet, directly over the fire, the object being to heat the feed-water before entering the boiler. The blow-off is attached to the rear head some distance above the bottom sheet, which arrangement prevents, to a large extent, the mud and scale from being forced out of the boiler. The dotted lines, Fig. 1, represent the feed introduced through the lower part of the front head; also, the proper connection for the blow-off pipe, which is protected by a sleeve or covering of asbestos.

In Fig. 2, the blow-off pipe is protected from overheating by a circulation of water through it. Here, also, the feed is admitted through a water arch, thence through pipe *A* to the boiler at some distance below the waterline.

A progressive step toward utilizing waste heat and preventing cracked walls and falling fronts and rear arches, is shown in Fig. 3. Both front and rear water arches are supplied; the feed, entering at *B*, and after circulating through

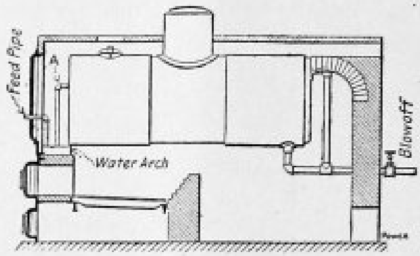


FIG. 2.

the rear arch, which is exposed to the hot gases, passes to the front arch and thence into the boiler, where it is discharged through a perforated pipe. The main blow-off pipe, besides being protected by the circulation of water, is

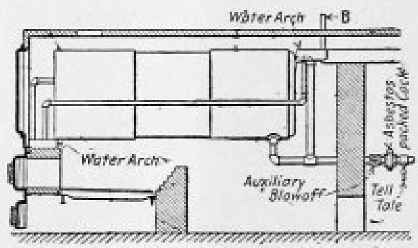


FIG. 3.

fitted with an asbestos-packed cock, an auxiliary blow-off valve and a "tell-tale." When the latter indicates leakage the auxiliary blow-off may be closed and the main blow-off repaired. Previous to the use of auxiliary blow-off valves there was no way of making repairs to the main blow-off cock without shutting down the boiler.

The boiler shown in Fig. 4 embodies the good points gained through many years of experience and represents probably the most up-to-date practice with return tubular boilers. The lugs rest on rollers, allowing free longitudinal expansion and contraction of the boiler, and both front and rear water arches are fitted. The rear wall has a door permitting inspection and

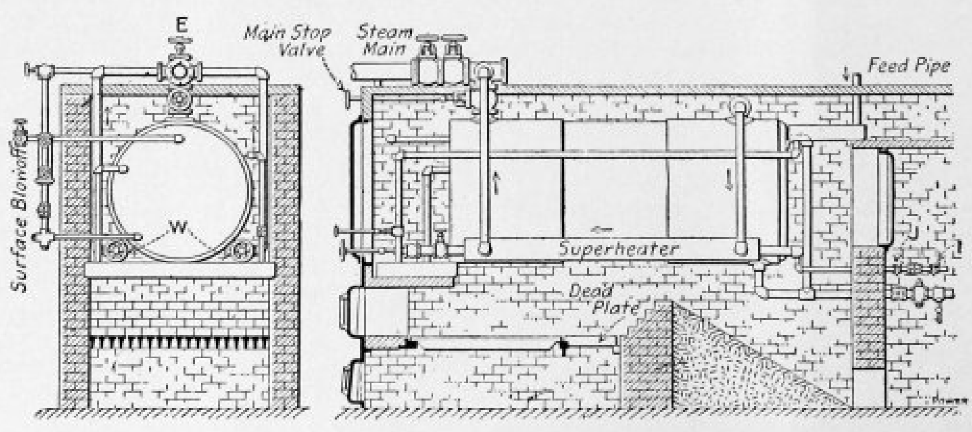


FIG. 4.

cleaning of the rear head. The steam is taken from the rear of the steam space and passes through a superheater extending the whole length of the boiler, thence to the main header, which is also connected directly to the steam space of the boiler. Both an ordinary steam gage and a recording steam gage are fitted.

The furnace is hand-fired, and at the rear of the grate is a dead plate, used for banking and cleaning the fires. The damper shaft is carried on roller bearings, which permit a very sensitive regulation of the steam pressure. A surface blow-off is attached at the front of the boiler, and an improved arrangement of regular blow-off, similar to that shown in Fig. 3, is fitted at the rear.

The water column is fitted with both a high and a low-water alarm in addition to self-closing gage-glass valves. Also, the water connection to the column is fitted with a tee and brass plug for use when cleaning the connection.

In raising steam the valves *W W* are first opened to allow a circulation of water through the superheater, and after the desired pressure has been reached they are closed, and any water in the superheater is blown out at the rear, through the valve *I*. Near this valve is placed a small valve *J*, used to indicate the quality of the steam in the superheater. When this valve shows dry or superheated steam the main valves *E E* are opened, and the boiler is put into service.

The boiler-feed pump should be fitted with a safety valve to prevent excessive pressure on the feed line; also a by-pass, allowing the pump to run at practically constant speed, any surplus water being discharged back into the suction line. The check valve on the feed line should be placed between two globe valves, thus permitting repairs at any time.

An essential feature with the foregoing equipment is that all pipes and fittings are extra heavy, and the connections allow movement and compensate for expansion and contraction. Furthermore, no expansion joints are used, the connections being so arranged as to screw and unscrew in the direction of the stress.—*Power.*

Vacuum Gage Testing Machine.

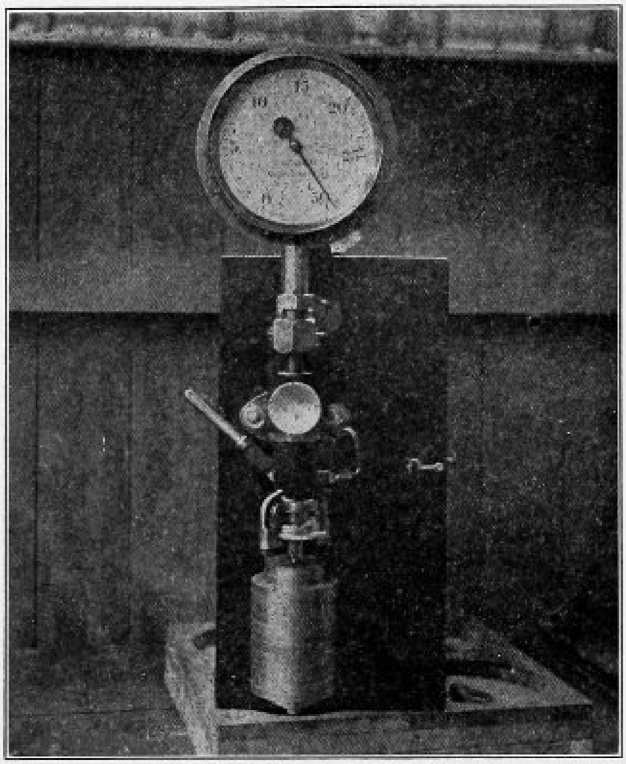
BY FRANK C. PERKINS.

The accompanying illustration shows a novel vacuum gage testing machine constructed at Peterborough, England. This apparatus consists of a small plunger air pump in connection with a cylinder in which a ram works. The cylinder can be connected to vacuum gages, barometric tubes or other apparatus in which absolute pressure is to be determined. It will be noted that the ram carries weights corresponding to any desired difference of pressure inside and outside the cylinder; when the ram and attached weights are sustained by the external pressure the difference in pressure inside and outside the cylinder, and in the connected apparatus under test, is measured by the total weight of ram and weights carried by it divided by the area of the ram. This latter is intended to be 1 square inch. The weights are intended to represent the equivalents of 2 inches, 1 inch, 0.5 inch and 0.25 inch mercury, respectively.

A column of mercury 29.95 inches high at 60 degrees F. represents 14.7 pounds pressure per square inch. The diameter of ram is 1.128 inches and the area .9993 square inch, while 1 inch column of mercury is equivalent to 3,434 grains load on the ram. The weight for 4 inches is 13,734 grains, for 2 inches 6,867 grains, and for one-half the weight is 1,717 grains and for one-quarter 858½ grains. The weight of ram and fixed parts attached to it = 13,734 grains.

It may be stated that the pump has a discharge valve which is submerged in oil in the small tank about it. This tank should always be kept full to seal the valve. The plunger at the top of its stroke raises the valve in order to avoid clearance volume. In working, the plunger should be raised as high as possible at each stroke. No inlet valve is fitted, but when the plunger is near the end of its down-stroke it has uncovered a hole leading to the ram cylinder.

In order to prevent entrance of air between the plunger, ram and cylinder, the latter are grooved internally near the lower ends. The grooves are supplied with oil from the upper tank. Any leakage to the cylinders is consequently of oil only



GAGE TESTING MACHINE.

and air is excluded. In order to admit air a small screw-down valve is provided with milled head. When taking a reading the pump handle should be right up, and the ram should be floating between the upper and lower stops. This can always be effected by slightly opening the air inlet valve momentarily. It may be rotated to reduce friction. The apparatus should stand level when in use. Only oil of the best quality, quite free from acid or grit, should be used in the machine. When not in use the openings in the case should be closed by the plugs provided.

The highest reading obtainable on a vacuum gage connected to the apparatus is dependent on the barometric height. It is held that the apparatus has been tested and compared with a standard instrument examined at the National Physical Laboratory, and is said to be correct to one-tenth of 1 percent.

British Boiler Explosions.

For the year ending June 30, 1910, in Great Britain and upon vessels under the British register, 106 boiler explosions occurred, resulting in 14 persons being killed and 62 injured. The entire death rate was due to 11 explosions, four on land and seven on ships. Among the causes given were: Twenty-six due to corrosion; 32 due to defective design and excess pressure; 16 due to defective material, workmanship or construction; 5 due to water hammer, and 8 due to ignorance or neglect of the attendants.

The Boiler Maker

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NOTICE TO ADVERTISERS.

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

Boiler Shop Kinks.

Articles have frequently appeared in our columns under the title of "Kinks." This is a general term which may be taken simply as a suggestion, usually a suggestion for some method of getting over difficulties in ordinary machine or hand work or utilizing a new form of machine or tool for doing work which has been done in other ways. The appliances thus described are not always simple. There are frequently elaborate and complicated arrangements for doing a simple piece of work in a way which will save time and cost in doing the work. Most of these "kinks" are the result of years of practical experience by men who applied their knowledge and skill to more efficient work. They often represent a digest of ideas obtained from a great number of sources, and which cannot be obtained except by personal acquaintance with skilled workmen and a number of different shops. One of the most valuable things to help a man evolve a good "kink" is to become well acquainted with other boiler shops, and find out what is being done by other people before attempting to apply any of his own ideas, which may be simply a repetition of what has been done before, and far better than he could possibly do it.

We recommend progressive boiler makers to make a careful study of such things and feel free to exchange their own ideas with others. It sometimes seems that a "kink" which has proved successful and a money-saver is the personal property of the man who devised it, but attempts to keep such matters secret very often mean little to the man who has been using the "kink." Greater freedom in giving publicity to such things will make the "kink" of more value to its inventor by adding to his reputation and making his services of more value to his employers, who are usually capable of recognizing a good thing when they see it and make the most out of it.

The Brick Arch.

For a good many years attempts were made to use the brick arch in locomotive fire-boxes, as it was recognized that such an installation offered opportunity for increasing the economy of fuel consumption if the device did not add too many complications to the maintenance of the boiler. It is only within a few years, however, that the type of arch and the method of installation have been so perfected that the added efficiency gained in the evaporation of water by the boiler was not seriously offset by difficulties in keeping the fire-box in condition without frequent renewals of the brick arch.

In early installations of the brick arch it was found necessary to frequently demolish the whole arch in order to get at the tubes and stay-bolts to stop leakage. Difficulties were also met in the installation of arch tubes for supporting the arch. For this reason the constant renewal of the device became an expensive item in the maintenance of the boiler, and its advantages were not as great as had been expected. Now, however, these difficulties have been largely overcome, and the brick arch is proving itself of great advantage every day. It is hard to find a boiler maker who has had experience with boilers thus equipped who does not heartily approve of it. In a report on this subject presented before the Traveling Engineers' Association, the results of tests are given which were made on the New York Central Lines, where a gain of nearly 15 percent was effected in the equivalent evaporation per pound of dry coal by the use of the brick arch and water bars. This is not a particularly startling result, for such gains have been expected by the use of brick arches, but the fact that the installation and upkeep of the arch does not present difficulties which disqualify its advantages is the thing which is of most importance to the motive power men on the railroads. One of the most important points in the installation and upkeep of the brick arch is the proper application of the arch tubes, for they have proved a troublesome item in many instances. Even the use of arch tubes alone, if properly applied, will result in a valuable increase in the evaporation of the boiler per pound of coal, due to the added heating surface and better circulation obtained.

COMMUNICATIONS.

Some Reminiscences.

Editor The Boiler Maker:

The cut of "Boiler Setting in Sweden" in the June number of The Boiler Maker, page 179, reminds me of old times. The side flues as shown were common forty or fifty years ago. In the year 1868 I had a little shop in a town in Canada, and there was a flour and oatmeal mill in a village close by that had two two-flue boilers 44 inches by 30 feet. I persuaded the proprietor to let me take one of the boilers and make two 14-foot tubular boilers out of it. The shell was very good, and the mill did not run for a month in summer. I told him the two 14-foot boilers would do as much as the two 30-foot ones, and would not burn as much wood; they were burning ten cords of beech wood in ten hours, running two sets of stones, and had hard work to do it. When I got the two tubulars in place, I directed the masons to construct side flues in the walls. The boilers were fired up and worked well, so well that they ran three sets of stones and the oatmeal mill, too, and only used five cords of wood in ten hours—and it was not beech wood, either, but a cheaper wood—and they had no bother with the steam.

In 1876 and 1877 I had charge of a shop in Dunkirk, N. Y. In Fredonia, a nearby village, there was a small sawmill, with a 15-horsepower portable boiler to run it; they burnt all of their sawdust and slabs, and had to buy coal. The proprietor came to me to see what I could do for him about it; I advised him to get a small stationary tubular boiler and try it. We had a 36-inch by 8-foot boiler on hand, and he took that. I went out to see that it was set right, and had side flues built in the walls. About a week after the boiler was fired up the owner came to the shop and told me he did not know what he was going to do with the slabs, as all he could use for fuel was the sawdust, and he did not have to buy coal.

I have often wondered at the way some boilers are set, with people knowing as much about steam and the steam boiler as they do. I have often seen the stack red-hot half-way up. I would think real economy would be in using all the hot gases to heat the water and steam in the boiler, and that cannot be done by allowing the hot gases to go direct from tubes to smokestack. By putting in side flues or, better still, building the flue directly over the boiler, you will add considerably to the heating surface and also get dryer steam. Some object to having the hot gases return over the boiler for fear of overheating. That is all nonsense, as it will reduce the unequal strains on the shell. I know, of my own knowledge, a battery of boilers with the return flue built over the tops of the boilers that was in use for years, and the owners are well pleased with them, as over one-third of the fuel is saved over boilers placed as they commonly are.

In 1889 or 1890 I was working in Buffalo, N. Y., for a large boiler shop, and they built some six boilers for a big establishment there. These boilers had the return flues all over the tops, and they extended down near to the brackets on each. I was at this establishment once connecting the smoke-drum. The boss of the boiler shop was present. It seems the engineer of the establishment did not like this style, so he told the proprietor a little story; anyway, the proprietor came to the boss, saying he did not believe it a good plan to have the hot gases go over the top of the boiler. The boss told him if the boilers gave out on top he would stand all damages; and another thing, in place of taking the cash for the boilers he would take the difference in the coal bills as compared with the old battery that was taken out as pay for the boilers. When the proprietor heard that, he thought there was something in it, and so kept the difference and paid for the boilers—and he was wise; for if he had taken the offer he would have been out several thousand dollars, as the establishment ran night and day the year round. John Cook.

Springfield, Ill.

What Makes a Flue Leak?

Editor The Boiler Maker:

In your July issue, page 204, is an article entitled "Trying to Make Flues Tight," by D. B. Hines in the *Railway and Locomotive Engineering*. In it is said: "Expansion and contraction has very little, if anything, to do with making flues leak."

I would like to have the author advance his theory as to causes of flues leaking, if it is not caused by expansion and contraction. I beg to differ with the author and will advance a few theories. We cannot prevent contraction and expansion, but must correct their effects, be it in flues, stay-bolts or plate. The flexible stay-bolt is a good illustration, and will convince the average man of this action in locomotive boilers and the possibility of eliminating the bad effects by the use of flexible bolts. It is known that iron and steel exposed to the weather will expand and contract; consider, then, what takes place when exposed to the temperatures of the firebox. After flues have been installed in a boiler and tested the engine goes out, and in a short while the flues start to leak. What causes this? Contraction or expansion, naturally. Some would say contraction only, but I contend both. There are many causes that produce flue leakage: Cold air on hot plates; accumulation of sediment, mud, scale; inferior workmanship; low-entering temperature of feed-water; deposits of oils, grease and foreign substances; inferior grade of material; improper care, housing and handling at terminals and unequal expansion. These causes generally go hand in hand; that is, "just a little bit added to what you have got makes just a little bit more." I will mention what I think will prevent flue leaks. The brick arch, in restraining the cold air from coming in contact with the flue sheet; automatic stokers have a tendency to favor plates and flues; frequent washing out of boilers by up-to-date systems; by specializing and adopting a standard in the application of flues will minimize inferior workmanship; by being sparing in the use of oil that may reach the interior of the boiler; boiler compounds that contain animal fat. In regard to inferior grade of material I am safe in stating that it is often only careless manipulation in back shops and round-houses. It is possible to receive an inferior grade from manufacturers when ordering the best by the carelessness of some employee. In my opinion our manufacturers produce a grade of material that has the required amount of homogeneousness, tensile strength, malleability, ductility and freedom of laminations and blisters. Besides being tested according to law, the best is none too good for boiler construction and repair. The improper housing of locomotives, or improper care of boilers in round-houses, is a lengthy subject, and here is where I give the general foreman of the round-house a bump; if the shoe fits wear it. I was never convicted for telling the truth. In my opinion half the damage to fireboxes can be traced to the round-house. How often has an engine come into a terminal with flues perfectly tight? After the fires are dumped the hostler discovers low water in the boiler. He puts on the injector, fills the boiler full of cold water and flues begin to leak, and by the time the engine gets into the house they are leaking badly and require the attention of a boiler maker. This is all unnecessary, and it runs into hundreds of dollars in repairs.

Improper cooling down of boilers produces cracked and crystalized sheets and broken stay-bolts. It is an everyday occurrence that an engine is brought into the round-house, steam blown off and the water dropped, leaving the sheets hot, and to have the washer start by running cold water over the hot sheets, which will result in the near future in cracked sheets and broken stay-bolts. Railroad officials are forever preaching economy to their subordinates and at the same time permit such daily practice, which costs them thousands of dollars each year. I hope some railroad official will read this article and get next to himself, for the above statements are facts not theories. GEO. L. PRICE.

Oskaloosa, Iowa.

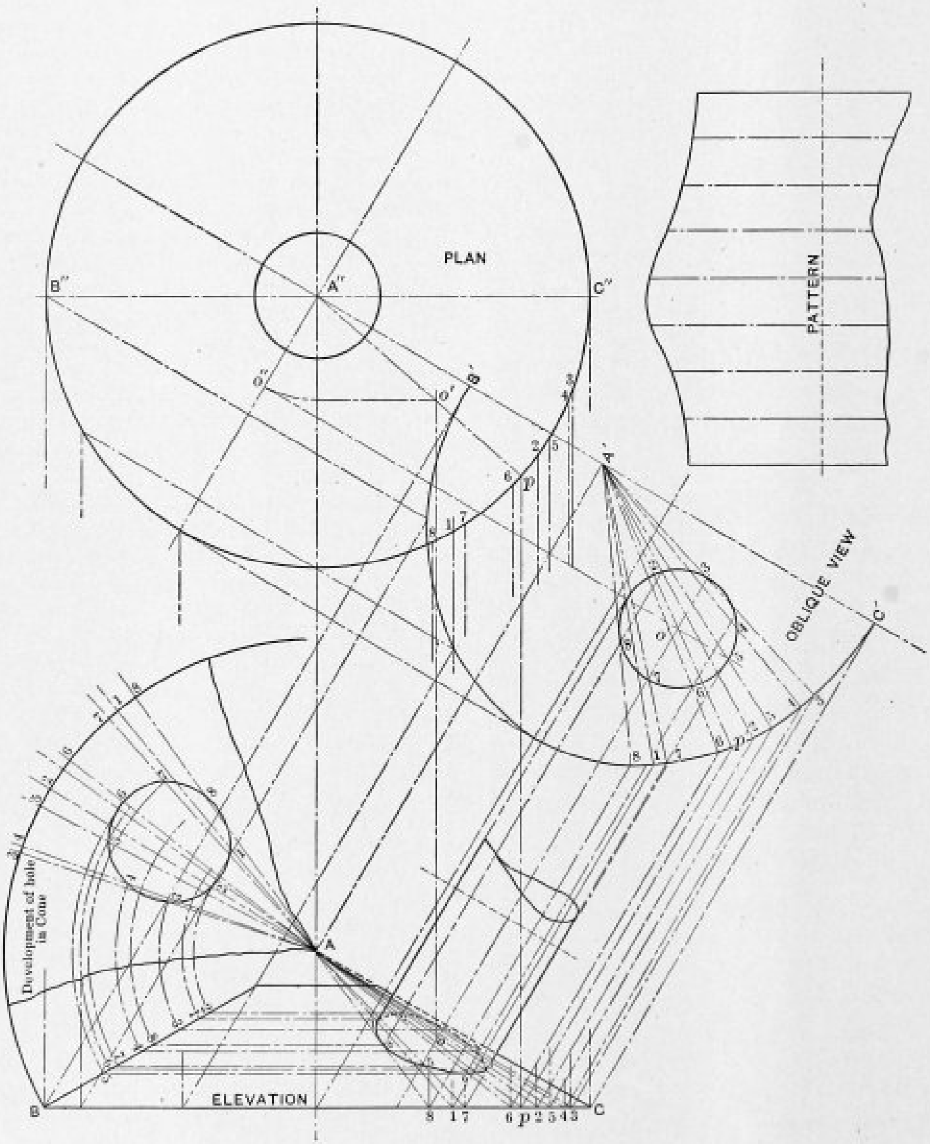
Inquiry of "Apprentice" Answered.

EDITOR THE BOILER MAKER:

In the July issue of THE BOILER MAKER, "Apprentice" asks for a method of development for finding the patterns of a cylinder which intersects a cone obliquely and off center. Herewith I submit a development and explanation, but, in order to show more clearly the principles of this development, a 30-degree cone and a cylinder intersecting it at an angle of 60 degrees to the horizontal is used. The same method of constructing same can be applied to the intersection required by "Apprentice." The drawings, it must be noted, are not made according to dimensions submitted.

Scranton, Pa. C. B. LINSTROM.

The Construction.—Draw the plan and elevation of the cone to the required dimensions. Locate the center of the intersecting cylinder in both plan and elevation, as shown at *o* in the elevation and *o'* in the plan. Through this center draw radial lines connecting with the points *A* and *A"* and which intersect the base of the cone in both views. The oblique view shown inclined to the elevation is a view of the elevation as it would appear when seen at right angles to the side of the cone; or, in other words, the elevation would appear in this shape when the line of sight is parallel with the axis of the intersecting cylinder. This view is necessary to obtain the intersection between cone and cylinder. To determine this oblique view, draw through the center of the plan a center line parallel to the axis of the cylinder. At right angles to this line and through the center of the plan draw another center line. It will now be seen that the plan has been swung around. Next divide the circle of the plan into a number of equal spaces. Drop these points to the base line of the elevation. They are then extended from the base line of the elevation an indefinite distance parallel to the axis of



LAYOUT OF A CYLINDER INTERSECTING A CONE OBLIQUELY AND OFF CENTER.

the cylinder. Corresponding points are then projected from the plan to intersect these lines in the oblique view. Through the points of intersection draw the irregular outline of the oblique view. The resultant curve is an ellipse. Next determine the point where the center of the cylinder passes through the oblique view. This is found by revolving the point *o'* around to the center line, as shown at *o"*. Then project a line from the point *o"* parallel with the axis of the cone until it intersects the line projected from *o* in the elevation, thus locating point *o"* in the oblique view. Using *o"* of the oblique view as a center, describe a circle equal to the diameter of the pipe. Divide it into a number of equal divisions; in this case eight. Through these points on the profile draw radial lines connecting with *A'*.

To find the line of intersection between cone and cylinder locate the corresponding radial lines in the elevation by projecting lines from the points 1, 2, 3, 4, 5, etc., until they intersect the base line of the cone. Connect these points on the base line with the apex *A*. Parallel with the axis of the cylinder draw from the points 1, 2, 3, 4, etc., of the cylinder the parallel lines as shown until they intersect the corresponding radial lines. Where these ordinates intersect, the radial lines determine the outline of the curve of intersection between cylinder and cone as it would appear from the front.

Development of Hole in Pattern of Cone.—The matter of developing the hole in the pattern of the cone is not a complicated thing to do. The only thing which remains to be done in order to lay out the hole is to determine the spaces on the stretchout for drawing the radial lines. These spaces are found by projecting from the base of the elevation the points 1, 2, 3, 4, etc., until they intersect the circle of the plan, as shown at points 2, 5, 4 and 3 to the right of the center line *A-p*, and points 6, 7, 1 and 8 to the left. The center line *A-p* is located on the pattern, and on either side of it locate the corresponding chord distances *p* to 2, *p* to 5, etc., of the plan. Connect them with the apex *A*. Then extend the points 1, 2, 3, 4, etc., of the hole at right angles to the axis of the cone until they intersect the outer element of the cone. With *A* as an apex swing these points around until they intersect their relative radial lines in the pattern at points 1, 2, 3, 4, etc. Draw the irregular hole where these lines intersect. The pattern for the cylinder is found by laying off a stretchout equal in length to the circumference around the pipe. It is divided into the same number of equal parts as its profile represented in the oblique view. Perpendiculars are erected from this stretchout line. The irregular curve or camber line is found by transferring the lengths of the ordinates shown in elevation to the pattern.

Something for the Boys in the Shop to Read.

EDITOR THE BOILER MAKER:

It must be a question with you what information a paper like THE BOILER MAKER should try to impart to its readers; they are to be found among the rivet boys and the office men. A certain kind of knowledge is wanted by the boys and another by the office men. Boys may become office men, but the office men will never become boys. I propose to give some information for the boys and men, and no doubt many in the boiler business throughout this country will know all I have to say, perhaps more, about boiler shop work than I do; but I have so often seen men and boys struggling in their daily work when they need not have done so, and they struggle simply because they lack certain information which I hope to impart.

I have been disappointed to find that what is written on various subjects for shop is often not understood, because the language is not clear to those who seek the knowledge. If a boy or man can read he can learn, if he is willing to do a little studying, provided the instruction is put before him in a clear manner. Things can be said which one man will understand and another will not. Let me make myself clear by an example. A plate of steel 1 foot each way, or 1 foot square and 1 inch thick, weighs 40 pounds. Now that certainly is easily understood by anybody and can be remembered. But, if I state that a cubic inch of steel weighs .283 of a pound, and if you multiply this by 144 you would get the weight of a square foot of steel 1 inch thick, I doubt whether that would be as easily understood or remembered.

I want to put everything I say in a clear way. Now as a square foot of steel 1 inch thick weighs 40 pounds, it is quite easy to understand that if the plate is only ½ inch thick it will weigh half of 40 pounds, or 20 pounds, and that if it is a ¼ inch thick it will weigh a quarter of 40 pounds, or 10 pounds. This gives a basis on which you can figure quite easily the weight of steel plates. You have to get the number of square feet and multiply it by 40, and you have the weight, provided it is an inch thick. If it is a ½ inch thick, as I said, you divide this by 2. If it is more than an inch you will have to add to the 40 pounds whatever the additional thickness of the plate demands, but you must not make the mistake that one young man did by saying that as a foot is 12 inches long, a half a foot is 6 inches, and a 6-inch square plate then would weigh half what a 12-inch square plate would weigh. Six inches, it is true, is half a foot, but 12 inches by 12 inches is 144; but 6 inches by 6 inches is only 36 inches, which is just one quarter of a square foot.

We all see things around us from day to day and hear them called by name and talked about, but we do not really understand what they are. Now steel is always used in boiler making. Iron used to be used. Steel is made from iron, which is made from iron ore, and the highest grade of steel is called cast steel, or crucible steel, as it is cast after being melted in crucibles and then worked. Cast steel is suited to be made into punches and dies and calking tools, etc., as it can be hardened and drawn down to various degrees of hardness and elasticity. This grade of steel is not used for boiler plates. Bessemer steel is appropriate for boiler plates. It is so called because a man by the name of Bessemer perfected the process and made this steel by blowing air through a bath of melted cast iron or pig, and this process was cheap. Steel varies in quality as much as pies or bread. It is generally designated as having a certain amount of carbon in it. A person will say, "I want point 40 carbon" or "point 60 carbon," and it is usually written as follows: .40 or .60. The little dot in front is a decimal point, but in speaking of it the word "decimal" is not used. Up to a certain amount the more carbon in the steel the greater is the strength and the better quality. Steel is tested by a machine which shows how much power it takes to pull apart one square inch, and what this amount is, is called the "tensile strength" of the steel. In actual practice a piece of steel 1 inch square is not used for a test, but generally a piece of steel with ½ square inch area is taken. This is because it would take a very heavy and much more expensive machine, as it would have to be stronger to pull apart the 1-inch piece, so a smaller section is used. The tensile strength of steel runs anywhere fom 40,000 pounds per square inch up to, say, 90,000 pounds, or even more; but good boiler steel runs from 50,000 pounds to 80,000 pounds in tensile strength. Two substances which hurt the quality of steel are sulphur and phosphorus, so in specifications it is usual to find that only a very small amount of either is allowed. It is very hard to get steel entirely free from both these substances. The study of steel is very interesting and cannot be gone into briefly.

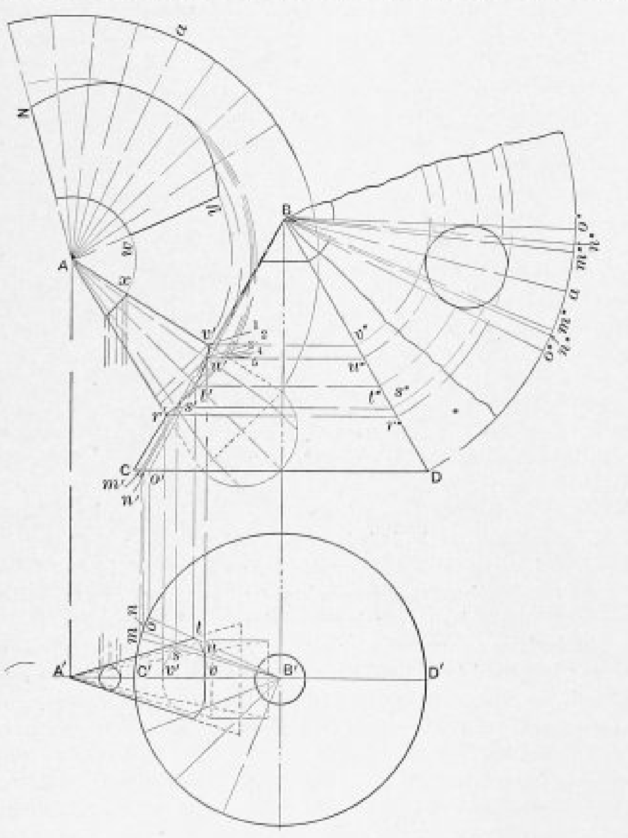
It is found that by adding to steel some certain other materials it is improved. There are a number of metals used, but the main ones are nickel, and when added to steel makes it stronger, as does manganese, chrome and vanadium. But when you get steel of very great strength, you usually get a steel which is easy to harm in handling in the fire; it might be called "tender." If you get steel too hot you burn it, and it seems to try to get back to its original state when burned, and no longer has the stringy nature of steel, but the crystalized nature of cast iron. You cannot restore burnt steel in a plate, although many claim to do so; but there is one thing to be remembered, that steel that has been burnt even to a small extent should never go into any part of a boiler. The nature of steel is, as I said, stringy. It is like a rope—you can hang a very heavy weight from a rope, but you cannot stand any weight on the top of a rope. Now cast iron is just the other way in its nature; it will support a very much greater weight than can be suspended from it. Now what I wish you to remember, and I hope this will suit the party by the name of "Kicker" who wrote in the June issue, that the weight of 1 square foot of steel 1 inch thick is 40 pounds; that burnt steel should not be used in a boiler; and that the tensile strength of boiler steel should be about 55,000 pounds.

Now if I find that what I have written is clearly understood, I shall write some more about steel, and I hope that any one who reads this article who does not find it clear will write to The Boiler Maker and state what is not clear, and I will try to make it so.

Pittsburg. F. Ormer Boy.

Correction of Fig. 3—Development of a Cone Intersected by a Cone Obliquely Inclined, which Appeared in the September Issue of the Boiler Maker.

The part in question is the development of the hole in the pattern of the large cone. It should be developed as per the



construction shown on the accompanying drawing. Instead of projecting from the points 6, 7, 8, 9 and 10 the arcs in the pattern should be drawn from the points r', s', t', u', v'.

C. B. Linstrom.

Safe Working Pressure for Cylindrical Cast Iron Vessels with Flat Cast Iron Heads.

Editor The Boiler Maker:

Occasionally the question comes up as to how the safe working pressure is found for cylindrical *cast iron* vessels with *flat cast iron heads*. Recently I came across the following rules which were prescribed by the United States inspectors of steam boilers, and which will probably be of value to many of the readers of The Boiler Maker:

When evaporators, feed-water heaters and separators are made of good cast iron, the shells cylindrical and the ends flat, the castings sound and of uniform thickness, the working presure shall not exceed that found by the following formulas: For finding the safe pressure on the *flat* surface this is the formula to be used:

$$P = \frac{20,000 \times T^2}{D^2}.$$

For the cylindrical part of the vessel this is the formula to be used:

$$P = \frac{3,500\ (T - 1/4)}{D}.$$

And to find the thickness of metal required, having the other values given, use these formulas:

For the flat heads

$$T = \sqrt{\frac{P \times D^2}{20,000}},$$

and for the cylindrical shell

$$T = \frac{P \times D}{3,500} + 1/4.$$

In the formulas given the value of the letters stand like this:

P = safe working pressure in pounds per square inch.

T = thickness of metal in inches, *provided* the thickness of the *ends or heads* of such vessels shall not be less than 3/8 inch.

D = *inside* diameter of the vessel in inches. When the *ends or heads* are bolted to the shell then D = the diameter of the bolt circle. When the pressure is to be determined for a part of a flat surface which is square or rectangular, the value of D in the flat surface formula shall be the *diagonal* of the square or rectangle. The numbers 20,000 and 3,500 are constants, evidently empirical, and found from experiment.

As it seems to me that there are few who have these rules at hand, it occurred to me to submit them to you for those who may need them. Charles J. Mason.

Scranton, Pa.

Installing Blind Stay-Bolts.

Editor The Boiler Maker:

Two readers of The Boiler Maker have written me about my article, "Installing Blind Stay-Bolts," which appeared in your August edition, pages 234 to 236, inclusive.

The first question asked was: "What is the meaning of your expression, 'Great skill is required in hammer testing, and trouble is found more by chance than by anything else'?" The reply is: The word "trouble" means defective staybolts.

The second question was: "You say 'Tests should be made frequently at least one a month.' Do you call that frequent?" The reply is: I have always advocated testing stay-bolts weekly. The word "week" should be substituted in place of the word "month." The Pennsylvania and other railroads test the stay-bolts weekly.

The third question was: "What business has an engineer examining stay-bolts?" The reply is: A locomotive engineer should note all stay-bolt leakage and report the same; if he plugs the tell-tale hole while the locomotive is on the road he should report that he did so when the engine arrives at the terminal point. That is what is meant by my article in regard to the locomotive engineer. It is as much his business and to his interests to note and report defects of the boiler as he does in regard to the machinery.

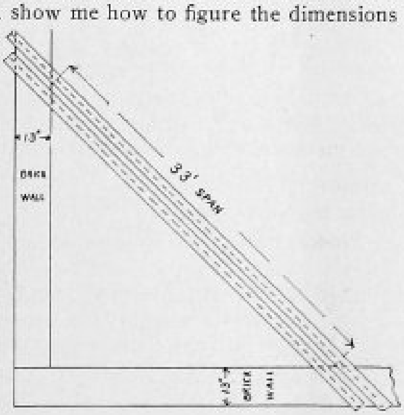
The stationary engineer is situated differently; he goes within a boiler, while a locomotive engineer never does. A man in charge of a battery of boilers is in charge of washing them out, or usually is, while a locomotive engineer has not the least thing to do with washing of a locomotive boiler. The stationary engineer prepares the boiler for the boiler inspector; that is, the boiler inspector of an insurance company. A locomotive engineer never so prepares a boiler; in fact, but few locomotive boilers are insured.

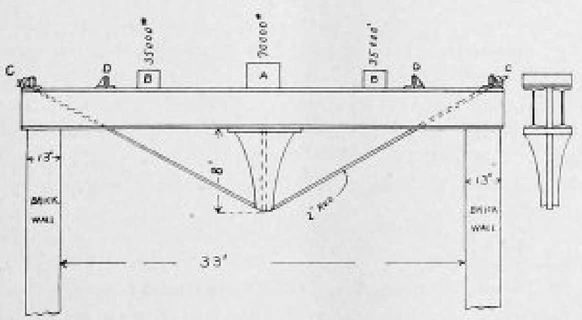
Washington, D. C. H. S. JEFFERY.

Design of a Girder.

EDITOR THE BOILER MAKER:

I am sending a sketch of a girder which I would be pleased to have some of the readers of THE BOILER MAKER consider and show me how to figure the dimensions for it. The girder





is to support a load of 70,000 pounds, placed as at *A* or *B-B*. The size of the rod is 2 inches, located as shown at *C*, or 8 feet from the end of the girder, as *a D-D*.

Besides determining the dimensions of the girder, I would also like to know what size and thickness of cast iron bearing plate would be suitable for such a girder? The wall is of brick, with a lime and sand mortar. Could a cheaper way be suggested for constructing a girder for such a load and span than the one shown in the sketch? C. G. T.

Beveled Plates and Calking.

EDITOR THE BOILER MAKER:

I have read with interest the various opinions on calking and as to whether beveling of the edges of plates is necessary for good work. I would say beveling the edge of the plate is certainly by far the best job, but I am of the opinion that splitting and calking is not necessary in good boiler work, but is only necessary when the plates have not been properly fitted—metal to metal—as all boiler work should be.

I have no doubt that my friends the calkers will not agree with me, as it certainly would do away with a good lot of their work; but nevertheless it is the case that splitting and calking does more harm to good boiler work while it does good to badly fitted boiler plates, as it is the only way to make the boiler tight, but it does not stand the test of time. While on good boiler work it is only necessary to stave the edges of the plates with a square set the full breadth of the plate, either with the air hammer or hand tools. My reason for condemning splitting and calking is that in doing so you are causing a great bursting strain upon the rivets, for by driving your calking tool on the edge of the plates it is acting just the same as a wedge would act if driven between two plates to burst them asunder.

It happened to be my lot lately to examine a boiler that had been giving a good lot of trouble. My first move on doing so was to find out the thickness of the plates and then measure them at the edges. In this particular case it was 1¼ inches thick, and when I measured the edges where the splitting and calking had been done they were nearly 1⅛ inches. This, of course, told me at once the boiler had been badly fitted or had been calked to excess. But after the rivets had been removed I found that the plates were not properly fitted, so splitting and calking was necessary in this case to cover a multitude of faults, whereas staving the edges with a square set the full breadth of the plate it would not have been an easy job to get the boiler passed by the inspector, so you see I am of the opinion the less calking a boiler requires the better the boiler.

Sorel, Quebec, Canada. WILLIAM NOBLE.

PERSONAL.

MR. DAVID JENKINS, foreman boiler maker of the Webber Iron Works, Birmingham, Ala., was killed on Aug. 8 by the bursting of an emery wheel.

MR. F. A. LINDERMAN, formerly supervisor of boilers of the New York Central Lines at West Albany, N. Y., has been appointed district superintendent of motive power on the New York Central & Hudson River Railroad, with headquarters at Oswego, N. Y.

MR. R. E. JACKSON has been appointed supervisor of boilers of the New York Central Lines at West Albany, N. Y.

MR. J. W. KELLY, general foreman boiler maker of the Chicago & Northwestern Railroad at Chicago, and first vice-president of the Master Boiler Makers' Association, is now connected with the National Tube Company, Pittsburg, Pa.

MR. W. E. HASWELL, formerly chief boiler inspector in Ohio, has been appointed secretary of the Ohio Board of Administration.

MR. J. J. MALDONADO, who is connected with the St. Louis & San Francisco shops in Oklahoma City, Okla., has been spending several days in New York and other parts of the East on an enjoyable vacation.

In the personal column of our September issue it was stated that the name of the W. B. Jones Streator **Boiler**

Works Company, of Streator, Ill., had been changed to the Jones & Heltzel Streator Boiler Company. This is an error, for the firm is still the W. B. Jones Streator Boiler Works Company, and the exhibits at the New York and Chicago cement shows were under that name.

ENGINEERING SPECIALTIES.

The Shoemaker Fire Door.

Figs. 1 and 2 show two views of a fire-door for locomotive boilers which is manufactured by the National Railway Devices Company, of Chicago, Ill. Fig. 1 shows the door open and Fig. 2 the door closed. The door-ring is attached to the locomotive boiler by the usual studs *A*. Bolted to the door-ring by the stud-bolts *B* are the door guides, and to the right-hand ends of same by bolts *C* is attached an upright plate to which the Shoemaker air cylinder is attached. An air-controlling valve (commonly called a foot valve), which is operated by a pedal, is fastened to the end of the boiler by stud-bolts *D*, the two holes for which being the only additional ones necessary to be made in the boiler other than are usually used for a swing door. All of the door parts proper, including the door ring, doors, door guides and operating levers, are the property of the railroad, or they will be fur-

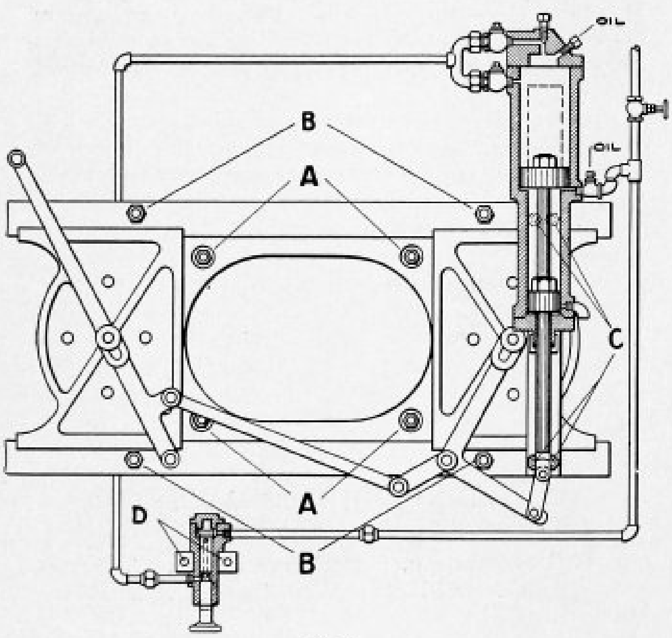


FIG. 1.

nished with the air parts complete if desired. The necessary piping shown completes the application.

Now considering the operation: It will be seen that the Shoemaker fire-door is composed of two distinct and self-contained mechanisms, each therefore possible to operate entirely independent of the other. These may be properly designated "door parts" and "air parts." The operation of the former when disconnected from the latter by removal of the pin joining the fulcrum lever arm to the piston is by a hand-operating handle. In the Shoemaker air cylinder the differential idea which has been so successfully embodied in the construction of a popular locomotive air pump is claimed to have been brought into equally ingenious effect; for by it the piston up-stroke or door-closing movement (the large piston head being above with pressure held constantly between it and the small head) is automatic. Here will be noted also a unique feature in pneumatic fire-door performance—that doors are locked shut by air in their "at rest" position, thus preventing the doors from working open by the swinging of the locomotive around sharp curves. The piston-down stroke or door-opening movement is secured by transmitting the air pressure through the foot valve to the upper side of the large head, which is accomplished by pressure on the pedal. Study of the foot valve will show that pedal pressure reverses it from an exhaust valve to that of admission. In both the up and down strokes the piston action is automatically cushioned, relieving jarring on doors, lever pins and the cylinder itself.

The Shoemaker fire-door is claimed to secure, among others, two main advantages which stand out prominently in overcoming the main difficulty in such a device: The elimination of parts scarcely operative under the intense heat conditions and the sufficient removal of all the air parts from

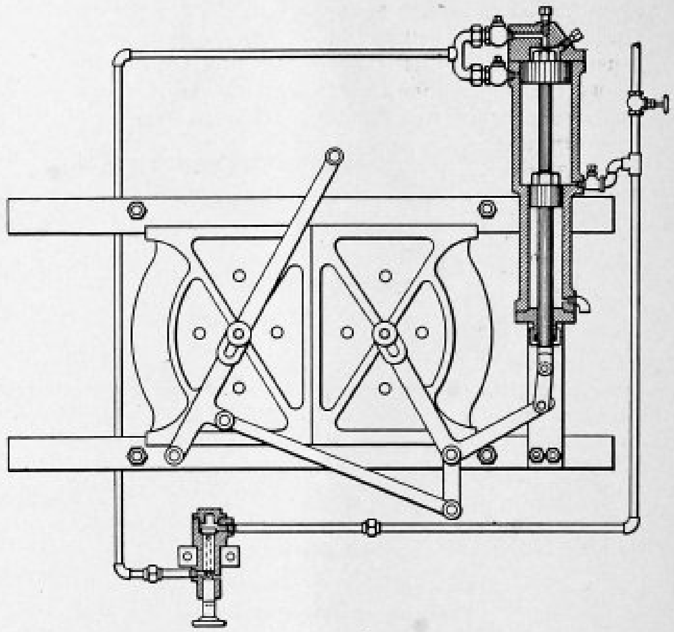


FIG. 2.

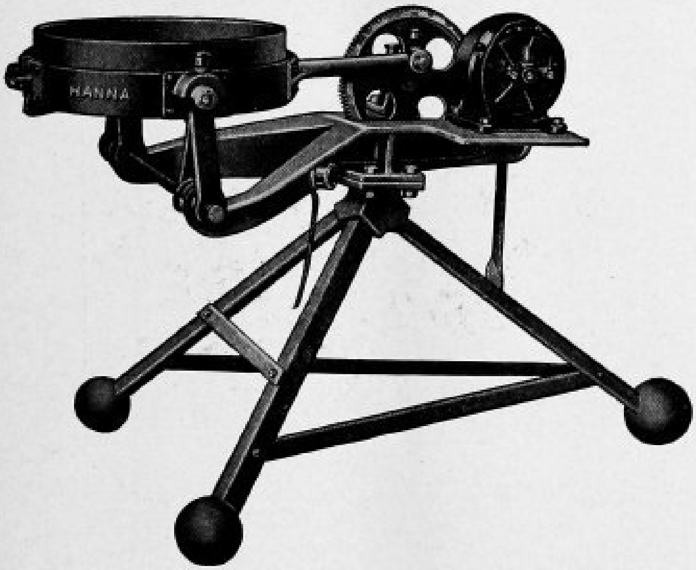
door opening to avoid the heat radiation, thus doubly meeting the obstacle which has made pneumatic fire-door maintenance a serious consideration. The problem from the manufacturing standpoint of the Shoemaker construction has been to prevent a wasteful leakage of air past the two piston heads resulting from constantly holding the air between same. This has been so fully overcome through skillful workmanship and the double air-holding means employed that the manufacturers are now claiming to hold the air absolutely tight against leakage, and under this guarantee are putting out trial devices to railroads unacquainted with the Shoemaker, subject to service performance.

Electric Riddle Oscillator.

The Hanna Engineering Works, of Chicago, Ill., have recently put on the market a riddle oscillator, as shown in the accompanying illustration, which in general design and dimensions closely follows the small pneumatic tripod shaker which they manufacture. The action of this machine is entirely different from any mechanical screening motion ever attempted for riddling sand and reproduces almost exactly the action of a molder screening sand by hand. This scientific action keeps the sand under a continuous motion, which tends to clear the meshes of the screen to a remarkable degree. This is said to be the most effective motion which can be had for riddling and mixing sand, and with the power of a

⅓-horsepower motor back of it, it is claimed that it will screen all the sand which one can shovel into the riddle.

The construction is such that at no point is there a dead center, and consequently there is no danger from undue shock or overload to the motor. The screen holder is arranged for accommodating the ordinary 18-foot foundry riddle, and is provided with a quick-acting clamp device to facilitate removal. The riddle oscillator is furnished with motor wound

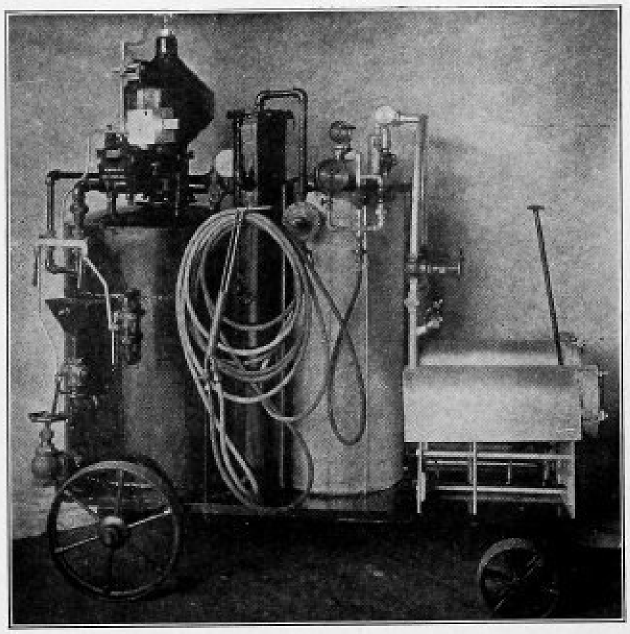


for any current and shipped complete with switch, short piece of cable and plug ready for attaching to the lighting circuit. The motor and gearing are protected by a housing so as to prevent sand from being thrown into the working parts. With this machine it is claimed that the proportion of core sand to compound or oil can be increased fully 50 percent, and obtain a better mixture than is possible by hand.

Portable Welding Machine.

A new portable welding machine is being manufactured by the Oxy-Carbi Company, New Haven, Conn. The acetylene generator on this machine is of the carbide-to-water type, and is claimed to have all of the most fool-proof interference devices required by the Board of Fire Underwriters. Its most particular feature is the carbide being shut off from the water at all times when not feeding, and it is also claimed that there is no possibility of the carbide rattling into the water at any time during the transportation, which would cause generation of gas. The generation is very simple in operation, as it is actuated by the weight falling against pressure, and the action gives very close pressure of gas at the blow-pipe. A very small amount of air is admitted to the machine when emptying, which is not exhausted when on refilling with water. The upper section is the expansion tank, which is entirely shut off at this time, and the only air left in the generator is the small amount in the tubs which the carbide falls through to the water. This obviates any dangerous mixture of air and gas. Its operation is so close that whatever point the weight may be placed on the lever the safety valve is never clogged. This prevents any acetylene gas escaping in the vicinity of the machine when in operation; even if used in a closed room there is no odor apparent. After charging and generator is started it is entirely automatic. When consumption begins generation begins, and the supply of gas is maintained as long as there is carbide in the holder. When consumption ceases generation is stopped until it is again called on, as there is no tarry substance from generating to clog the pipes or valves.

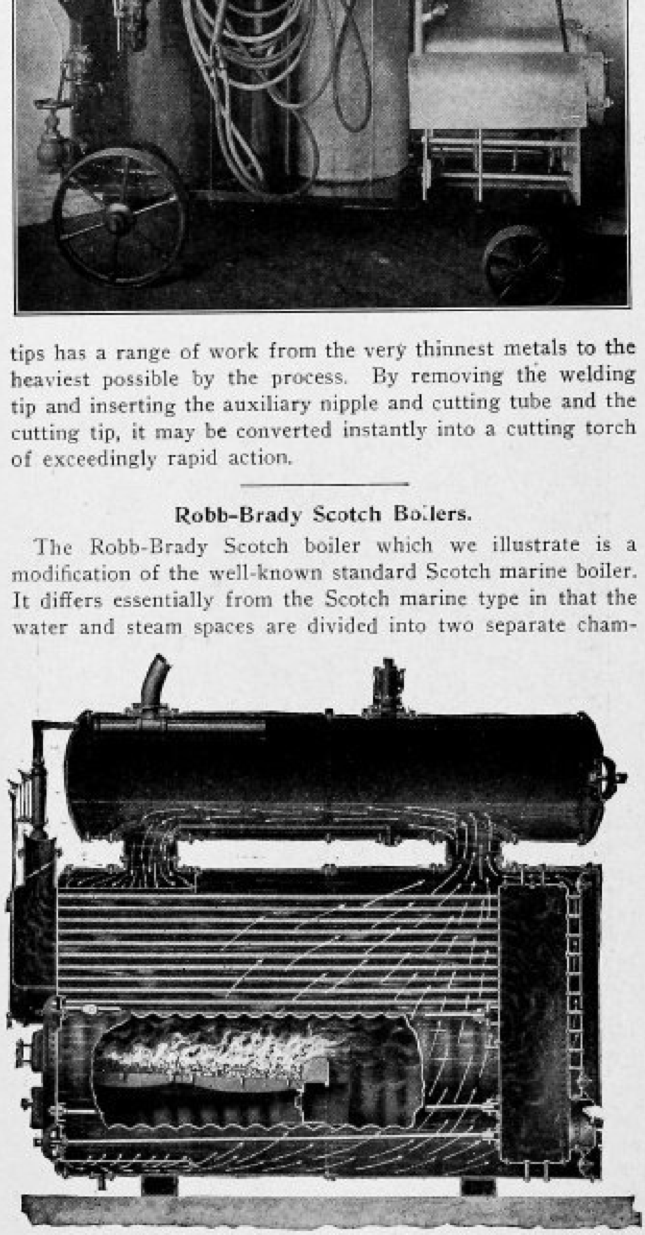
The oxygen generator at the front of the machine is for generating from potassium chlorate as the gas is desired, and has the same important features of cleaning and retaining the gas in the holders after generation, generating this gas with the least possible loss. The blow-pipe used with this machine is designed for lightness and reliability. It can be used in the closest possible quarters, and with the numerous changes of



tips has a range of work from the very thinnest metals to the heaviest possible by the process. By removing the welding tip and inserting the auxiliary nipple and cutting tube and the cutting tip, it may be converted instantly into a cutting torch of exceedingly rapid action.

Robb-Brady Scotch Boilers.

The Robb-Brady Scotch boiler which we illustrate is a modification of the well-known standard Scotch marine boiler. It differs essentially from the Scotch marine type in that the water and steam spaces are divided into two separate cham-



bers. The upper drum forms the steam space, while the lower shell is entirely filled with water.

The combustion chamber is cylindrical and of a diameter nearly equal to that of the larger shell. Because of the cylindrical shape and absence of flat top there is no need of girder or crown bar-stays, only short screwed stays being used. Longitudinal or through stay-rods are not required, as the small diameters of the two shells and the simplicity of staying lessen the cost of construction.

Positive circulation is obtained by compelling the hot water from the steam drum to flow down the front neck and around the shell through the annular space. The water from this annular space empties below the furnaces and replaces the hot water and steam which take the shortest path to the top, passing to the steam drum through the rear neck. The rapid circulation increases the economy of the boiler by keeping all the heating surfaces clean, and results in uniformity of expansion and eliminates the necessity of providing a special pump to increase circulation. This new type of boiler, which is built in units from 50 to 300 horsepower, and for working pressure up to 225 pounds, is internally fired and is adapted for both marine and stationary use.

The Robb-Brady Scotch boiler is built by the Robb Engineering Company, South Framingham, Mass., and at Amherst, Nova Scotia.

Cleveland Four-Piston Air Drill.

The Cleveland Pneumatic Tool Company, of Cleveland, Ohio, has recently placed on sale an improved type of four-piston air drill. This drill embodies several new features of interest to mechanics. Fig. 1 shows an exterior view of the machine, showing the one-piece body and lever reverse, though they are made with throttle handle reverse or non-reversible. Fig. 2 shows an interior view of the same machine. The one dominant feature in the new drill is the mounting of the

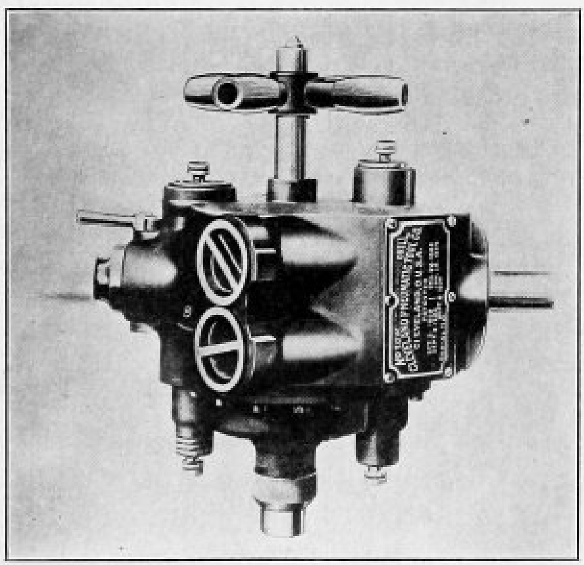


FIG. 1.

crankshaft upon the annular ball bearings of the silent type in lieu of plain bronze bearings as heretofore used in drills of this type. The ball bearings, it is claimed, practically eliminate all friction and wear, and prevent the heating of bearings as in the old type of plain bearing machine. It is further claimed that they maintain the driving crank in a fixed position, allowing no lateral motion, so detrimental to pinions and large gear. The valve is a rotary duplex type, which is placed between and equidistant from each vertical set of cylinders. The valve being gear driven supplies air power automatically to each set of cylinders without any variation. The body is a one-piece steel casting provided with hand-holes, through which access is had to the crank and connections. The pistons are secured to connecting rods by a ball and socket joint, allowing of universal motion and adjustment of wear, or renewal of individual parts. The gears are enclosed in an

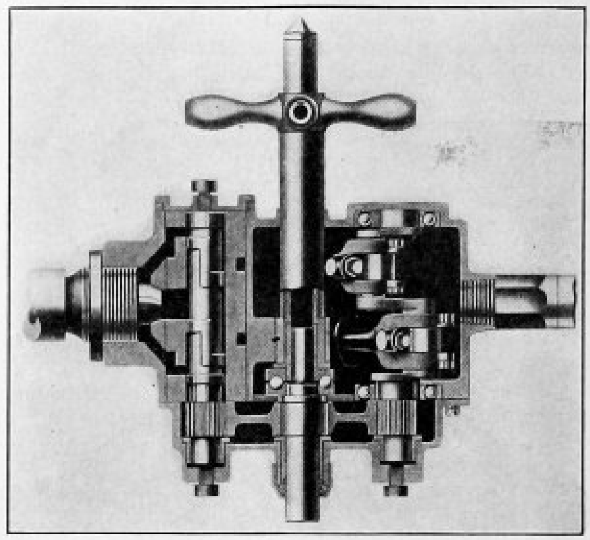


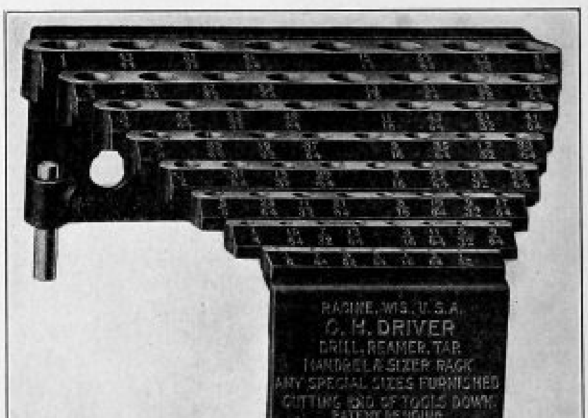
FIG. 2.

individual chamber separated from the crank chamber by an aluminum shield plate, which protects gears from accident and admits of separate and permanent lubrication.

The C. H. Driver Drill Rack.

A rack which is convenient for holding drills, reamers, taps, mandrels and sizers is manufactured by C. H. Driver, 1417 Sixteenth street, Racine, Wis.

The illustration shows the rack ready to receive drills. It is so constructed that it can be placed either on the wall or on the bench. It is a simple matter to put the tools



in their proper place by inserting them in the rack without referring to the size marked on the tools or the rack. Also if, as frequently happens, the size of the tool has been rubbed off by its frequent use in a chuck, its size is immediately indicated by the rack, since the insertion of the tool in the rack will show whether it fits the hole or not. This does away with the necessity of calipering or using a drill gage or micrometer. In fact, the rack is practically a limit gage, since a tool cannot be put in a larger or smaller place than where it belongs. The variation of size of the holes in the fractional sections of the rack can be had by 64th, 32d, 16th or 8th of an inch.

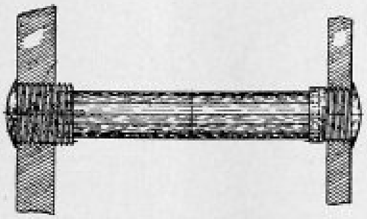
SELECTED BOILER PATENTS.

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

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

996,167. FLEXIBLE STAY-BOLT. HENRY W. UHL, OF PORTSMOUTH, OHIO.

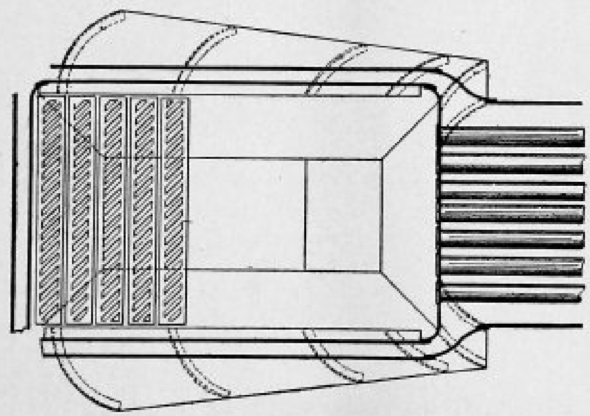
Claim 1.—A flexible stay-bolt, comprising a body-portion consisting of a plurality of strands or rods assembled in close contact with rela-



tively conforming intervening faces and collectively forming a body of metal of virtually solid cross section. Five claims.

996,093. ASH-PAN. ROSCOE B. KENDIG, OF CLEVELAND, OHIO.

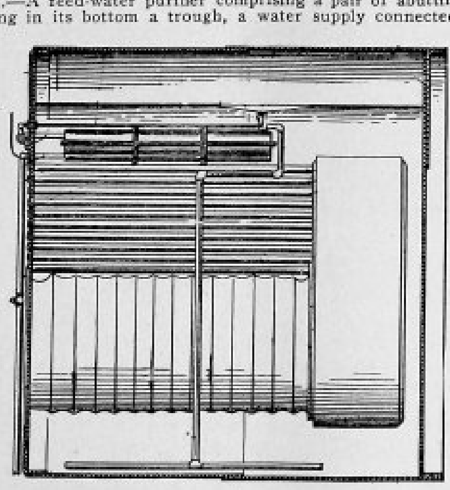
Claim 1.—A locomotive ash-pan having admission means formed to admit a substantially continuous body of air along its side wall, and means for deflecting the air through such admission means on the for-



ward movement of the locomotive comprising a plurality of vanes obliquely inclined with respect to the side of the ash-pan and arranged one after the other along the admission means. Four claims.

998,741. FEED-WATER PURIFIER, HEATER AND CIRCULATOR. JAMES C. BENNETT, OF DETROIT, MICH.

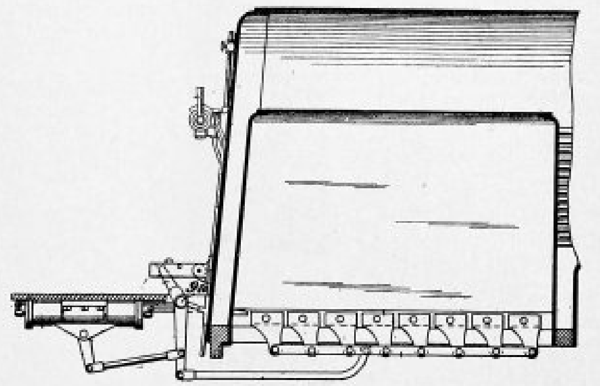
Claim 1.—A feed-water purifier comprising a pair of abutting sections, each having in its bottom a trough, a water supply connected with one



section, a discharge pipe connected with the other section, a baffle-member in each section and having an aperture in its bottom opening into said trough, a blow-off pipe connected with said trough, and a valve in said blow-off pipe. Six claims.

998,882. LOCOMOTIVE-GRATE SHAKER. ALBERT G. ELVIN, OF EAST ORANGE, N. J.

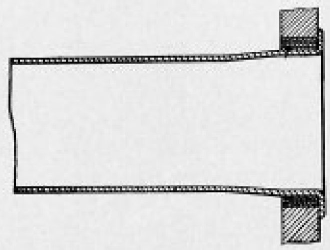
Claim 1.—The combination, in a grate-shaking appliance, for locomotives provided with a foot plate, of a horizontal motor cylinder secured under said foot plate and in a rear of the fire-box of the locomotive, a piston working therein, an operating valve controlling the admission and exhaust of fluid to and from said cylinder, a double



armed actuating lever pivoted adjacent to and projecting into said cylinder and adapted to move in substantially a vertical plane and having one of its arms located in position to be oscillated by the piston, and connections for coupling the opposite arm of said lever to a rocking grate. Nine claims.

998,886. TUBE SETTING. JOHN JOSEPH FINNIGAN, OF ATLANTA, GA.

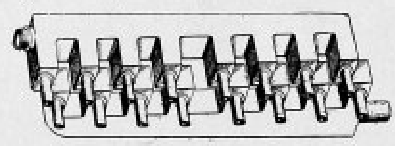
Claim 1.—The combination with an apertured tube sheet, and a tube, of a tube setting, consisting of a series of concentric rings of substantially the width of the metal at the aperture of the sheet, fitting in



said aperture about the end of the tube, the rings in contact with the wall of the sheet aperture and the outer circumference of the tube, being of a soft, pliable packing metal, and the intermediate ring being of a non-compressible flexible metal. Two claims.

999,147. MANIFOLD. CHARLES E. BONINE, OF PHILADELPHIA, PA., ASSIGNOR TO NEWTOWN PRODUCING COMPANY, OF NEWTOWN, PA., A CORPORATION OF PENNSYLVANIA.

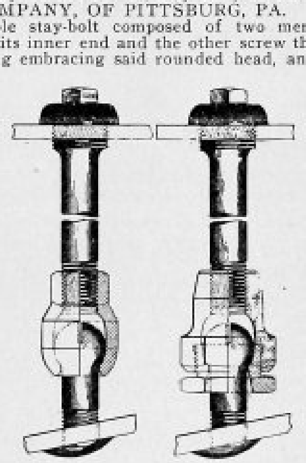
Claim.—In a fluid circulation system, a series of parallel pipes lying in a single plane; two interfitting complementary manifolds, each comprising an elongated receptacle with a series of similar offsets spaced to



permit the interposition of offsets of one manifold between offsets of the other; said offsets being of sufficient depth to permit members of said series of pipes to be connected to one or other of the manifolds without departing from the plane in which the series lies. One claim.

999,898. FLEXIBLE STAY-BOLT FOR BOILERS. BENJAMIN E. D. STAFFORD, OF PITTSBURG, PA., ASSIGNOR TO FLANNERY BOLT COMPANY, OF PITTSBURG, PA.

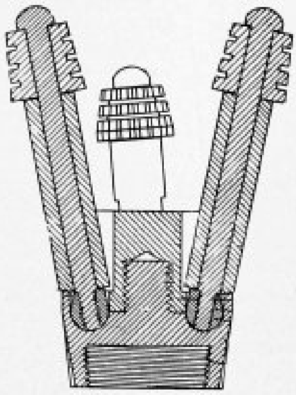
Claim.—A flexible stay-bolt composed of two members, one having a rounded head at its inner end and the other screw threaded at its inner end, and a coupling embracing said rounded head, and having a curved



bearing for the portion of the head adjacent to the body or stem of the bolt, and also having a curved seat or bearing for the rounded free end of said head, the said coupling also provided with female threaded portion to directly engage the threaded end of the other member of the stay-bolt. One claim.

1,000,060. TUBE CLEANER. HENRY F. WEINLAND, OF SPRINGFIELD, OHIO, ASSIGNOR TO THE LAGONDA MANUFACTURING COMPANY, OF SPRINGFIELD, OHIO, A CORPORATION OF OHIO.

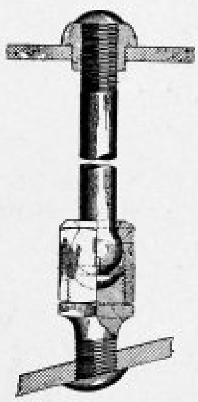
Claim 1.—A rotary tube cleaner having a supporting head with pivoting heads seated therein, swinging arms, cutters and means to carry said



cutters at the free ends of said arms, said means being immediately secured to said pivoting heads and removable therefrom without disturbing said pivoting heads from their position in said supporting head. Fourteen claims.

1,000,046. FLEXIBLE STAY-BOLT FOR BOILERS. BENJAMIN E. D. STAFFORD, OF PITTSBURG, PA., ASSIGNOR TO FLANNERY BOLT COMPANY, OF PITTSBURG, PA.

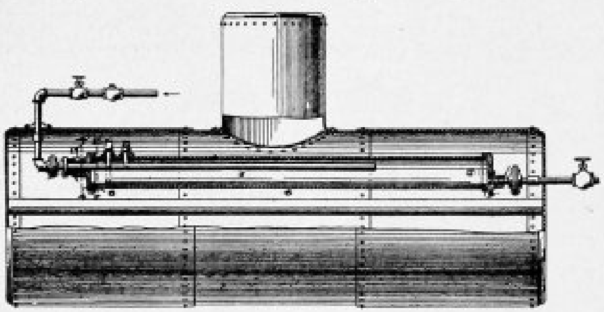
A flexible stay-bolt for boilers consisting of two members, one having a rounded head and the other an enlarged integral head having a recessed face adapted to coact with the rounded head on the first men-



tioned member, the said enlarged head being screw threaded externally, and a sleeve having a flaring throat through which the stem of the first-mentioned member passes and embracing the head of said member, the said sleeve having female threads whereby it is adjustably secured direct to the internal recessed head of the other member.

1,001,189. FEED-WATER PURIFIER. CHARLES H. CORT, OF SAN FRANCISCO, CAL.

Claim 4.—A feed-water purifier for boilers comprising a tube arranged horizontally in the boilers, a feed-water pipe entering said tube at one



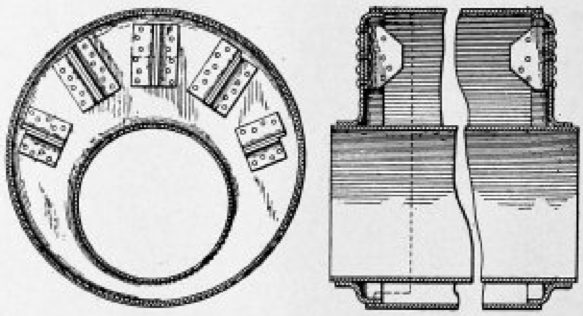
end thereof, and extending the greater part of its length in the upper portion of the purifier, a discharge pipe leading from the purifier at the same end, and a blow-off pipe leading from the lowest portion of the other end of the purifier. Five claims.

1,000,014. FLEXIBLE STAY-BOLT. JAMES W. KELLEY, OF PHILADELPHIA, PA., ASSIGNOR TO FLANNERY BOLT COMPANY, OF PITTSBURG, PA.

Claim 1.—The combination with spaced boiler sheets, of a stay-bolt engaging one of the sheets and provided with a substantially spherical socket housed between said sheets, and a plug threaded in the other sheet and having a reduced neck defining a substantially spherical head fitting within said socket, said neck being angular in cross section, thereby to permit the plug and bolt to rotate in unison when applying said bolt to the boiler sheets. Five claims.

1,000,266. MEANS FOR STIFFENING BOILER HEADS. ARIYA INOKUTY, OF TOKYO, JAPAN.

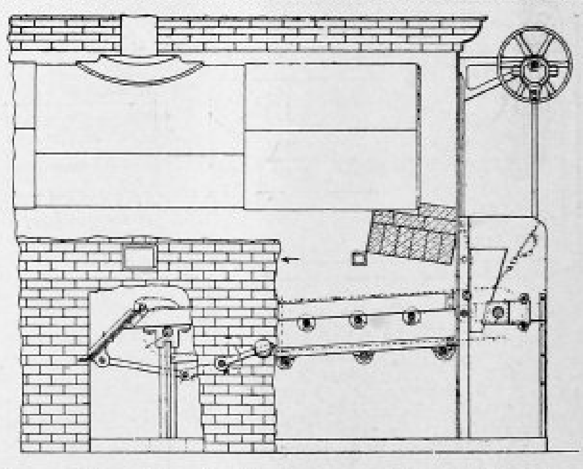
Claim.—A boiler comprising in combination, a shell, end plates or heads therefor and a flue extending through the shell and supported by the end plates and disposed eccentrically with respect to the longitudinal axis of the shell whereby greater area of the inner faces of said heads



is disposed on one side of the flue than on the other side thereof and a plurality of stiffening devices for such greater area of each head, said devices being radially disposed with respect to the longitudinal axis of said shell and each device being independent of and unconnected with the remaining devices, and each device comprising a pair of angle pieces having two of its flanges secured to the head and the remaining flange of such pair secured to each other. One claim.

1,000,586. STOKER MECHANISM. PAUL L. CROWE, OF JERSEY CITY, N. J.

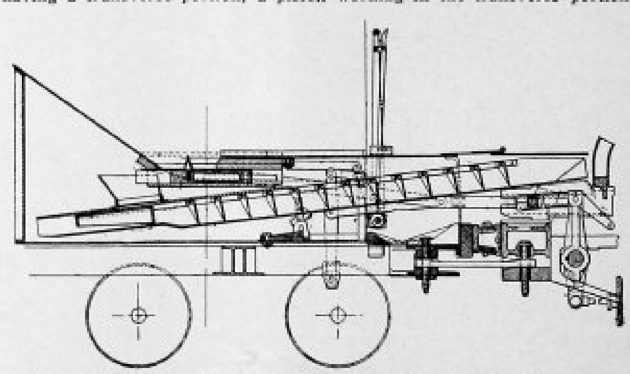
Claim 1.—An endless chain grate comprising a grate frame, a series of traveling grate bars mounted to move in said frame, the bars arranged with their longitudinal axes transverse to the path of movement of the said bars and formed with fuel supporting surfaces which slope grad-



ually upward from the ends of the bars to a point intermediate the ends, and a plurality of rollers, arranged substantially parallel to the traveling bars, said rollers having a concave supporting surface complementary to the fuel supporting surface of the grate bars adapted to co-operate with said inclined surfaces of the grate bars at the lower grate run. Four claims.

1,000,733. STOKER-FEED MECHANISM. WILLIAM C. A. HENRY, OF COLUMBUS, OHIO.

Claim 1.—In combination in apparatus for supplying coal to a locomotive fire-box, a tender provided with a gravity discharge passage having a transverse portion, a piston working in the transverse portion



and arranged to carry the coal rearwardly, a chute having its rear portion in position to receive the discharge from the passage and extending forwardly to a point adjacent the fire-box, and reciprocatory means in the chute for feeding the coal therethrough. Nine claims.

THE BOILER MAKER

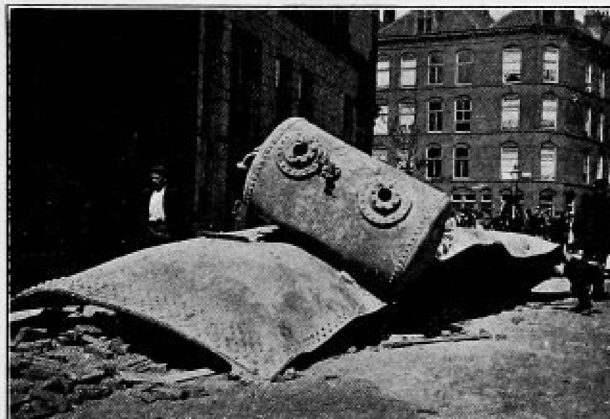
NOVEMBER, 1911

BOILER EXPLOSION IN ROTTERDAM.

BY D. KOOIJMAN.

A disastrous boiler explosion, by which six men were killed and nine badly wounded, occurred in Rotterdam on the morning of Aug. 10. At ten minutes before seven the starboard boiler of the passenger steamer *Gutenberg,* of the Ventu Dusseldorper Steamship Company, exploded. The ship was being placed in readiness to start for Germany at seven o'clock. There were very few passengers on board. In Fig. 5 the position of the boilers in the ship is shown. The S. B. boiler shell was burst at *a*, so that the boiler was moved by the reaction force as indicated. On its flight the shell was bent entirely straight, all of the rivets were broken, and the rest of the boiler, exclusive of the shell, was hurled on the shore at point *C*. The shell, with the dome, was thrown over the corners of the roofs as shown, and then fell in the street. The distance between the boiler shell and the other part was about 250 feet. The ship was damaged but did not sink. By the bending of the shell plate the other boiler was severely injured, but this did not explode. The funnel was found at the other side of the river. A part of the deck was found on the roof of one of the houses.

The only causes that can be found for this explosion are too high steam pressure in the boiler or poor construction or material; but the steam pressure is not known, as all of the men who knew this were killed. It is certain that this boiler had a weak point.



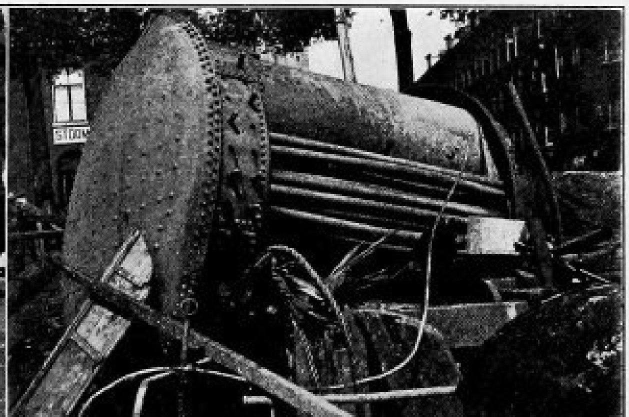


FIG. 1.—DOME AND FLATTENED SHELL.
FIG. 3.—DECK OF THE SHIP AFTER EXPLOSION.

FIG. 2.—HEADS, TUBES, FURNACES AND COMBUSTION CHAMBERS.
FIG. 4.—FRAGMENT OF THE BOAT HURLED ASHORE.

The shell plate consisted of two parts, riveted with double-butt straps, one pair of these straps lying in the steam space, the other at the underside as shown. Some of the stay-bolts were used as rivets, and how these were placed is shown in Fig. 6. The rivet holes were 1 inch, the stay-bolts 1½ inches, the pitch of the stay-bolts and rivets as shown.

It is clear now that the strength of the material at *a* is less than at *C*, the percentage at *a* being 61, at *C* 85 percent. The shell plate burst as indicated; the fracture commenced at the

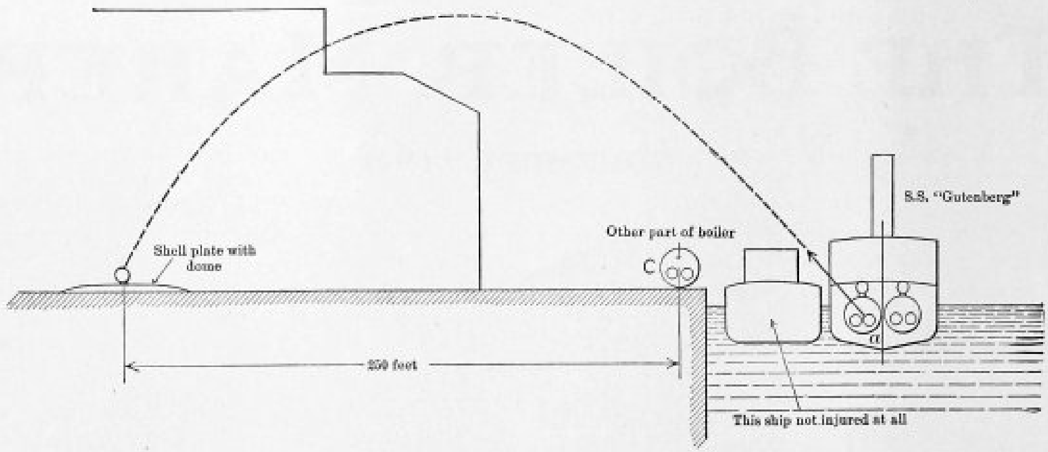


FIG. 5.—DIAGRAM SHOWING LOCATION OF EXPLODED BOILER.

back, which is shown by the fact that the whole boiler was moved in the direction shown in Fig. 8. When completed

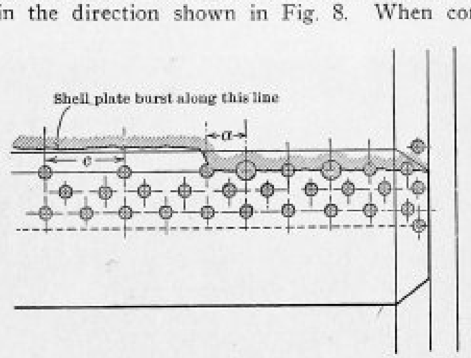


FIG. 6.—FRACTURED SEAM.

these boilers were, of course, tested by water pressure; but perhaps the material at *C* was of minor quality, due to a blue

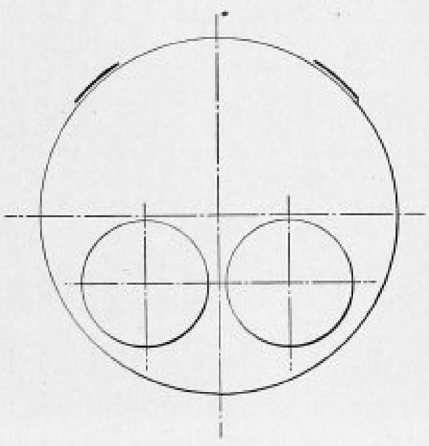


FIG. 7.—PROPER POSITION OF SHELL SEAMS.

heat. It is not possible to assume this, however, until it has been proved by a public investigation. But in every case the

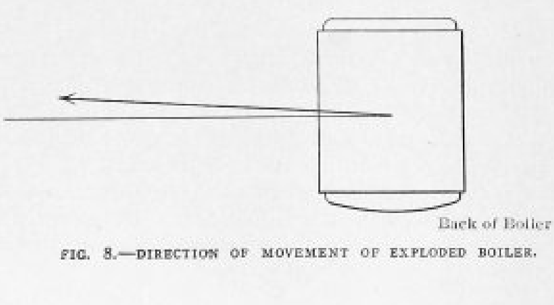


FIG. 8.—DIRECTION OF MOVEMENT OF EXPLODED BOILER.

cause of the fracture has shown that it is not good practice to take away as much material as at *a*. Generally it is thought that this was allowed because the back plate was so near, but it is clear that it is a much better practice to place the straps as indicated in Fig. 7, the shell consisting of a long and a short plate.

Buckling of Flue Sheets.

In answer to the question of "Flue Sheet" in the September number, as to the cause of the buckling of back flue sheets on locomotive boilers, I would say—expansion. The enormous amount of expansion exerted by the flues in one direction and the flue sheet itself in another direction is cause enough to buckle the flue sheet. It should be remembered that the flue sheet itself depends for support entirely on the flues which are held in place by friction, and the bead at the flue end. The very best of feed waters always have a little residue which is deposited about the flue sheet.

In regard to his question as to whether the flue sheet can be straightened without removing it, I would say—yes. If, as was stated in the September number, the bulges are in spots, remove all flues in the bulged places, heat the spots in any convenient way, and with a wooden flanging maul carefully hammer the bulge until it is back in place. If this is done carefully the sheet will not be damaged.

Should the entire sheet be bulged remove all the flues from the boiler, and with an old crown-bar bolted to the flue sheet at both ends, and with three or four ⅞-inch or 1-inch bolts passed through the flue sheet and bar, tighten up the bolts until the sheet is drawn back to place. If you have no crown-bar handy make one out of two 5-inch by 1-inch iron bars, and place ferrules, made out of 1-inch pipe, between the bars to keep them apart, the bar to be made of whatever length is required. When using this device place a piece of 1-inch iron under each end to form a suspension.

Pittsburg, Pa. G. H. HARRISON.

The oxy-acetylene process of cutting steel has been used in a noteworthy manner in connection with the salvage of the battleship *Maine*, the wreck of which is now being dewatered in Havana harbor. Much of the work involves the cutting of armor plate 9 inches thick, as well as the usual plates, beams and bars used in the structure of a ship. Much of this work is difficult to accomplish and illustrates the usefulness of the apparatus as outlined in another article in this issue describing the cutting up of old boilers and other sheet metal work.

WATER CIRCULATION IN LOCOMOTIVE FIRE-BOXES.*

BY H. B. MACFARLANE, M. M. E.

The design and development of the Jacobs-Shupert fire-box have caused considerable discussion of the relative value of this new type of sectional construction in comparison with the ordinary fire-box, with its flat sheets and numerous stay-bolts. Water circulation was the main question considered in the discussion of this fire-box at the recent master boiler makers' convention at Omaha, Neb., the discussion being reported in the *Railway Age Gazette* of June 2, 1911, page 1263. The circulation in a locomotive boiler results from the motion of the locomotive itself, from the velocity of the entering water, from temperature changes in the body of the water itself, and from the drawing off of steam from the boiler. The circulation at any instant is variable, depending on these conditions. Of the forces causing circulation, the most active is due to the inertia of the water itself. Water circulation produced by heat conductivity is the least efficient in establishing uniformity of temperature throughout the boiler. While temperature measurements made at different points of the fire-box are indicative of circulation to a certain extent, they are not a positive measure. This is especially true for relatively low velocities, such as must occur in a fire-box with large water legs.

A special study and investigation of the circulation of water, and the location of solids and suspended matter in the water spaces around the fire-box of a locomotive when in operation, was made on the Atchison, Topeka & Santa Fe, while road tests were being conducted on locomotives of the ordinary type fire-box and with the Jacobs-Shupert type. The results obtained were of value in establishing a satisfactory theory of water circulation in the fire-box, and in determining the principal location of solids and suspended matter at times when the engine is working hard and is liable to foam on account of bad water. Samples of water were taken for analysis at various times during each run from the same relative position around the fire-box of both engines. Four sampling tubes were arranged in a vertical row on the left side of the fire-box about midway from front to back. Tube No. 1 was placed at the mud-ring; No. 2 was at the top of the brick arch, or about 8 inches above the mud-ring; No. 3 was half way up the side of the fire-box, about 42 inches above the mud-ring, and No. 4 was near the waterline of the boiler.

The sampling tubes consisted of cylinders 2 inches in diameter and 8 inches long. One end of each cylinder was connected to the fire-box by means of a short piece of 1¼-inch pipe fitted with a globe valve. A pet cock was attached to the bottom of the cylinder. In taking the sample of water the pet cock was first opened and then the globe valve. The water blown from the boiler forced the air out of the cylinder and also washed out any sediment that might have been deposited in the piece of pipe. After the cylinder was thoroughly cleaned out the pet cock was closed, and a few minutes later the globe valve was closed. In this way about a pint of water, representative of conditions at this point of the fire-box, was obtained. The water was allowed to stand in the cylinder until it had cooled sufficiently so that when drawn from the cylinders into a sampling tube it did not flash into steam.

Since all particles of undissolved matter in the water would be carried along in the boiler and in the water leg, due to the velocity of the current of water, a study of the location of suspended matter at different times and for different positions will give some idea of the direction and force of these currents. Therefore the suspended matter, and also the total solids, as determined from the water analysis, may be used to indicate the nature of the boiler circulation. The samples of water secured for analysis from the various points in the boiler must be taken at the same time, before conditions of circulation change, in order to obtain consistent results. There was, however, some irregularity in these analyses, due to the fact that during the tests the samples of water could not be taken at exactly the same time.

The data showing analyses of waters secured from the two different engines are presented in the accompanying table. In analyzing the conditions as obtained from the composition of the water samples taken from the engine with the Jacobs-Shupert fire-box, definite conclusions can be drawn as to the circulation of the water in the boiler. As long as the suspended matter is nearly constant at the various points there is assumed to be a positive circulation around the fire-box. For example, a study of the samples taken during run No. 12, going into Yampai, shows a great uniformity and reveals the fact that there is a regular increase in the suspended matter as well as in the total solids from bottom to top, showing the force of circulation toward the top of the boiler. These samples were taken after pulling up a 75-foot grade from Pica, a distance of 5 miles, with the locomotive working at its full capacity. A consistent uniformity of conditions is also found in the samples taken upon arrival at Needles at the end of the trip.

During run No. 11, there is a uniformity of conditions with the same general increase in suspended matter and total solids from bottom to top, indicating an upward circulation. On this trip the samples taken while going up Kingman Canyon show a regularity in the total solids but an irregularity in the suspended matter, which may be accounted for by the fact that the injectors were on at the time the samples were taken. In noting the analyses of samples 5 to 8, inclusive, taken at Kingman on the same run, it will be seen that there is a decrease in the amount of suspended matter in each of the samples, showing how effectively the suspended matter has been thrown down after the engine had stood for some length of time.

It is to be noted for the round-trip runs, 11 and 12, that there is a continual increase in the total solid matter in the samples from any given tube. This is explained by the fact that during a complete round trip more and more water is taken into the boiler and evaporated, consequently the total solids remaining must increase gradually, although blowing off has the effect of a temporary decrease. There is a greater decrease in the total solids for trips Nos. 13 and 14 than for trips 11 and 12, because the boiler was washed more thoroughly after trip 12 than after trip 10.

Samples 42 to 45, inclusive, from trip 16, were taken while going into Hackberry. They show the same general relation of the total solids, indicating currents towards the top, and also that there was no undue amount of solids at the bottom of the water leg near the mud-ring. These figures confirm all predictions regarding positive circulation claimed for the Jacobs-Shupert fire-box, and denotes clearly that there is a very complete circulation around this fire-box.

A careful study of the analyses of water samples from the engine equipped with a fire-box of ordinary construction in comparison with those from the engine equipped with the Jacobs-Shupert fire-box reveals a difference in the water circulation in the two fire-boxes. In most cases the total solids and the suspended matter for the engine with the ordinary fire-box show an inclination to increase towards the bottom, indicating a very much decreased force of upward currents, or possibly the presence of currents in another direction. There is no regular increase in the total solids and the suspended matter from the bottom to the top of the boiler, as is the case of engine with the Jacobs-Shupert fire-box. On run 25 samples of water were taken from the four tubes after the

*From the *Railway Age Gazette*.

ANALYSES OF WATER FROM JACOBS-SHUPERT FIRE-BOX.

RUN 11.

Sample Number.	Tube Number.	Grains per U. S. Gallon. Total Solids.	Suspended Matter.	
1	1	122.4	17.5	Going up Kingman Canyon.
2	2	163.8	37.9	
3	3	192.4	19.8	
4	4	188.9	20.4	
5	1	138.7	25.9	After standing 30 minutes at Kingman.
6	2	158.0	13.4	
7	3	177.8	11.1	
8	4	220.4	17.5	
9	1	208.7	30.7	Going into Peach Springs.
10	2	213.4	30.3	
11	3	223.3	33.2	
12	4	241.9	36.1	
13	1	184.8	29.7	Pica, before blowing out.
14	1	181.3	50.7	Pica, after blowing out.
		RUN 12.		
21	1	219.2	36.1	Going into Yampai.
22	2	211.1	36.1	
23	3	246.0	39.0	
24	4	245.4	40.8	
25	1	202.9	32.6	Upon arrival Needles.
26	2	200.5	27.0	
27	3	222.1	39.1	
28	4	227.9	40.2	
		RUN 13.		
29	1	60.6	2.3	Leaving Needles.
30	1	174.9	13.4	Going into Hackberry.
31	2	167.9	14.6	
32	3	199.4	19.3	
33	4	192.4	22.1	
		RUN 14.		
34	1	180.7	40.2	Going into Hackberry.
35	2	181.3	39.1	
36	3	190.6	39.6	
37	4	199.4	42.0	
		RUN 16.		
42	1	155.1	36.6	Going into Hackberry.
43	2	159.2	36.7	
44	3	176.6	33.2	
45	4	166.7	36.7	
46	1	176.6	28.6	Taken at Kingman after standing 30 minutes with injectors off.
47	2	176.6	31.5	
48	3	195.3	35.0	
49	4	200.0	29.1	

ANALYSES OF WATERS FROM ORDINARY FIRE-BOX.

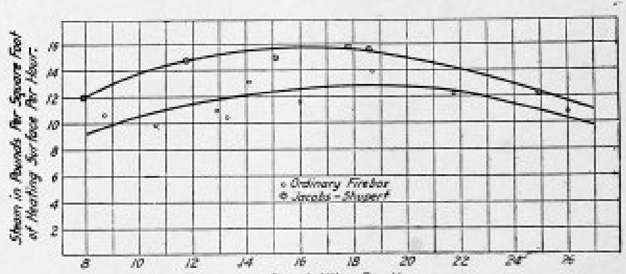
RUN 23.

Sample Number.	Tube Number.	Grains per U. S. Gallon. Total Solids.	Suspended Matter.	
1	1	174.3	21.6	Going up Kingman Canyon. Throttle open. Injector on.
2	2	180.7	17.5	
3	3	174.3	15.2	
4	4	185.5	16.9	
5	1	148.1	32.9	After standing 30 minutes at Kingman. Injector not working.
6	2	172.6	25.6	
7	3	166.7	20.4	
8	4	172.6	19.2	
10	1	159.1	16.3	Same as Sample 5. Taken after blowing off.
		RUN 25.		
11	1	46.6	8.2	Leaving Needles.
12	1	139.9	16.3	Going up Kingman Canyon. Throttle open. Injector on.
13	2	135.8	18.6	
14	3	151.6	14.6	
15	4	146.9	15.7	
16	1	153.9	17.5	After standing 30 minutes at Kingman. Injector not working.
17	2	153.9	18.1	
18	3	152.2	16.3	
19	4	148.7	16.3	
20	1	151.6	22.7	Same as Samples 16, 17, 18 and 19, after blowing off.
21	2	158.6	21.0	
22	3	155.7	21.0	
23	4	155.1	16.9	

engine had been standing for thirty minutes with the injector off. Blow-off cocks were then opened, after which further samples were secured. A comparison of the analyses of samples secured before and after blowing off shows an increase in the amount of the total solids as well as the suspended matter at the points where the samples were taken. Such results apparently indicate that the object of blowing off, which is to reduce the suspended matter and solids, had not been accomplished. Such a conclusion, however, would not be correct. The apparent paradox is explained as follows: The water in the back head of the fire-box, due to cooler temperatures and less circulation, undoubtedly contains a great many more grains of solids and suspended matter per gallon than that in the front portion around the fire-box. The blow-off cocks being located in the front portion of the fire-box, will, when open, draw the water from the back to the front. This movement causes an increase in suspended matter and solids at the middle sections where the sampling tubes were located during and just after the period of blow-off.

This fact shows that a complete substantiation of the theory of boiler circulation cannot be effected, nor the location of solids and suspended matter around a fire-box be fully determined, by taking water samples from only one vertical section of the fire-box. However, the results in this direction show that the circulation in a Jacobs-Shupert fire-box is very positive and much better than in an ordinary fire-box. Rapid and positive circulation in a boiler, especially around the fire-box, results in a higher rate of heat transmission through a unit of heating surface, and hence a better steaming engine.

This data on the analyses of the waters was obtained during comparative tests of the same class of power handling practically the same tonnage over the same district. The evaporative performances of the two engines were practically the same, although the evaporation per square foot of heating surface per hour was somewhat greater on the engine with the Jacobs-Shupert fire-box than on the engine with the ordinary type of fire-box, the actual increase being about 20 percent. Further road tests on an engine with the Jacobs-Shupert fire-box and an engine with the ordinary fire-box



RESULTS OF COMPARATIVE TESTS.

shows an increase in evaporative efficiency per square foot of heating surface per hour of 35 percent. Comparative tests of two engines over the same territory, one with the Jacobs-Shupert fire-box and the other with the ordinary type of fire-box, shows an average evaporation per square foot of heating surface per hour to be 29 percent greater for engine with the Jacobs-Shupert fire-box than for the engine with the ordinary fire-box, at speeds ranging from 8 to 16 miles per hour, as shown in the accompanying chart.

The Largest Crane in the World.—A report from Consul J. N. McCunn, of Glasgow, describes what is said to be the largest crane in existence, which has been erected at Govan, on the Clyde River, for the Fairfield Shipyards. The crane is 160 feet high, with a jib, which is of the hammer-head type, with a total length of 270 feet, and extends 169½ feet outward from the center, and can be utilized within every point of a circle 336 feet in diameter. The crane is operated by electric motors from 60 to 90 horsepower, located in a machinery house at the rear end of the crane. On slow gear the crane can lift 200 tons extended 75 feet along the jib, and on quick gear it can raise a load of 100 tons at 133 feet. The maximum load of 200 tons can be lifted from 30 feet below wharf level to 140 feet above, or a total of 170 feet.

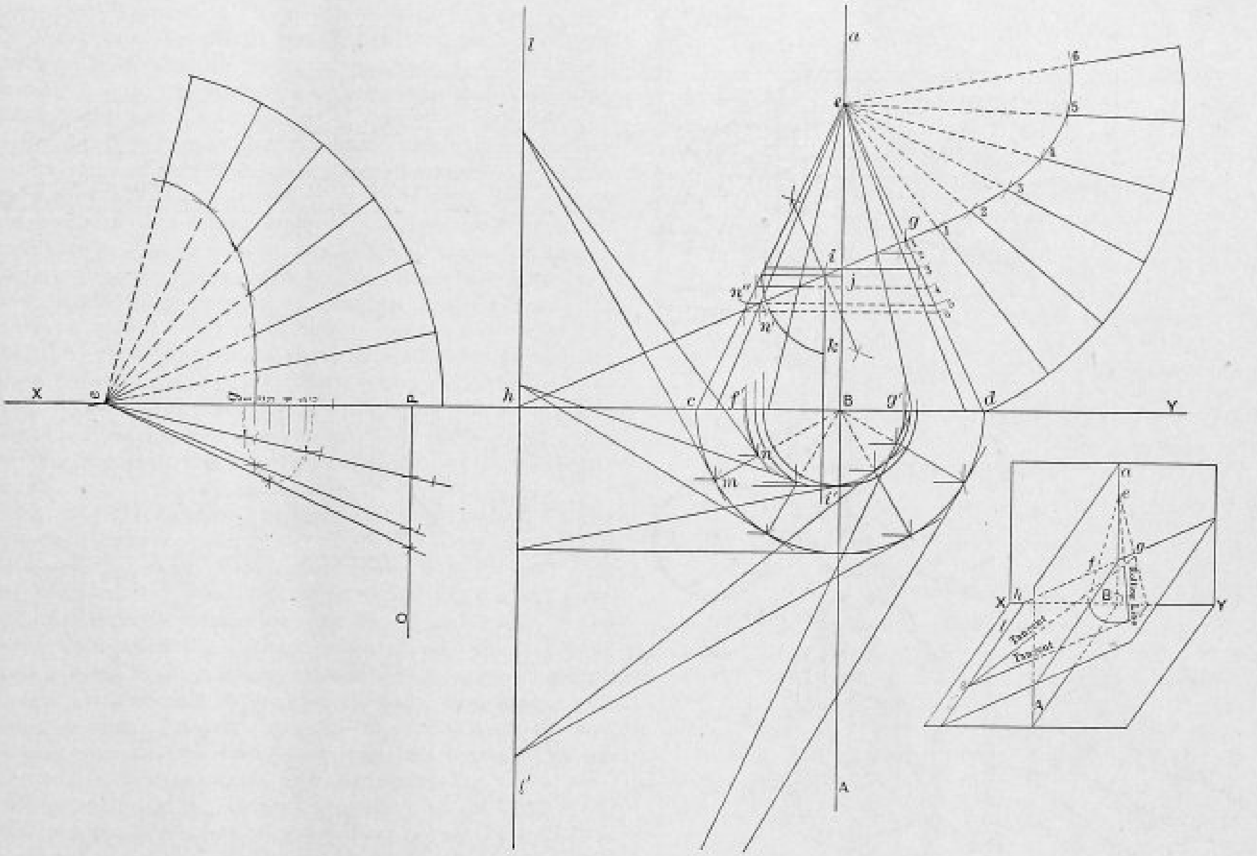
Development of a Frustum of a Right Cone, Cut Off at an Angle with Tangents and Crossing Planes.

BY I. J. HADDON.

Draw the line *X Y* representing the intersection of the horizontal and vertical planes, draw the line *A a*, representing another vertical plane; all the planes are shown in perspective in the small rough sketch.

With *B* as center draw the semi-circle representing the half plan of the base of the cone; draw *c e, d e*, representing the elevation of the cone.

Draw *f g*, representing the cone cut off at an angle, and produce until it cuts the line *X Y* in *h*; bisect *f g* in *i*; draw *i i'*; drop *f* and *g* onto the line *X Y*, as *f' g'*, which will be the plan of the major axis of an ellipse; to obtain the minor axis project the point *i* to the side of the cone, and with *j* as center project them to the side of the cone; but had it not been a cone it may have been necessary to proceed as follows: With *B* as center and *B n* as radius draw the arc as shown, then project up from the line *X Y* until it meets a line drawn from *n'*, being the elevation of the point *n* parallel to *X Y* in *n''*. Of course, this will be on the side of the cone; the other points would be obtained in a similar manner. To develop, use *e* as center and *e g, e* 1, *e* 2, as radii, describe small arcs as shown, and with *e* as center and radius *e d* describe the large arc; measure around the large arc the divisions as shown in the semi-circle of the plan, and draw lines to *e*, cutting the small arcs in 1, 2, 3, 4, 5, 6 as shown; draw a fair curve through these points, which will complete one-half of the pattern. It is unnecessary to explain how to draw the remaining half. Now to proceed to develop from another view. Draw the line *O P* at any convenient distance from the plan, and project the points on the semi-circle up to this line, then from *P* along the



LAYING OUT JOB BY TANGENT AND CROSSING PLANE METHOD.

describe the arc as shown cutting the line *i i'* in *k*, then *i k* will be half the minor axis; describe the semi-ellipse as shown in *f' i' g'*. Now just imagine that a flat surface or plane was laid on the cone where it is cut at an angle, the flat surface or plane would meet the line *X Y* at *h*, the plan of which would be the line *l l'* of indefinite length. Now from anywhere along the line *l l'* draws lines tangent to the semi-circle and semi-ellipse as shown; connect these points of intersection as shown at *m n*, which will be the plan of straight lines on the cone, and also rolling lines, produce these lines until they meet the plane *A a* as at *B*; now project the points on the semi-ellipse and semi-circle up to the lines *f g* and *c d*, respectively, then draw lines through these new points and they will all meet the plane *A a* in one point as at *e*. Had this not been a cone they may not have met at the same point. Now to obtain the true length of these lines all that it is necessary to do is to line *X Y* mark off the points 6, 5, 4, 3, 2, 1, *g* and *e* equal to the vertical heights taken from the elevation in the other figure; from these new points draw lines parallel to *O P*, as shown; now project the points on the semi-ellipse to cut these lines as shown; then if lines be drawn through where they cross from the points on the line *O P* you will find they will all meet at the point *e*. As I said before this happens so because we are dealing with a right cone. Now with *e* as center mark off their respective true lengths on each line as shown, and proceed to develop as before.

The small perspective sketch shows four planes with their lines of intersection, and if the eye was placed anywhere along the line *l l'*, as at *S*, the whole of the top and bottom of the frustum would be seen, and if tangents were drawn from the point as shown, and connected as shown, it would give the correct rolling line.

IN DEFENSE OF THE TRIANGULATION METHOD.

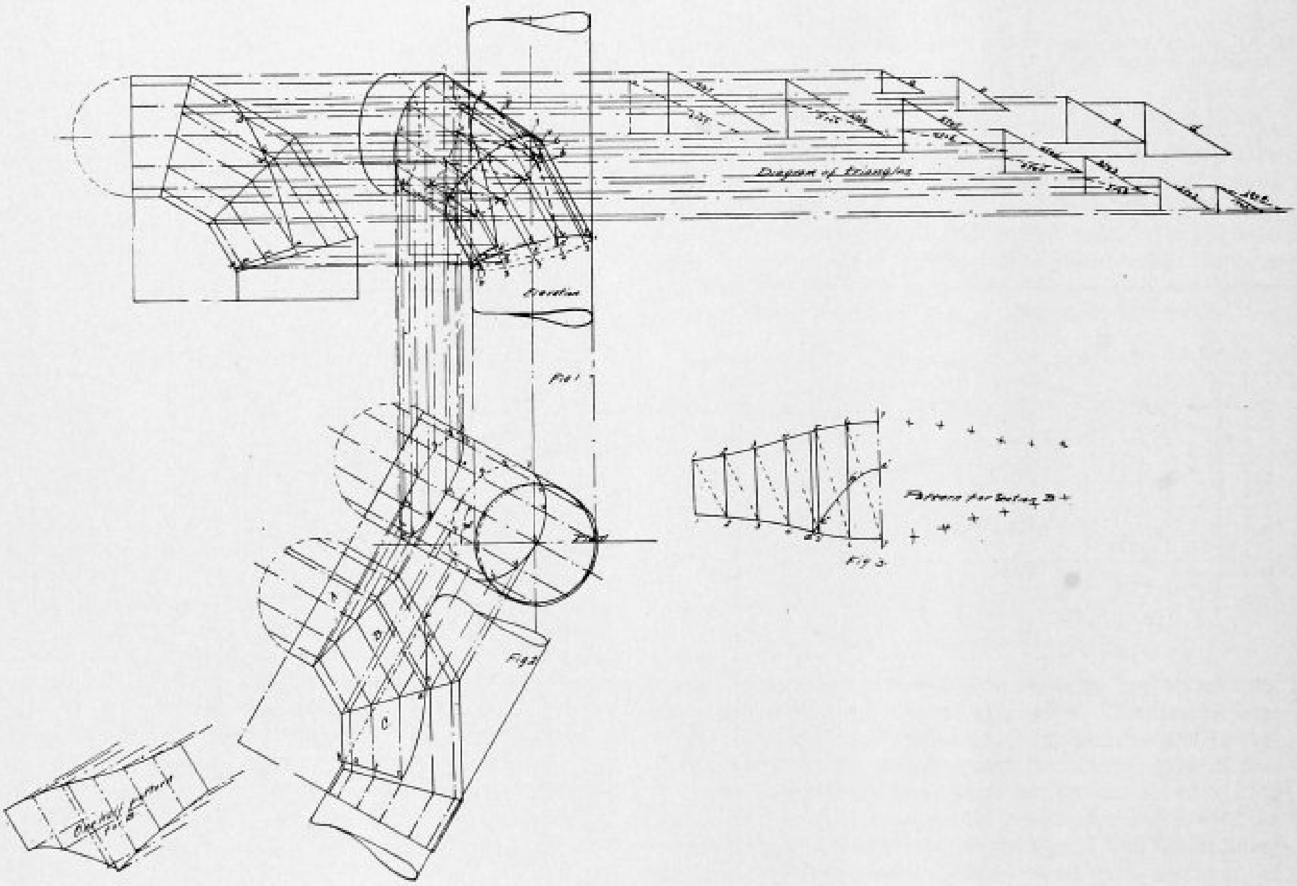
BY C. B. LINSTROM.

In the October issue of The Boiler Maker, Mr. Haddon has given several illustrations and a description of the proper way he considers of obtaining correct developments of Y-pipe connections. By a careful reading of what he says it will be understood that he is endeavoring to prove the impracticability of applying the triangulation system of development to problems of this character, and offers in its stead what he considers a more accurate and practical method.

Now as different arguments have been presented, I wish to make a few general remarks showing, if possible, that Mr. Haddon's method is not any more practical, all conditions considered, than the triangulation system.

Before entering into this discussion I would say that the method Mr. Haddon champions is the one in general use throughout the British Isles instead of the triangulation method. In this country both methods are used.

I have no bone to pick, but I wish to go on record and state that the triangulation method will render as practical a solution to the problems submitted by me in the December issue as the one advocated by Mr. Haddon in the October issue. The main contention of Mr. Haddon is that the rolling lines which are assumed to be on the surface of the object are not true rolling lines but straight lines, and that they cannot be found by accurately spacing the top and bottom of the surface into equal parts. Now, according to the principles of triangulation, it is assumed that the surface is divided into a series of triangles, which are supposed to run parallel with its surface. Of course, it will be understood that they do not run parallel with each other, nor do they incline toward each other with any degree of regularity.



DEVELOPMENT OF ELBOW INTERSECTING CYLINDER OF EQUAL DIAMETER.

In all constructions, which are in a vertical or perpendicular plane of projection, and in a plane parallel with that plane the lines can be measured from the elevation in their true length, but as soon as the object tapers irregularly or becomes rounded and inclines obliquely from the vertical plane, distances cannot be measured from the elevation. Therefore, it is very essential in sheet metal and boiler work to know of methods suitable for finding the true lengths of the oblique lines. The elevation gives the height of the line measured vertically, and the plan shows its dimension horizontally. Therefore the true length of lines oblique to the different planes of projection can be obtained by using the most simple of geometrical problems; that is, to construct a triangle having three sides given. Having the height of the oblique line given in the elevation and the base in the plan, it is very easy to erect a perpendicular to the given height and base equal to the horizontal projection of the oblique line. Connecting the height and base gives the required true length of line. It will now be seen that to develop a problem by triangulation simply involves the operations of dividing its surface into triangles, find their true lengths and assemble them in their regular occurring order in laying off the pattern.

In Mr. Haddon's development, shown in Fig. 1 of the October issue, he illustrates a development by radial lines. These radial lines, as will be noted, are shown foreshortened; hence, it is also necessary to find their true lengths. This he has illustrated by revolving the lines in the plan to their horizontal axis and then projecting them to the elevation.

This is another principle of triangulation and is used generally in developing regular polygons, which taper to an apex, and especially in constructions in the shape of scalene cones. For convenience, when the apex is not attainable, it has been found very satisfactory and practical to use the triangulation method, as it will give a pattern close enough for most any practical purpose.

To show the reader a little more clearly the principle of triangulation drawing, a perspective drawing is herewith given, which shows to a degree how the triangles are supposed to be on the object. The solid lines from 1 to 1 indicate the true rolling lines. The dotted ones from 1 to 2 are not exactly true, as the surface of the object is bent while the line is straight; but if the object was divided into a greater number of divisions it would be seen that the lines would be nearly in contact with its surface. They are, then, practically true rolling lines. These dotted lines, however, are considered as rolling lines and are sufficient for practical purposes. To show that they are not out to any great extent, a development of an elbow intersecting a cylinder of an equal diameter is shown in Figs. 1 and 2.

Fig. 1 shows the one-half pattern of section *B* developed by projection. Fig. 2 shows its construction by triangulation. Its pattern is shown in Fig. 3. A comparison of the two patterns will prove that the triangulation method gives practically the same pattern as the projection method. It will be found through a little experimenting and comparison of the results obtained through the application of the radial projection and triangulation methods that the latter will beyond question render satisfaction and produce patterns accurate enough for any boiler maker to assemble in order to make the required construction. But where conditions warrant, the use of the radial, or projection method, should by all means be used in preference to the triangulation system. Cases will arise, however, where it is possible to use the radial method; but it would be found very impractical to use it owing to the fact that it is very inconvenient and requires too much time and space to secure the patterns. There is also great possibility of error in the work, especially in cases where the sides of the object are prolonged in order to locate the apex or center for striking the arcs; the lines invariably will not be accurately drawn.

Fig. 2 of Mr. Haddon's article illustrates a method for determining the true rolling line. Now this to me appears that he is splitting hairs. The method shows how the solid lines are obtained, but what about the dotted lines which complete the triangle; would they not be out as much, if not more, than when the surface is spaced into equal spaces? Rest assured there is no reason why the layerout should go to this extra trouble of drawing so many unnecessary construction lines. Another thing, this method is a specific or a limited one. In how many cases can the tangents to the ellipse be accurately located with convenience?

Refer to *J*, Fig. 2. Tangent to point 1 on the large circle plan near the line intersects somewhere on line *DE*. Now it works out all right on the drawing board; but, in the shop, how far would such a line have to be carried in order to determine the points of tangency? Somewhere, maybe, within a radius of many feet or miles.

The sum and substance of the whole matter resolves itself into this: If Mr. Haddon was as thoroughly familiar with the triangular method as he is with the radial triangulation he would not offer an impractical solution as that given in under the heading *Second Method*, Fig. 2. There is one other thing which should not be lost sight of; and that is, "There are usually an infinite number of solutions possible in laying out work which are more or less correct.

Summing up, the following conclusions are in evidence:

TRIANGULATION.

1. Some variation in the work due to the fact that the straight dotted lines do not follow the surface of the object.

2. Some variation in the work owing to the fact that the chord distances of the spaces do not equal the true length of the arc of which they are the chord.

3. In view of these variations, the method can be applied to any problem with a practical degree of accuracy.

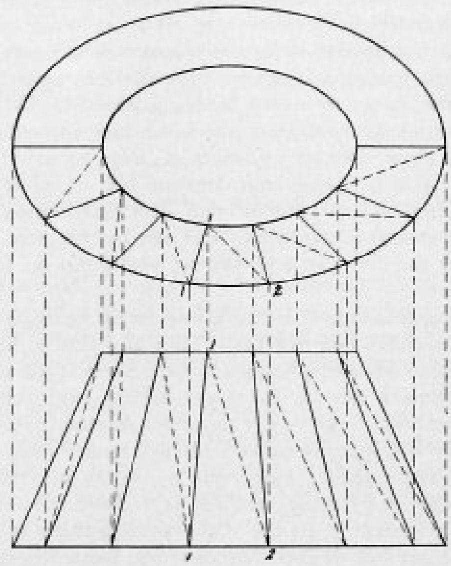
TANGENTS AND CROSSING PLANES, OR THE RADIAL TRIANGULATION METHOD.

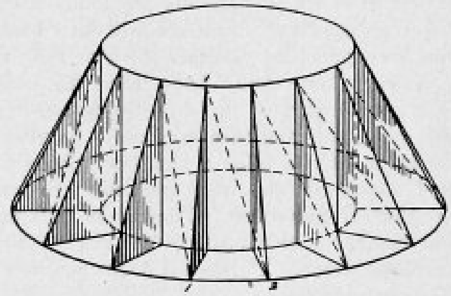
1. Only applicable to problems in which the sides intersect at an apex.

2. Inconvenient if apex is located at a great distance from the work.

3. Apex of intersecting sides cannot be located accurately, as there will invariably be some variation in drawing a line a great distance.

4. Sides of the object sometimes will run nearly parallel,





PERSPECTIVE, SHOWING GENERAL ARRANGEMENT OF TRIANGLES.

hence a difficult matter to locate the point of intersection between them.

5. Requires too great a space to lay out some problems. Hence is very inconvenient.

6. Method is applicable and accurate when applied to problems which can readily be developed within a reasonable space within the shop.

7. The method is not applicable to all problems, while triangulation can be applied to any problem.

In conclusion I might mention that some time ago I questioned the application of the tangents and crossing planes method to problems tapering to an apex, in which the apex was unattainable within the limits of the shop. Mr. Haddon did not apply this method to the problem he submitted in the July issue, but substituted another, which, I suppose, he considers an answer to the challenge.

OXY-ACETYLENE TORCH IN CUTTING METALS.

The possibilities of oxy-acetylene in cutting metals when we attempt to do work in a space which is restricting progress is naturally slow. Nowhere is this more noticeable than on board ship, where we have all sorts of constructions to work against, and rarely is there sufficient time allowed to get the work properly done, so ripping and tearing is resorted to, which make subsequent work more expensive than it should be. To try and cut out a brace, or chip off a rivet, where a good swing of a hammer can not be used, is heartbreaking to the workman and expensive to the owner. Next to ship work, this trouble of lack of space, comes boiler work, and work of this kind consisting of demolishing a boiler by means of an oxy-acetylene cutting torch opens up an avenue of possible relief in this direction. It must be, of course, remembered that in the use of the oxy-acetylene torch care has to be taken in confined spaces that air be provided without fail, or the workmen would be badly affected. While some skill is required in handling the torch and apparatus, it requires no great amount of ability to soon become proficient and to be able to do an enormous amount of work as compared with what can be done with sledge and chisel. It has to be remembered that while steel can be cut, cast iron can not be by the oxy-acetylene system, yet it can be fused and welded.

From manufacturers* we have interesting figures as to what can be done by their torches. They say that a cut 3½ by 1½ inches, in some equaling 5¼ square inches, took 5 seconds, the preliminary heating necessary taking only one minute, the average time being 12 1/3 seconds. Another cut of 9 by 4 was made in 9 minutes 15 seconds per square inch.

Briefly and typically stated, the procedure of cutting with an oxy-acetylene cutting torch is as follows: The metal is first highly heated by the use of the welding flame at the point where the cut is to begin. A second jet, located in the immediate vicinity of the heating nozzle, discharges a stream of oxygen upon the highly heated metal, and this results in a removal of the metal by a process which appears to be combustion in part or in whole. Moving the double nozzle along, the metal will be cut just as a handsaw will cut a board in two.

In cutting through metal, whether thick or thin, the cut is made all the way at one time. Thus, in cutting 6-inch metal, the cut is not made part of the way through upon one passage of the jets across and then finished by another passage. The cut is made just as with a handsaw. Indeed, the jets are directed downward and with the upper portion leaning in the direction of movement. The cut is thus made in a very similar manner to that made by the saw. However, the profile is perhaps steeper. Further, it is not precisely straight, but has a slight curvature.

Of course, it is the practical application of a process which interests the industrial world. At the same time it should be remembered that a knowledge of the underlying principles of the process can hardly fail to prove useful, especially where variations from established practice have to be made. It is recommended that the foregoing account be well digested.

The cutting of sheet steel is a matter which has been pretty well attended to. The practice varies somewhat in respect to the pressures to be used. However, the following may be taken as typical: If the steel is ½ inch or less in thickness, then the oxygen of the heating tip is kept at 14 to 18 pounds and of the cutting jet at 20 pounds. For heavier steel, but not thicker than 1½ inches, the two pressures are 14 to 18 and 30 pounds. For sheets thicker the pressure may be kept at 18 to 22 and 45 to 75 pounds. Where a factory has a great deal of cutting to do of a few sizes, a little experimentation should be made to determine the most economical pressures. These may very well vary with the character of the steel itself. The consumption of oxygen is, at times, an important point. It is more expensive than the acetylene and much more is used. However, when the high pressures are employed the cutting can be rather quickly performed, so that the total amount will be reduced for that reason, although increased because of the pressure.

A mechanical means of cutting sheet metal has been devised. The apparatus is carried across the sheet with precision and regularity. This is probably the best way to cut sheets. Further, a device has been gotten up for the purpose of cutting steel tubes when in the vertical position.

*Davis Bournonville Company, 90 West street, New York; Walter Macleod & Company, Cincinnati, Ohio.

How to Tell if a Crown Sheet Has Been Hot.

Low water, however caused, always produces excessive heating, and if the temperature rises sufficiently to weaken the material failure may occur by stripping of the stay-bolts or rupture of the sheets by bulging between them, or otherwise. If the temperature has raised the material to a low or bright red color this can be readily determined by superficial inspection. While the fire-side will show red rust or a black color, the water or steam-side will invariably show a typical steel-blue scale, which will not disappear even after years, as it is a so-called rustless coating. If this be once oiled it will always be distinguishable, even if the plates had been exposed to moisture and gases for years. The color of this scale will depend somewhat upon the temperature at which it was produced, being brightest at those points where temperature was the highest. Carefully made tests, with autographic diagrams, of such material will again demonstrate changes of properties which are very characteristic. The yield point will be found very low, while the diagram will show a material drop of curve just after the yield point. The elongation will, however, as a rule, be materially increased, with a diminution of tenacity. Nicked and quenched bending tests will again show marked difference between strips cut from the sheet at points which in one case were overheated or were above the low-water line, and in others were taken from a part below this line. The fracture will also be materially different. To demonstrate the temperature at which the plates happened to be at the instant of explosion, it is necessary to cut strips from points of the overheated plate below the waterline. These strips, polished on the edges, are then held in a clear fire so that one end remains cold while the other is heated to a dull yellow or a very bright red. This temperature being reached, the bars are withdrawn, and while one is rapidly plunged with one end into a pot of boiling water the other is allowed to cool in air, but not in contact with wet metal or stone. When the piece which had been immersed in boiling water about 1 inch deep has become nearly cold, below blue heat, it is plunged into cold water.

On the polished edges of both bars will be found scale and heat colors, the temperatures producing them being well established. These bars are then carefully nicked at points opposite every change of color and then broken off at these nicks. By comparing these fractures and their scale and color with those obtained from pieces cut from the overheated plates, the temperature at which they were at the instant of explosion can be determined with great accuracy. Having thus determined the temperature at which the sheets were during operation, it is also known whether the metal was sufficiently soft to bulge off or strip from the stay-bolts; examination of plates and bolts will verify the conclusion.—*Railway and Locomotive Engineering.*

The Hydrostatic Test.

There seems to be a general impression among laymen and those associated indirectly with power plants that if a boiler shows no signs of distress under a hydrostatic pressure of a certain number of pounds, it is, therefore, capable for the next twelve months of carrying with safety a steam pressure equal to two-thirds of the hydrostatic pressure applied; or, to put it in another way, if the boiler does not rupture or show signs of distress under a water pressure of 150 pounds, it is safe to carry a steam pressure of 100 pounds. This is very illogical, and one might as well say that because a man can lift 150 pounds 6 inches from the floor once, he ought to hit a blow of 100 pounds all day long for the next twelve months. We are aware that the comparison is a little overdrawn, but there are times when only a strong contrast will bring out vividly a commonplace truth.

Suppose a boiler with an ultimate bursting pressure of 400 pounds, using a factor of safety of 5, the allowable working pressure would be 80 pounds, and 1.5 times 80 pounds would be 120 pounds, which would be the logical hydrostatic test to apply. As the elastic limit is generally a little above one-half the ultimate breaking strain, this boiler would stand a water pressure of, say, 200 pounds without stretching the metal beyond the elastic limit. Suppose such a pressure were applied, and then that pressure were divided by 1.5 to obtain the steam pressure. The result would be 133 pounds, giving a factor of safety of only 3, which, of course, is dangerously low. The boiler would appear to act about the same, whether it was subjected to a hydrostatic test of 120 or 200 pounds. In one case the allowable pressure would be 80, and in the other 133 pounds, such figures, of course, being meaningless until the accompanying factor of safety is determined.

Not only may the boiler be strained beyond its elastic limit by the application of the hydrostatic test, and a permanent set take place, but a boiler almost wholly void of ductility would show no signs of distress under the application of a steady hydrostatic load, whereas such a boiler might fly all to pieces when subjected to the alternating stresses produced in it when under steam.

That there is no relation between the hydrostatic test and the steam pressure to be allowed, is shown by the lack of uniformity on this question among different governing bodies. While the United States Board of Supervising Inspectors of Steam Boilers requires 1.5 times the steam pressure on ordinary boilers, it requires that the hydrostatic pressure be twice the steam pressure on all coil and pipe boilers. The American Boiler Manufacturers' Association recommends that the hydrostatic test shall not exceed the working pressure by more than one-third of itself, and this excess is limited to 100 pounds. The rules formulated by the Board of Boiler Rules of the Commonwealth of Massachusetts make the hydrostatic pressure equal to 1.5 times the maximum allowable working pressure, though twice the maximum working pressure may be applied to boilers to carry not over 25 pounds, or on pipe boilers. The British Board of Trade and Lloyds require twice the working pressure; the National Boiler Insurance Company of England, 1¾ times the working pressure, and the Scottish Boiler Insurance Company of Scotland for pressures above 80 and under 150 pounds, the working pressure plus 80 pounds; above 150 pounds, the working pressure plus one-half the working pressure, etc., all showing that there is little uniformity in regard to this ratio.

We do not wish to be understood as condemning the hydrostatic test; it is an excellent thing in its way, and at times very valuable. In the case of small boilers which cannot be entered for inspection, or in specially fitted work, or in testing cast iron boilers, or in special vessels such as jacketed kettles, whose interiors can be viewed only through a 2-inch plug hole, the hydrostatic test is practically the only available means of testing. In such cases, when that test has been applied, all that it is possible to do has been done. The hydrostatic test is also valuable in testing new boilers in the boiler shop, to determine whether or not they are tight.

In a large measure it is unfortunate that the hydrostatic test does not give definite and absolute quantities, for if this were the case boiler inspection, which is now a rather disagreeable job, would be made quite easy and pleasant, and instead of crawling through small holes into hot and dirty interiors, and later making many computations on the strength of each part of a boiler, the efficiency of the riveted seams, strength of the braces, resistance of the flat places, etc., all an inspector would have to do would be to keep his eye on the gage.

Since there is no connection between the hydrostatic and the allowable steam pressure, the latter can be stipulated only after an inspector has carefully examined the boiler inside and outside, taken careful measurements, computed the strength of the weakest part, and applied to that part a factor of safety approved by the dictates of good engineering practice.

* *Power.*

Experience with a Second-Hand Boiler.

BY WILLIAM F. JOY.

In a Southern city some time ago the old "shot-gun" boiler which Jones was operating blew up, and then Jones was in the market for another boiler. He accordingly went to a second-hand dealer and negotiated for a first-class second-hand boiler.

Now Jones had a friend named Allen, representing an insurance company, to whom he had told his troubles. Allen's advice was not to buy a second-hand boiler without having expert opinion on it. He suggested that one of the insurance company's inspectors look over the boiler before Jones purchased it, and if it was found to be in good condition the company would be glad to insure it.

"Oh, no!" said Jones, "Smith, the second-hand dealer, and I went to school together. I have every confidence in him; I know he is on the level and he will give me a square deal."

Later Jones thought better of the advice of his friend Allen and decided to insure the boiler. When the inspector visited the plant to examine it he found it to be of an old type, such as was used on towboats a generation ago, with a fore-and-aft steam drum. To get into the boiler from the top, one first had to enter the drum, then squeeze down through the neck into the top of the boiler itself. A number of braces on both heads were broken, the tubes were pitted and the sheets corroded, but the outside of the shell was nicely adorned with a thick coat of tar. Jones wondered what good the tar did, but was told that all second-hand boilers must be covered with tar to preserve them.

When the inspector saw the tar he at once became suspicious. He heated a brick, and with the aid of a pair of tongs began removing the tar. This showed the shell to resemble a sieve. The boiler was guaranteed by the dealer to be safe for 110 pounds pressure. After calculating the probable strength and considering its condition, the inspector told Jones he would allow 50 pounds and no more.

This decision annoyed Jones, and caused him to say, "If you don't want to insure it there are others, and I'll get a company that will." Accordingly an inspector from another company was called in, and was requested to examine the boiler. A further application of the hot-brick treatment disclosed more trouble, making matters look still worse and adding "insult to injury"; so a third inspector was tried, but with the same result.

Jones became angry when he realized that no one wanted to insure his boiler; so back he went to Smith.

"Say, Smith, I don't want that old boiler; no one will insure it. You will have to take it back and return my money."

Jones had paid part cash and given his note for the balance. Of course, Smith could not see it that way and refused pointblank.

"That's a good boiler," said Smith, "because Kelly says so, and he knows more about boilers in a minute than those inspector chaps know in a month."

"Well, I'll sue you," replied Jones.

"Go ahead and sue," said Smith; so the controversy came to trial.

For reasons unknown to the uninitiated Jones lost his case, and was compelled to pay the costs of the suit, besides losing the amount he paid for a bond to protect his note to the dealer, and as Jones had already paid $500 cash to bind the sale, that went too, and he had to make his note good for several hundred dollars more. All he had left was his first-class second-hand boiler, and that was useless.

Finally the boiler was relegated to the scrap heap and Jones bought a new boiler.—*Power.*

A Modern Electric Hoist Equipment.

BY FRANK C. PERKINS.

A 2-ton electric hoist is being used to advantage in boiler shops and structural iron works. One of these is shown in Fig. 1, where the hoisting is hung from a steel trolley which operates upon an I-beam track. With this hoist one man can hoist and trolley any load up to 2 tons with the least possible effort. Fig. 2 shows the lifting of an armature in the lathe, while Fig. 3 shows the raising of a boiler shell with this device. Every up-to-date machine shop is now equipped with special and automatic machinery, which in a great many instances has more than doubled the plant output, and the great problem of to-day is how to get the material to these labor-saving machines, and how to get the finished products away from the machines at a speed that will keep pace with them and not interfere with their output.

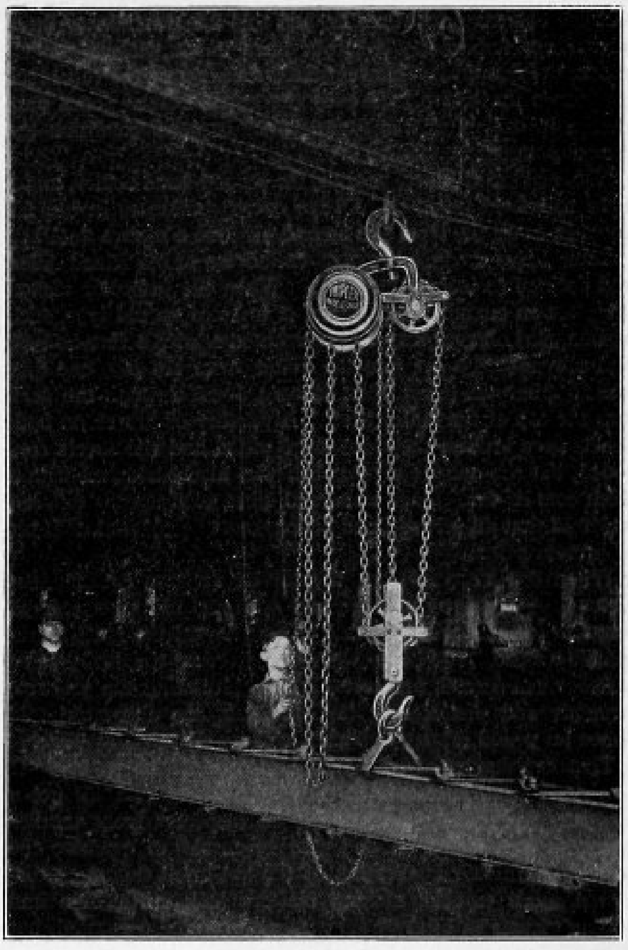


FIG. 1.

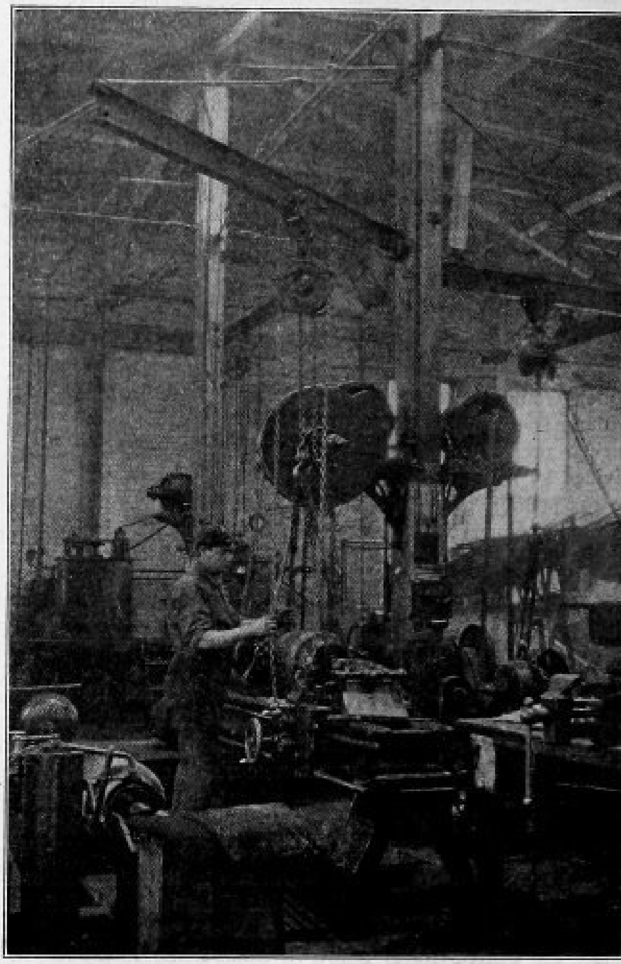


FIG. 2.

It will be seen that one of the great advantages of the electric hoist equipment, as shown in the photographs, is that the floor space is kept clear at all times. Besides this advantage this machine is quicker, not likely to get out or order, inexpensive in operation and absolutely safe at all times. It has been found that in the average plant an electric hoist is as important as a heavy-duty crane. Without doubt the cost of lifting by manual labor is an expensive item, and realizing this electric power hoists varying from ½ to 10 tons capacity are now extensively utilized. These are high-grade machines, designed to give uninterrupted service at minimum cost. A direct-current motor is used to advantage to operate through an efficient gear reduction to the cable drum, and the motor is handled by a controller on which limit switches are provided, so that damage cannot occur when operating the hoist in either hoisting or lowering.

Safety should be considered the prime object in the design of these machines, and they are usually so constructed that the load is sustained at all times and is always under perfect control, so that it cannot drop. It is maintained that an elec-

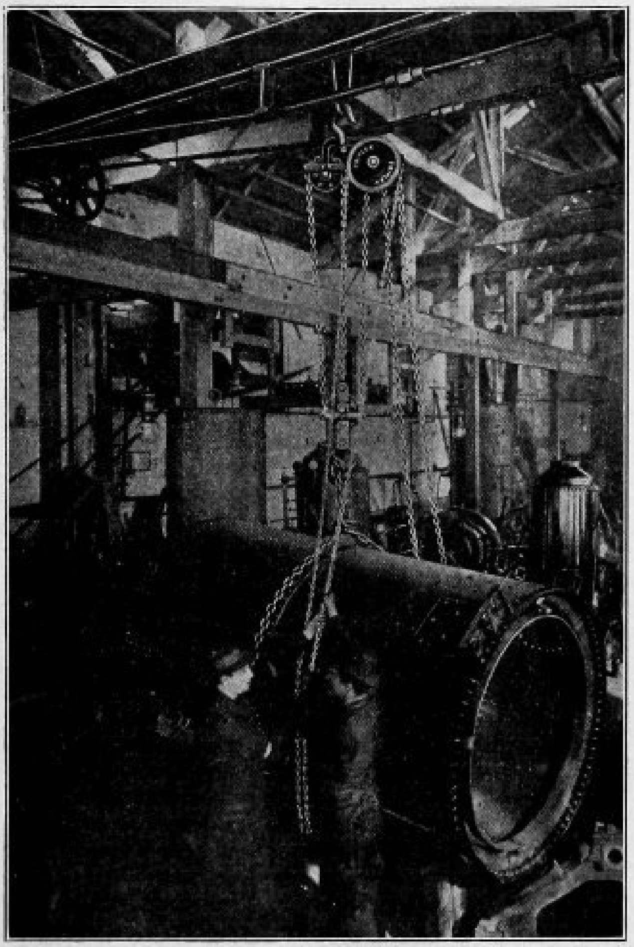


FIG. 3.

tric hoist, properly constructed, mounted upon a tramrail system or upon the bridge of a traveling crane, will save its cost several times every year, not only in the time saved by its speed but by the economy of its operation.

SOME BOILER EXPERIENCES AT SEA.

There is a little anecdote knocking around, but only partially believed, of a philosopher skipper of a coasting vessel who met with a nasty accident to his boilers. He broke it gently to his owners by telegraphing, "Cannot put to sea. Boiler gone out." His owners thought it was a case for the lunacy commissioners, but wired back, "Light the fires again." The reply was, "Cannot light fires. Boiler gone out through deck." While the experiences to be related are by no means so harrowing as this, they may contain points of interest to other engineers that will make them worth printing.

First of all, however, it may be said that looking after a boiler while at sea is by no means the same proposition as attending to the comforts of a steam installation on land. In the latter case there are usually plenty of tools of all sorts available, if not on the works at least within telephone call, and in case of serious trouble the makers of the boiler can be got hold of and renewal parts dispatched without much difficulty. On board a vessel it is different. Often the supply of tools is not excessive; the materials for repair beyond the ordinary joint rings, etc., have to be sought for, and often trouble occurs just when it ought not to, as heavy weather always finds out the weak places. Even if a vessel can be got to port it is as likely as not a few thousand miles from anywhere where engineering supplies can be bought cheaply, and where, probably, there is nothing to speak of in the way of an engineering shop in the whole place. For this reason the marine engineer is thrown very much on his own resources. Some of the jobs he makes of repair work are crude if effective, until one takes account of the materials and opportunities at his disposal. Then they are oftentimes marvelous.

In one case the top of the boiler round about the main stop valve had become badly corroded and very thin. The cause of this in the first place was due to allowing the gland of the stop valve to leak. This had caused the covering to be worn off the boiler near the valve and corrosion had set in. Ultimately the boiler gave out while steam was being raised. On examination it was found that a considerable area had been affected by corrosion, so that a piece was cut out of the bad plate measuring about 2 feet by 1½ feet. A piece of steel plate about ½ inch thick was found on board, and this was cut down to about 2½ feet by 2 feet. It was then heated and hammered until it was brought as near to the curve of the boiler shell as possible, and holes were then drilled through the boiler shell ¾ inch diameter by about 2½ inches apart. The plate was then put through into the inside of the boiler, and the holes marked off on it while it was in place. After drilling it was bolted and hammered up into its place, afterwards being riveted with rivets made of the best Swedish iron. These rivets, by the way, had to be made on board from bar-iron, as no rivets were procurable. When the riveting was complete, the plate was securely calked, the valve was replaced, and the part where the patch was being lower than the boiler shell, owing to the plate being on the inside of the boiler, was filled up with cement and smoothed over in order to prevent any water lying on the boiler. It was not, perhaps, a pretty repair, but it served its purpose.

Very nasty occurrences can happen owing to improper treatment of boilers. They may stand it for some time, but eventually there is the devil to pay. Some engineers, for example, when giving orders to light the main boiler fires, light the middle ones only, and leave the wing fires until the next morning. They then wonder why the boiler begins to leak at the seams on the bottom. A little consideration will show that the top will be hot, under such circumstances, long before the bottom is heated up, and therefore unequal expansion will follow, with the inevitable result of leaky seams. The proper way to treat a boiler is to light all the fires at once and to keep on circulating until the steam is fully up. A marked difference in the state of the seams will be found with careful treatment of this kind.

Another thing in the treatment of a boiler which requires careful watching is the use of mysterious compounds known as boiler fluids. Some of these are good, others are not; even with the best of them they ought to be treated as physic and given to the boiler in measured doses. Reckless use of such materials may easily lead to serious trouble. On one occasion a Fox tube, forming the center furnace of a boiler having three furnaces, collapsed suddenly, and the cause of the collapse was found to be owing to the reckless use of such a boiler fluid. This liquid was supposed to bring the scale off the water-side of the heating surfaces, and the chief engineer used the fluid in unduly large quantities. The result was that so far as the small tubes and the tube plates were concerned, the scale was brought off most effectively, and the same action occurred on the tube crowns of the wing furnaces. The unfortunate part about it was, however, that all the scale ran down upon the crown of the center furnace tube, with the result that it became overheated and laid down for a rest upon the fire-bars. As soon as the occurrence was discovered the dampers of the faulty boiler were at once closed, and steam was taken off the boiler by opening the engines full out, putting the cold-water feed upon the other boiler and running the ballast donkey pump. As soon as it was safe to do so the boiler with the damaged furnace was shut off until the collapsed furnace tube had been built up hard and solid with fire-bars, firebricks, scrap iron and anything else safe and handy. Then the other two fires were set away in the boiler, which was then only worked with the wing furnaces. The voyage was completed by using steam at a reduced pressure, and the danger of too much boiler fluid was amply demonstrated.

One rather lively experience in connection with a boiler furnace tube shows the inadvisability of thinking that they will work forever and a day. In one old steamer a piece of metal about 1½ inches wide and 2½ inches long blew out of the center furnace tube, which was plain, slightly above the line of the fire-bars and a little in front of the bridge, as shown in Fig. 1. The engineer on watch when the occurrence happened, on hearing the noise (which was considerable), went to the stokehold, but could see nothing but steam. He could, however, hear plenty of water flying about. He therefore went back to the engine room and had a look at the gage glasses. He found that the water was rapidly going down in the port boiler, and therefore put the extra feed full on, shut

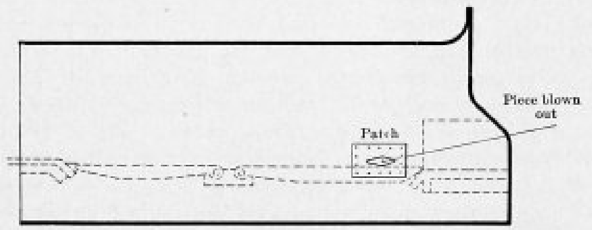


FIG. 1.

the other check down in the remaining boiler, opened the engines out, shut the main damper, and got the donkey feed pump under way as well. By this time the chief engineer had got to the scene of action, and together they made an attempt to get into the stokehold, but they had to come out again in a hurry. Of course, they knew that the trouble was located in the port boiler, and as soon as the steam got right back they shut this boiler off. They eased the safety valve and blew all the steam off, the vessel stopping. As soon as this was done they succeeded in getting into the stokehold, from which the firemen had escaped, one with a very bad scalding. The place presented a rather disorganized appearance, as the furnace had no fire-bars in and everything loose had been distributed round the stokehold. Steam was got up again in the starboard boiler, and the ship proceeded again at half speed on one boiler, while the hole in the port boiler was repaired by putting a patch on the inside of the furnace tube, as shown in the first sketch. The patch was secured by ¾-inch bolts, and to stop the fire from burning the double thickness of plate which was now on the furnace tube, due to the patch, the bridge was built further out so as to come over the bolt heads and so protect the weak part. Steam was then got up again, and the repair carried the vessel safely to port. The cause which led up to this piece blowing out was that pitting had gone on to a very considerable extent at this point and trouble was expected, though not to such an alarming extent. It should be said, by the way, that the joint between the patch and the furnace tube was made with Portland cement and gauze wire. The way the repair was effected may not recommend itself very much to the aristocrats with unlimited engineering means at their disposal. The "classy" way of effecting a repair on a furnace tube would be to bevel the hole, and then bevel the plate which forms the patch. Then the patch should lie on the fire side, and thus, theoretically, there would only be one thickness of metal. But the practical marine engineer who attempts to make the repair in this way while the vessel is at sea is either an extraordinarily clever fellow or else he has bitten off more than he can chew.

Another instance of first-class trouble in a boiler due to

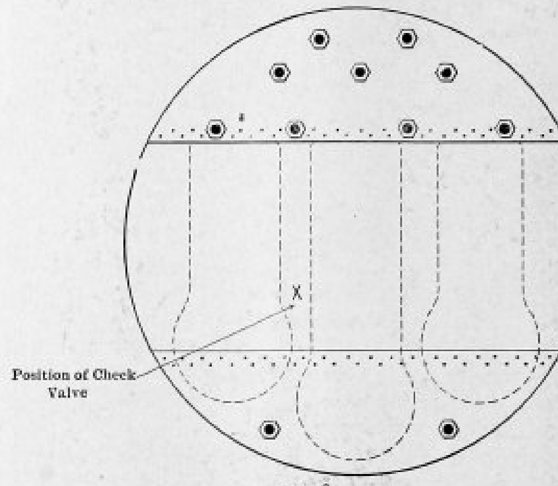


FIG. 2.

apparently insignificant causes can be related. In this case the wrapper plate of the combustion chamber of a boiler became holed owing to the way the feed-water impinged upon it. Fig. 2 shows generally the way in which the boiler was arranged with the position of the check valve on the end of the boiler. Fig. 3 shows more clearly the shape and general arrangement of the internal pipe leading from the check valve into the boiler. It will be seen that this internal pipe was screwed on to an extended spigot which passed through the hole in the boiler plate back of the check valve flange. This internal pipe, as originally fixed in the boiler, was arranged to stand in an upright position, but in course of time it became loose on the screwed spigot and turned round till it hung downwards. This caused the water to be discharged into the boiler in a stream, which impinged onto the wrapper plate of the combustion chamber. The result was that the local action of the cold feed water upon the hot plate soon weakened the latter, and ultimately this weak part was blown out. The repair of this failure necessitated the blowing down of the boiler and waiting till it was cool enough to enter. The hole was then patched with a plate on the fire-side, the bolts being put through from the water side and the

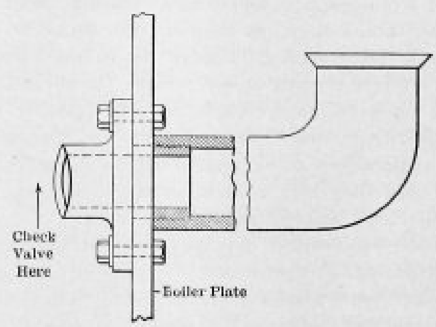


FIG. 3.

nuts being therefore on the fire-side of the plate. The task of getting this plate bolted up into place will be seen to have been no easy one, when it is considered how all the small stays of the boiler got in the way of the engineers while at work. When the job was done the internal pipe was secured in its proper position so that it would not turn round again. This pipe was about 18 inches long, and stood in between the two combustion chambers, the back plates of the combustion chambers being about 7 inches off the back of the boiler. The wrapper plate was holed in the plain part a little distance from the cover seam.

A little negligence goes a long way towards causing trouble in connection with a boiler, and the firemen need to be care-

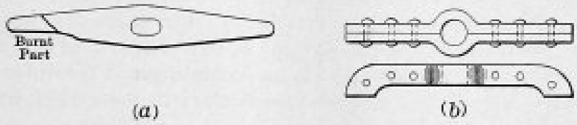


FIG. 4.

fully watched in this respect. A word may be said regarding the habit of leaving the hot ashes on the footplates near the boiler. This is a very bad practice indeed and should not be allowed on any account. Apart from the danger to boiler doors the front plates of the boilers in time become burnt, necessitating expensive repairs. Moreover, if the ashes are cooled by throwing sea-water over them, and the ashes allowed to lie there in this wet state, one of the best ways of starting external corrosion of the boiler plates will have been indulged in, and this practice will sooner or later involve disaster if it is not noticed in time. An instance where a repair, which, although of a minor character, is sufficiently typical, occurred through the firemen allowing the clinkers to remain on the footplates after cleaning the fires, is illustrated in Fig. 4. In this case the trouble was located in the dog of a boiler man-hole door. This was on the bottom boiler door, and in the stokehold, and the firemen allowed the clinkers to remain, covering the door. The result was that the dog got burnt to the shape shown in the sketch (*a*) and the engineer of the vessel rightly considered it unsafe, in its weakened state, should there be a vacuum formed in one of the boilers when the steam was off. It, therefore, became necessary to extemporize a new dog as shown in plan and elevation in (*b*) by bending two pieces of iron to the shape indicated, drilling 1-inch holes through them, and then riveting the two pieces together. This made a good strong dog.

Trouble does not always occur in the main portions of the boiler. The smallest details have to be watched as well. This was shown in a happily little experience which occurred with a salinometer cock. The engineer one day went to open the cock in one of the boilers to draw some of the water in order to take its density, and to his surprise the cock flew out of the shell as soon as it was turned, as the thread in the gland nut had stripped. The engineer found the cock again

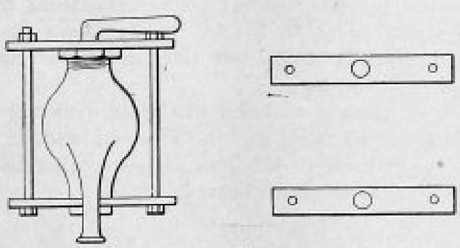


FIG. 5.

and, at the expense of being scalded to some extent, he managed to get it into place again by holding it over the shell and giving it a sharp tap with a hand hammer. He then hung on to it and held it down in its place until one of the other engineers arrived and bound it down with some copper wire. In order to make a permanent job of the matter, two small plates were cut, as shown in Fig. 5, and these were arranged with two ⅝-inch bolts and nuts so that they braced the parts of the cock together, as shown in the illustration. This arrangement left the cock so that it could be worked in the ordinary manner without danger.

Every engineer with sea-going experience will know the great difficulty which is experienced with the packing of boiler fittings, so far as the material used is concerned. It is oftentimes a most tedious and difficult matter to deal with a refractory stuffing box, so far as the trouble of getting the old stuffing out is concerned. The packing has often to be cut and chipped out with a hammer and chisel, as it becomes, in contact with water, hard with encrusted salt and in addition is baked solid with the heat of the boiler and stokehold. The amount of time taken up by chipping and picking the old packing out is enormous, and it is to be feared, if one may go by the unpleasant appearance in some stokeholds of leaky glands with great lumps of salt sticking to them, that the job of repacking is sometimes shirked when it ought to be attended to without delay. One engineer, impressed with the trouble and annoyance in connection with the use of ordinary packings, made the experiment of trying lead as packing for some of the stuffing boxes of his boiler mountings, and he found that the idea worked splendidly. In order to pack a stuffing box, he first cleaned it out thoroughly and then carefully rubbed the valve spindle and stuffing box over with some black-lead powder on every part which would be covered by the lead. He then ran the stuffing box up to a certain distance with molten lead, leaving sufficient room, say a quarter of an inch, for the gland to enter. When the gland was put on and tightened down, it was packed in a way which lasted for years without any further trouble. The only thing necessary when opening or shutting the valves was to slack the gland back a little before beginning the operation, and to tighten it up again after the valve had been turned. With the heat of the boiler the lead was kept somewhat soft, but, of course, never obtained its melting point, which is between 400 degrees F. and 500 degrees F., as the boiler water did not reach that temperature. This method of packing is not to be advocated indiscriminately for every gland to be found on a boiler, as some valves, such as the main check valves, are constantly being worked, and such a packing would not be suitable. Where, however, valves are only used intermittently, say once or twice a week, such as, for example, the scum valves, blow down valves, etc., this form of packing gives excellent results, and may be recommended to sea-going engineers with confidence.

In conclusion, it need hardly be said that these notes do not pretend to cover or even hint at the range of possible breakdowns which may occur on a marine boiler. Unfortunately, the variety of trouble which can happen with a boiler is almost endless, and a book could be written on this subject alone. The above remarks are, however, typical of some of the things which a marine engineer has to look out for, and if they stimulate other engineers to contribute their experiences on parallel lines they will have served their purpose.

An Old Contributor.

In a paper on "Marine Boilers," read before the Institute of Marine Engineers by Mr. Jas. Innes, the author points out that there have been very few cases of late years where it has been necessary to repair the shell plating of boilers, although during the old compound engine days it was common. This has been due to the fact that in almost all cases the shell plates have been made of steel of large size, and have been riveted by hydraulic pressure. Not only have the shell joints—viz., the longitudinal and circumferential seams—been properly designed, but the former have been properly placed well up on the boiler side.—*The Engineer.*

LAYING OUT WRAPPER SHEET FOR LOCOMOTIVE TAPERED FIRE-BOX.

BY WILLIAM H. DAMON.

Usually once in the life of a locomotive boiler its fire-box must be renewed. In doing this it is not sufficient to follow the original drawings, for many times considerable variation is found, especially when a mistake has been made in the original layout, in which case every effort is made to hide it by building the rest of the boiler to fit. The writer found a case where one side of the fire-box conformed to the drawing, but the other was totally different, this being made necessary by a careless mistake in the original layout.

In the case in question, *A* and *B* represent the boiler drawing, the crown sheet having a drop of 2 inches throughout its length. *C* is one-half of *A*, showing also the contour of the back edge of the wrapper sheet. It will be noticed that the front and back contours coincide at *g* and continue on as the same line to the mud-ring. *D* is the outline of the wrapper sheet taken from *B*, O_2, O_1 representing the exact length of the top center line of the wrapper sheet. The ends of the rows of stay-bolts are located by projecting over from *C*, and are noted at both ends as shown.

A base line is then drawn above *D* parallel to the center line of the boiler, and to that line are projected the points O_2, a_1, b_1, etc., from *D*. An enlarged detail of the area *M* is shown where they intersect with this parallel line, to make the description clearer. The point O_1, on the right end of the line, is projected up from *D*, and at O_1 a perpendicular is drawn. On this perpendicular lay off the distance O_2 *a*, as shown in *C*, from O_1. This gives the point *a* on the perpendicular; also lay off a_1, *b* (taken from *C*) from O_1 which gives point *b* on the perpendicular. Follow this same process until all these dotted diagonals shown in *C* are measured off. From *h* on the horizontal lines of the stay-bolts are parallel to the center line of the boiler so that they will coincide with the base line of this diagram. Now the distance from where the line projected up from the back end of *D* intersects the base line at *M*, as for instance e_1, to the point *f* on the perpendicular gives the diagonal distance between e_1, on the back of the sheet, and *f* on the front end. This will be used later.

Next, below *D* draw a base line parallel to the center line of the boiler and project down the points O_2, a_1, b_1, c_1, etc., the enlarged detail at *N* being shown, as at *M*. From the front end also erect a perpendicular as in the previous case. On this perpendicular lay off from its foot the distance O_2 O_1, a_1 *a*, b_1 *b*, etc., taken from *C*. Now a line drawn from the point of intersection at *N* of, say c_1, to the corresponding point *c*, on the perpendicular will give the exact length of the sheet along that line of stay-bolts. With these two sets of triangles and the drawing *A* the sheet is ready to be laid out.

LAYOUT OF SHEET.

The layout of one-half the sheet is shown at *E*. First draw a center line O_2 O_1, which may be taken from the drawing *B* or from the lower set of triangles. O_2 is the back end and O_1 the front. With O_2 as a center, scribe an arc with a radius equal to O_2 a_1 (drawing *C*), and with O_1 as a center draw an arc with a radius equal to O_1 *a* (drawing *C*). Now with O_2 as center scribe an arc with a radius equal to O_2 *a*, taken from the set of triangles above *D*, intersecting the arc scribed from O_1. This will locate point *a* on the front edge of the sheet, which is the front end of the line for the first row of stay-bolts. Point a_1 at the back end of the first line is located by taking *a* as a center and scribing an arc, with a radius equal to a_1 *a*, taken from the set of triangles below *D*, intersecting the small arc drawn from O_2. By following out this same method with the remaining points the wrapper sheet is laid out in its development, the bottom or mud-ring end being put in from the drawing *B*. The stays are also located from *B*.

The drawing *F* shows the angle that each row of stay-bolts, 1 to 7, inclusive, makes with the wrapper sheet. To find the angles draw the line o_2 o_1, representing the outer shell of the fire-box. At each end of this line erect perpendiculars and lay off from o_2, the distances between the outside and inside sheets at the back end and from o_1 the corresponding distances at the front end, these measurements being taken from drawing *C*. Connect the points a_1 and *a*, b_1 and *b*, etc. These lines give the relation of the outside sheet to the inside sheet at the different rows of stay-bolts. Erect perpendiculars to these lines from the line o_2 o_1, then draw perpendiculars to the lines a_1 *a*, b_1 *b*, etc., from the points where they are intersected, and the space shown on the outer shell line gives the distance the stay-bolts have to be moved forward in the wrapper sheet or backward in the outside shell sheet. The rows of stay-bolts beyond 7 are straight, so no allowance has to be made.

Lay out the rivet holes in the wrapper sheet for the flue and door-sheet seam with about a 2-inch pitch. After this is done take two strips of soft iron the same thickness as the wrapper sheet, about ¾ inch wide and long enough to take half the rivet holes from wrapper sheet. Bend the strips edgewise to the contour of the line that the rivet holes are laid off on, and mark the holes on the strip, centering them with a prick punch. Now bend the strips flat-wise to the contour of the flue and door sheet, as on plan *A*; draw the circumferential lines on the flanges of both sheets with a center line on top. Put the strips on and hold them with a small C-clamp as close to the sheet as possible. Now mark the rivet holes on the circumferential line that has been drawn on flange. This will lay out correctly rivet holes, also the last hole will locate the line for the front and back rivet holes in the mud-ring. To lay out the side rivet holes in the mud-ring square down from the first straight row of stay-bolts across the mud-ring rivet line; using this point for a center will make the exact location of the rivets correspond with the stay-bolts.

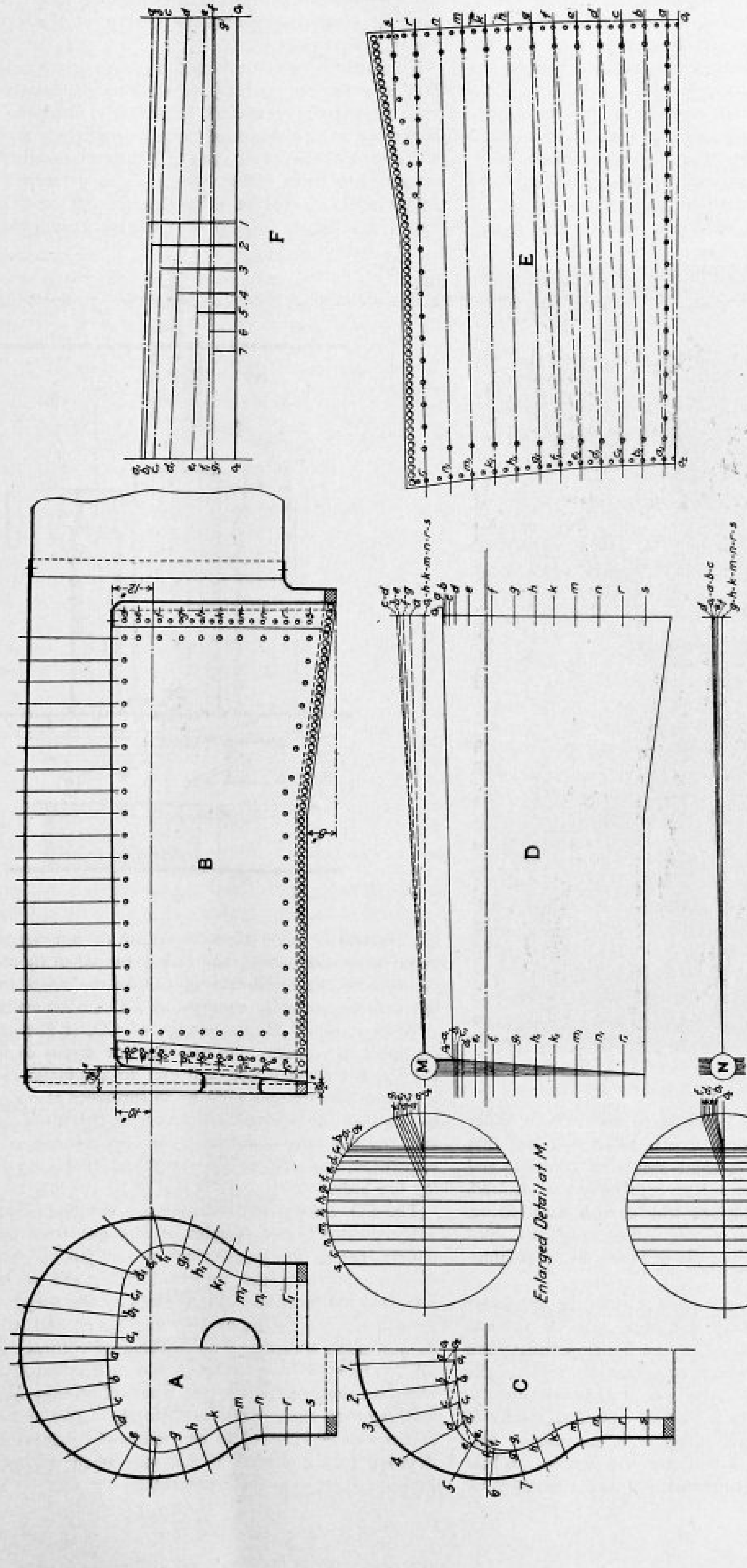
*From the *Railway Age Gazette*.

Annual Convention of the American Boiler Manufacturers' Association.

The twenty-fourth annual convention of the American Boiler Manufacturers' Association of the United States and Canada will be held at New Orleans, La., March 11 to 14, 1912. The headquarters of the convention will be at the St. Charles Hotel, and the city's Progressive Union have offered their rooms, just across the street from the hotel, as a meeting place for the convention. A very fine programme of entertainment for the members of the association, ladies and guests is being prepared by the Supply Men's Association, including receptions, automobile rides, a harbor trip, theater parties, dinners and banquet.

It is being planned to bring the Eastern members to the convention via the Morgan Line steamer, and, if possible, return by river route to Memphis, or some other river point, from which they can return home by rail.

Master Boiler Makers' Convention.—The annual convention of the Master Boiler Makers' Association for 1912 will be held at the Fort Pitt Hotel, Pittsburg, Pa., May 14, 15, 16 and 17. Those who are not already familiar with the scope of this association should read the review of the annual proceedings for 1911, which is published on another page. While comparatively young this association has accomplished much, and each year its work becomes of more importance and greater usefulness to the boiler-making industry.



LAYOUT OF THE WRAPPER SHEET FOR A TAPERED LOCOMOTIVE FIRE-BOX.

A NOVEL CO_2 COMBUSTION RECORDER.

A unique combustion recorder is shown in Figs. 1 and 2. It is so called because by recording the percentage of CO_2 in the combustion of coal it enables large savings to be effected. It is of interest to every coal consumer, because it promotes conservation of fuel.

The automatic CO_2 combustion recorder of the Simmance-Abady type noted in the photograph is provided with a drum chart for recording CO_2, the chart being renewed every twenty-four hours. Many thousands of dollars are spent by individual firms in boiler installations, and a large amount of capital is invested in settings, automatic stokers, fuel economizers and feed-water heaters. Whatever the form of boiler installation, and however modern it may be, it is a fact that the personal element must have some means of guidance and control if economical and smokeless combustion is desired, because it is the personal element which, with hand firing, controls both stoking and damper regulation, and with automatic stoking controls by means of the dampers the proportioning of air to fuel used.

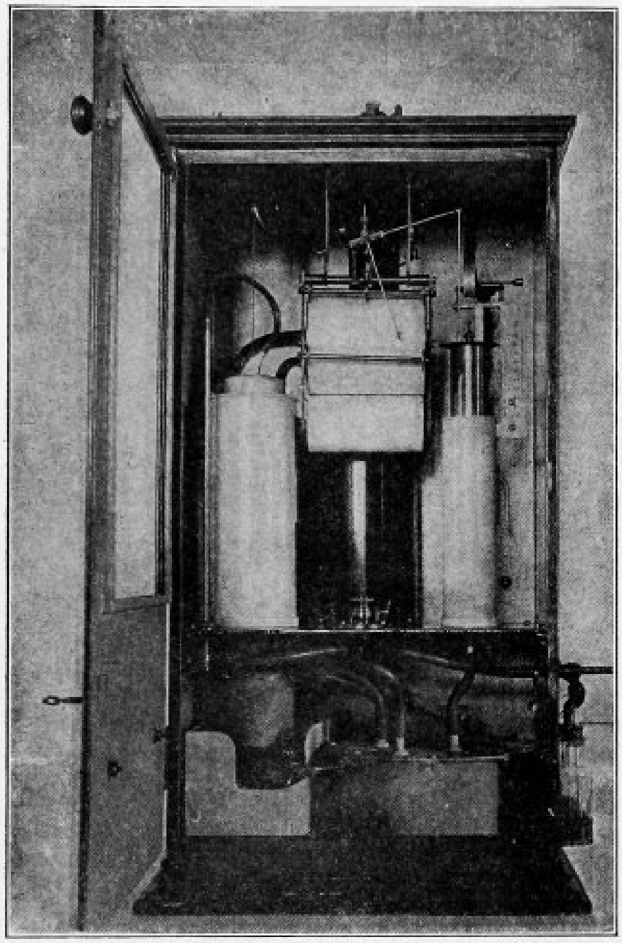


FIG. 1.

Without doubt it is the percentage of CO_2 in the flue gases which is the ultimate guide to the perfection of stoking, damper control and the condition of the boiler settings, and so it is that an instrument which automatically records the percentage of CO_2 in the flue gases has been proved by experience all over the world to be a real practical means of reducing coal bills and keeping them at a minimum. Unquestionably a CO_2 combustion recorder will enable the best results to be obtained from boiler settings and fuel good or bad. It will not turn an inherently bad setting into a good setting or a bad fuel into a good fuel, but it is a certain thing that without this recorder it is impossible to get continuously the best results even with the most perfect arrangement of boiler and settings.

No matter how well equipped or up-to-date a boiler installation may be, yet economy in working is entirely dependent upon the firemen or stokers, because it is they who control the frequency and thickness of the charging; it is they who control the admission of air, and it is they who ought to keep the settings in proper order. In order to perform their duties properly (*i. e.*, produce a high percentage of CO_2) they require some simple hall-mark of efficiency, something they do not necessarily understand the reason of, but can nevertheless make no mistake about, and this is furnished by an automatic recorder of the percentage of CO_2 in the waste gases, which can only be efficiently obtained by a CO_2 combustion recorder.

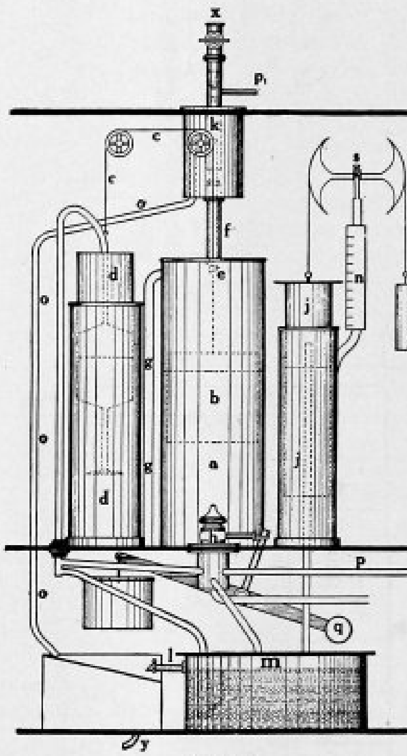


FIG. 2.

Without doubt the percentage of CO_2 is not only the one sign-post to economy, but also the one means of ascertaining the actual monetary loss, and that an automatic record which a fireman can see and work up to furnishes at once a guide as to whether the settings are leaky, to the speed of the draft fans, to the rate of injection, and to the degree of damper regulation, and also to the speed and frequency of charging the fire beds.

The CO_2 combustion recorder is a simple instrument which automatically draws samples of flue gas from one or more boilers, passes the gas through a solution of caustic potash, thereby absorbing the carbon dioxide, and at three-minute intervals indicates and also records by the length of lines on a chart the percentage of CO_2 in the gas, and it is therefore an automatic chemist. The working of recorder can be seen all the time, so that although the instrument is in a locked case, yet the firemen can see what effect they are producing and regulate their work accordingly. The accuracy of recorder can be checked at any moment by opening a tap and drawing in air instead of flue gas, when the apparatus will indicate zero (*i. e.*, no percentage of CO_2). There is no troublesome adjustment, no continuous changing of chemical solution. No glycerine oil or other similar liquids; but the apparatus is always accurate and unaffected by temperature evaporation and all the dusty condition of a boiler house and it contains no perishable parts.

LAYOUT FOR A PIPE WITH SPIRAL SEAM.

BY J. SMITH.

In Fig. 1 set off the right angle *A-B*, then along the line *A* set off the circumference of the pipe, figuring the neutral diameter. Along line *B* set off the length or height of pipe desired. Now if the seam is to make one turn on the length of the pipe, set off on the perpendicular line from *C* the circumference of the pipe, as was done on line *A*, locating point *D*. From point *D* again set off the circumference of the pipe to point *E*. Connect points *E* and *D* to line *A*, and the pattern is complete up to the rivet line; a lap, however, should be added.

Care must be exercised in rolling such a sheet, as it is

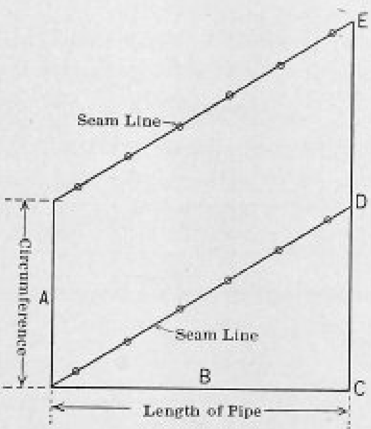


FIG. 1.

very easy to get a sheet badly twisted. The sheet should be rolled parallel to line *B*. If more than one turn is desired in the length of the pipe, set off from the point *C* as many circumferences as turns desired in the pipe. If two turns are desired set off from point *C* twice the circumference and connect to line *A*.

LAYOUT OF SPIRAL SEAM BY USE OF PARALLEL LINES.

Make a sketch (Fig. 2) showing the height and diameter of the pipe required; at both ends of the pipe draw a half section, and divide the semi-circumference into equal parts. Connect these division points in the top with the division points in the bottom, making the parallel lines shown in the sketch. Divide the length of the pipe into twice the number of parts used in the semi-circumference, and from these points draw parallel lines intersecting the lines already drawn. Where the corresponding lines intersect will give the seam or rivet line.

For the pattern, set off right angle *A-B*, making line *A* of indefinite length and line *B* equal to the height of the pipe. Along line *A* set off four times the number of points contained in the semi-circumference; erect perpendiculars to the points, and then from line *A* on the elevation take distances to rivet holes, transferring them to line *A* on the pattern Allow for laps and the pattern is complete.

To Prevent Locomotive Flue Leaks.

Charles S. Coleman, of Spokane, Wash., a veteran railway employee and boiler maker of twenty years' experience, has invented and patented a device to prevent leaks in locomotive flues.

His invention is a flue point so devised that even if the bead melts off the nature of the hole is such that the pressure keeps it leak-proof.

On personal assurance from Louis H. Ledger, National organizer of the Order of Railway Employees, himself a practical locomotive engineer of more than twenty years' experience, that this invention is one calculated to increase the safety and efficiency of railway service, a description of it is here briefly presented, purely for the news value of the thing and in no sense for a financial exploitation of the enterprise.

Anything designed to promote the safety and efficiency of railway operatives is good reading matter for this magazine. But any scheme that merely poses as such, while seeking to grab investors' dollars, can not even buy a line in the advertising section.

From an explanatory letter written by the inventor himself are taken the following paragraphs:

There is only one cause for flues leaking. It is simply that the joint is made on the wrong side of the fire-box sheet and is not protected by the water in the boiler.

The fault can not be attributed to bad workmanship. I have served as a boiler maker and at machine work on various railroads for about twenty years. Usually a boiler maker does all the work in the fire-box end of the flues, while his helper does the work in the front end. The front end of a set of flues is removed and put back time after time. The back end, or fire-box end, always has a new joint put in, and the work upon it done by a boiler maker; it gets the best work a

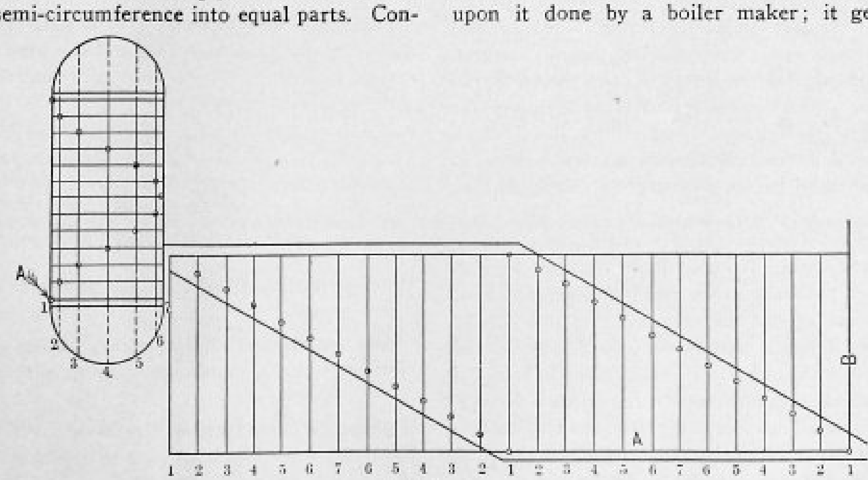


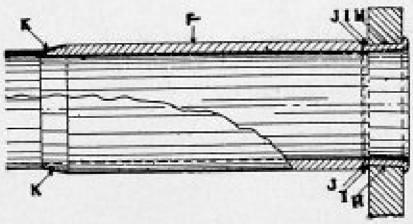
FIG. 2.

boiler maker can do. The skilled work is all performed on the fire-box end of a set of flues.

My invention, a flue point, for which a patent was granted me in October, 1910, consists of an improved joint on the inside of the boiler, or water side of the sheet, where the temperature is always the same and where it is protected by the water in the boiler and is not exposed to the extreme heat of the fire. This improved joint is in the water on the opposite side of the sheet from the fire.

By the old method the joint or bead is made in the fire-box and has no protection by water. No joint can be made and exposed to a hot fire and stand 200 pounds pressure and hold for any length of time without proper water protection.

When the engine is being fired up and expansion is taking place instead of a pushing away from the sheet there is a pushing against the shoulder on the inside of the boiler. As the engine is cooling down you will note the spreading hole.



COLEMAN'S FLUE-POINT.

F is flue-point 6 inches long, double strength and thickness.

K K shows where applied to ordinary standard flue by making a weld.

J J shows bevel shoulder on inside of boiler, where a never-leak joint is made by setting shoulder very tight against copper ferrule put through flue-sheet.

I I is copper ferrule which goes through hole in flue-sheet, as indicated by heavy line.

H H shows copper ferrule where it goes through flue-sheet, so that when shoulder is drawn tight and flue expanded tapering hole will hold shoulder permanently tight.

My flue point, being firmly expanded, brings the sheet back to place without letting the joint loose on the inside of the boiler.

This new type of point is six inches long and of double strength and thickness. It is put in a lathe and, where it goes through the sheet, is turned back far enough to make the bead in the fire-box and leave a joint on the inside of the boiler. A copper gasket is put in the hole in the flue sheet from the inside of the boiler, leaving a rolled rim of copper between the shoulder and the flue sheet on the inside. This shoulder is drawn very tight by holding a heavy weight on the front end of the boiler and by driving a solid steel tool in the flue at the fire-box end of the flue. Then the flues are rolled and are beaded in the fire-box, just as they are by the old method. As my flue point is put through a spreading hole, even if the bead all burns off, the spreading hole will hold the shoulder tight on the inside of the boiler. I claim that my points, when properly put in, will remain there in service in a locomotive until the flues have to be removed for other causes than leaks.

It costs from $1,000 to $1,500 to remove, repair and replace a set of flues in a locomotive. It costs about $4,000 a year to keep flues repaired and the engine in service. One-tenth of the locomotives are tied up all the time and out of service pending repairs to their flues. These various costs in the aggregate represent about 10 percent of the total efficiency of earning capacity of all the locomotives in the railway service. When a locomotive has had its flues calked from trip to trip it is impossible to use the brick arch. This fire arch saves 20 percent of the fuel, and if the leaking of flues can be prevented the brick arch can be used all the time and without being disturbed.

When locomotives are sent to the shop to get a new set of flues or a new set of flue points a saving of between $100 and $200 can be made on each locomotive job by installing the flue point that I have devised. And when such flue points are once in a locomotive all further trouble from leaky flues is ended. —*Railway Employees' Magazine.*

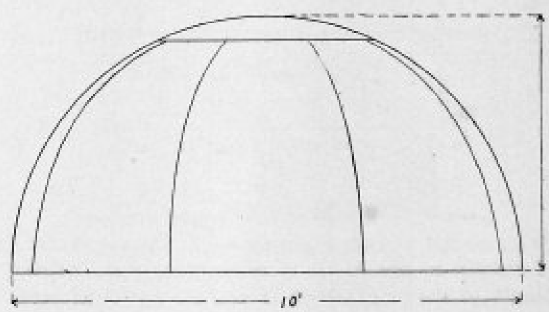
Questions from Subscribers which Readers are Invited to Answer in the Next Issue.

Reinforcing for a Manhole.—Size of hole, 11 inches by 15 inches; thickness of plate, ½ inch. What size should the ring be, and also how many rivets should be used for both single-riveted and double-riveted rings?

Shearing Strength of Rivets.—The shearing strength of rivets is frequently quoted as 38,000, 40,000 and 42,000. Where and how were these values obtained?

Size of Rivets.—In building a boiler for 100 pounds steam pressure with ¼-inch plate, the rule for size of rivets shows that ⅝-inch rivets should be used in lap joints, etc. Now, where three thicknesses of plate go in, for instance, at the fire-door ring in a vertical boiler, is it good practice to use ⅝-inch rivets, or should a heavier rivet be used on account of the extra thickness of plate?

Dome Head.—What is the rule for allowing for shrinkage in dished plates on a round-top tank, and what is the best rule for laying out the plates in such a tank as shown in the

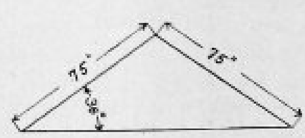


DOME HEAD.

sketch? The diameter is 10 feet, the height 10 feet, and the plate ¼ inch thick, being divided into eight parts.

Converter Top.—Will some reader of The Boiler Maker kindly show how to lay out a converter top?

Length of the Base of a Triangle.—In the triangle shown, two sides are 75 inches long and the lower angle is 36 degrees.



DIMENSIONS OF TRIANGLE.

What is the length of the base and how is this figured?

Subscriber.

Size of Stacks.—What is the best way to ascertain the size and height of a smokestack for a stationary boiler?

J. J. M.

Slope of Locomotive Fire-Box.—Why is the back end of a locomotive fire-box always 2 to 4 inches lower than the front end or the back flue sheet? J. J. M.

SOME POINTERS ON BOILER INSPECTION.

BY F. A. CORNS.

This subject is one which receives much less consideration by boiler designers, operative engineers and owners of steam plants generally than its importance demands. In the most common type of boiler in general use we still see the longitudinal seam with a lapped joint. Boilers constructed in this way are dangerous, as when the steam pressure rises the shell of the boiler tends to form a true circle, but the lap will not permit this, so that every time steam is raised or the pressure varies a few pounds, bending of the plate takes place, naturally at the weakest part, which is along the row of rivet holes. This being repeated at every change of pressure for months or years will ultimately crack the sheet, generally resulting in some one being killed or badly hurt. You may hear the boiler had just been inspected, but the only way to make a satisfactory inspection of the weakest part in that boiler shell would require the lap seam being opened up and then remade. In many of the States this type of boiler is not permitted, and there is certainly no just cause for allowing the lap joint in Canada; it does not even benefit the manufacturer, for a boiler with lap joints costs more than another boiler of the same strength and capacity made with a double butt-strap joint.

Again, we have boilers which are so constructed that access for cleaning and inspection is practically impossible. In this case, if the water does not contain any scale-forming matter and is free of acid, the boiler may work all right for years; nevertheless, it is taking chances even under the best conditions, and the number of reports of crown sheets coming down in this form of boiler is sufficient evidence that they are not reliable under ordinary working conditions. Even the Scotch multi-tubular boiler may be brought under this heading when not properly designed, as there are some with the stays so arranged that the engineer is unable to examine the furnace crowns. In such cases as the above the inspector has to rely more on the hydrostatic test, as he is unable to use the hammer to try if the stays are sound and if the plates are getting thin owing to corrosion. Boilers which come under the supervision of government inspectors undergo the hydraulic test every year; this can hardly be necessary where the boilers admit of a thorough examination, yet it is the rule. One thing is certain, a testing with a hammer, where practicable, is far more reliable than the hydrostatic test. Of course, in the case of new boilers or when extensive repairs have been made, the hydraulic test is the only one applicable, yet we tested a locomotive boiler which was not one-sixteenth of an inch thick, but covered with scale ¼ inch thick at the back of the fire-box, near the bottom; it withstood a water test of 180 pounds, but the center punch went through with a very light blow. On another occasion a boiler gave out ten minutes after the water pressure had been applied, and while the boiler was being emptied. In this case there were no thin plates, so that the plate which cracked must have taken on a permanent set when the pressure was on, and being unable to spring back to its normal position when the pressure was released, the plate fractured.

Let us now see how a boiler is prepared for inspection—and for the benefit of a few engineers and owners of small plants we may point out that a boiler inspector's duties commence where the fireman and engineer leave off. The boiler should be cooled down and scaled, then washed out and dried before the inspector arrives. It is unreasonable to expect an O. K. report from the inspector when the inside of the boiler is covered with scale and perhaps 2 or 3 inches of water laying in the bottom, to say nothing of the outside of the boiler in the flues being covered with soot. Another class of offenders are among the dealers in second-hand boilers, who leave the inside of the boiler alone even if choked up with scale, put a lovely coating of coal-tar over the outside, then call up the inspector for a report and feel aggrieved if he wants the manhole doors removed to examine the inside.

We must not lose sight of the engineer who likes everything in order, and who works for a firm who do not mind him ordering a few cents' worth of lime wash to keep the boiler room bright and fresh. It was my pleasure at one time to inspect a range of ten boilers of the "Lancashire" type; no chipping hammers were ever used, just scrapers; all the valves and cocks were open for inspection, every part of the plant thoroughly clean, even the side flues had been given a coat of lime wash, and, as you may surmise, this firm believed in efficiency, which in its true sense is economy.

When boilers are subject to hard usage and have a bad water supply, the "Lancashire" type is pre-eminently superior to any other, owing to its being so readily cleaned and inspected; in any case it gives greater economy as regards coal consumption than most boilers on the market. This type has not been built in Canada to any extent, but now we hear of a considerable number being on order for various up-to-date steam plants in Montreal and district.

These few jolts, by the way, are not intended as a guide to the boiler inspector in pointing out the most frequent causes of trouble and how to locate or prevent the same, but are written in the hope of raising a discussion, as at the present time the question of making a Canadian standard for boilers is prominently before engineers and boiler makers, and we think that a boiler which cannot be examined should not be permitted. Let us have a standard which some may consider too high when the boiler is new, for, after the boiler has been in commission a few years, its strength will certainly be reduced by wear and corrosion.—*The Engineering Journal of Canada.*

LOCOMOTIVE FIRE-BOXES.

We all know that the weakest part of a locomotive engine is the internal fire-box, in the sense that it wears out quickly and costs much money for renewals and repairs. It is therefore not a little remarkable that no complete study of fire-boxes has ever been made. Much has been written about them, no doubt, but the literature of the fire-box is desultory and unsatisfactory. No principles of dimensions or form have been settled. As to material, there is a wide diversity of opinion, resulting in an equal diversity of practice. Theory has been invoked, limited practice has been cited, and so at this moment the duration of the fire-boxes in any particular group of engines seems to be more a matter of luck than guidance.

The internal fire-box presents itself for consideration in two aspects—first, as a chamber in which to burn fuel to the best advantage; secondly, as a chamber whose external superficies constitute heating surface. In so far as combustion is concerned, the proportions of the fire-box are largely determined by the quality and formation of the fuel burned. Thus, to cite extreme cases, we have the anthracite pea coal, which must be burned on a close-barred grate, in a thin stratum, with a gentle draft; a sharp draft would lift it off the bars and send it flying unburned up the chimney. Thus, grates as much as 8 feet wide and 9 feet long have been used. Again, in Belgium, fine bituminous slack coal is well watered until it resembles mud, and this is burned on grates of about the same dimensions. For good bituminous coal a grate 3 feet 5 inches wide and 9 feet long is freely used in this and other countries. To get a still larger grate, the fire-box has been made to overhang the side frames, and we have in this way grates 5 feet wide and 6 feet long. The distance from the crown sheet to the grate-bars is an important point, varying with different kinds of coal. Some coals must be fired "thin," some "thick." A thick fire in a shallow box will usually make a great deal of smoke; a thin fire in a deep box will not keep steam. But the locomotive boiler is very accommodating, and unless there are outrageous defects in proportion, a skillful fireman will usually surmount difficulties. Theoretically, the level of the fire-bars ought to admit of adjustment with the character of the coal and the load behind the tender. In practice this idea could not be carried out, save, indeed, to the extent that grates may be altered both in level and width of opening to suit the coal of particular districts on which the engines are working for the time being. The difficulties met with in securing complete smokeless combustion are fairly well understood. We have no intention of discussing them here. It is enough to say that none of the refinements dictated by theory can be applied in practice. The regulation of the air supply can only be done roughly; everything depends after all on the coal and the fireman. The first consideration with him is to keep the safety valves very nearly lifting. After that he will take account for economy and smokelessness.

The way in which coal is burned seems to have little effect on the life of a fire-box. That depends in the main on the performance of the outside of the box as heating surface. We have shown not long since that if the surfaces are clean, and kept really wet, the presence of the plate may be disregarded, the temperature of the plate at the fire side not being much greater than that of the water in the boiler. But the "if" involves a great deal, and some facts learned in practice are rather curious. Thus it seems to be proved that fire-boxes with narrow grates will last much longer than those with wide grates. There are so few locomotives with wide grates running in Great Britain that experience had with them is far too limited to count for much. In the United States it is not so. We find much information in a paper by Mr. Seley, read before the Western Railway Club not long ago. Mr. Seley is mechanical engineer of the Chicago, Rock Island & Pacific Railway. He finds that one of the special troubles with the wide fire-boxes on several roads has been the short life of the side sheets as compared with those of narrower boxes, involving a large increase in the maintenance and repair expenses. Discussing this paper, Mr. J. F. De-Voy, assistant superintendent of motive power of the Chicago, Milwaukee & St. Paul Railway, was very emphatic. Of eighteen passenger locomotives of the 4:4:2 class with narrow (42 inches) fire-boxes, only four have had new door, tube, crown or side sheets in ten years. Of twenty-eight engines of the same class with wide (66 inches) fire-boxes, each had had at least one new sheet in seven years, and some had had as many as three sets of side sheets in that time. In one year, 140 stay-bolts were applied to the narrow boxes as against 585 in the wide boxes. Of sixteen freight locomotives of the 4:6:0 class built in 1900, and having narrow fire-boxes, all retained their original boxes in 1906. Of sixty-six locomotives of the same type, but with wide fire-boxes, built during 1901 to 1903, fourteen had had new door, tube, crown and side sheets in 1906. Tubes lasted nearly twice as long in the narrow boxes. During one and one-half years there were 152 new stay-bolts applied to the narrow boxes, as against 1,127 for the wide boxes.

At first sight it is very difficult to account for these rapid failures. Generally speaking, the water spaces in the fire-box legs are wider with the large than the small box. The water is the same for all the engines. It is reasonable to suppose that the combustion is less fierce in the wide than in the narrow box; indeed, to secure slower combustion is one of the objects had in view. So far as we can learn there is small difference in the explanation given by various engineers. It has been argued that to slope the sides of a fire-box inwards over the fire must be a good thing, as it favors the absorption of heat by the water, and facilitates the rise of steam bubbles, instead of permitting them to cling to the metal. But in practice it is found that somehow this theory does not work, and it is best to make the side sheet either stand up straight, or, still better, incline outwards. There is reason to believe that although water cannot, if left to itself, be heated from above downward, save with extreme slowness, yet that a rapidly-flowing current will freely take heat from a plate above it. It is known that the currents in water legs are very rapid. The explanation given of the injurious effect of sloping the plates inwards is that the rising current is so rapid that it interferes with the descending current, the result being that the leg is filled with foam instead of solid water, and the plate is overheated; whereas, when the plate inclines outward, the action is not so violent, and clashing of currents does not in effect take place. It may be added, we think, that deposit is far more likely to cling on a sheet inclined inward than under a sheet inclined outward. However, be the explanation what it may, it seems to be clear that the wide fire-box will not stand as well as the narrow box.

Mr. Hughes, chief mechanical engineer of the Lancashire & Yorkshire Railway, read this week, during the Liverpool meeting of the Institution of Mechanical Engineers, a paper on the locomotives built at Horwich which contains a great deal of useful information. Nothing is said, however, concerning fire-boxes which throws any light on the questions we have raised. We find, however, that the water spaces have been made wider, as constantly advocated in our pages, with the best results. Mr. Hughes has not found the Hoy corrugated circular fire-box a success. No fewer than 108 large eight-coupled coal engines were built in 1900 with Belpaire boxes, and a further twenty-one with the corrugated fire-box. Particulars will be found in the paper itself. The point which claims particular attention here is that these furnaces became distorted, coming in, not at the top, but at the sides. They were set out again with a 200-ton hydraulic jack in the usual way. Up to the present it appears that fifteen of the boxes have been twice jacked, with an average mileage of 61,700. It is obvious that there is something exceptionally wrong here. We can cite the case of a large steamer with six double-ended boilers and thirty-six furnaces carrying 160 pounds; only two furnaces have needed jacking in eighteen years. Mr. Hughes says that the circulation in the Hoy boiler is bad; but he does not say why, nor can we see any reason why the furnace plates should become short of solid water. It is, of course, true that the combustion is much more rapid and the heat intense than it is in a marine boiler. It is suggestive that the sides come in, tending to raise the crown, instead of the crown coming down. This seems to support the contention that the sides of a box should not turn in over the fire.

Of course, there are a great many factors to be considered, as, for example, the material of the box and the treatment which it receives. Information is too small to permit of any dogmatic assertion of opinion. Facts, however, whether they can or cannot be explained, must not be ignored. Those we have given are too consistent and too serious not to possess a great deal of value if they are properly used. In this country extraordinary and indeed unaccountable differences are met with in the duration of fire-boxes. No satisfactory conclusions can be drawn until facts are collected and compiled—a work well worth doing.—*The Engineer.*

A noted expert in boiler design has expressed the opinion that it is far better to make the butt-straps of a boiler narrow, and correct the weaknesses in the seam by making the butt-straps thick, and thus prevent cracking and similar mishaps with riveted joints.

The Boiler Maker

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The Laying Out Controversy.

Criticisms have appeared in this and previous issues regarding the method of laying out sheet metal work by triangulation. The principal criticism which has been made regarding this is the inaccuracy of the triangulation method, due to the fact that the lines used in constructing the patterns are assumed to be straight lines, whereas on the object itself they are in reality curved lines, and, consequently, their actual length is slightly different from that obtained in the development. This difference in length is small, however, since it is really only the difference in length between an arc and its chord when the rise or height of the arc is a small part of the diameter. This difference, or error, if figured out mathematically, will prove to be, for most purposes, almost negligible. The methods of laying out which are offered in place of triangulation promise greater accuracy than triangulation, but usually the amount of labor and time involved in laying out the patterns is much greater than when the same work is done by triangulation. Whether the greater accuracy is worth the extra time and work involved is a question which can best be decided by the man who is doing the work and the nature of the work which is to be done. Perhaps a good rule to keep in mind regarding laying out is that the work should be made as simple as possible; that it should involve no abstruse theoretical and mathematical work, and that it should be done with some rapidity. Usually laying-out work does not require the precision and accuracy of delicate machine work, where an error of a thousandth of an inch is of considerable importance; but it does make a big difference if, in a mass of intersecting construction lines, one of them is inaccurately drawn and a misfit results.

Engineering in Boiler Making.

Beginners in the boiler-making trade often view the possibilities of the trade from a limited point of view. If they can learn how to read a drawing and understand the operations necessary in laying out the plates, shearing, punching and rolling them, fitting them together, riveting and calking the boiler, so that the finished product is exactly as specified in the drawing, they feel that they have mastered the trade very nicely. In fact, when they have done as much as that they have made considerable progress, and will probably be classed as good mechanics, able to do the general run of shop work. Having got thus far, however, it would be strange if the beginner had not found that his experience had led him to inquire into the nature of the metal with which he had been working, the principles of mechanics which govern the operation of the machinery and tools used in the shop, the generation and transmission of power which has been provided for operating the machinery, the effects of heat in shaping metal like steel plates, iron bars, rivets, etc. Even after the boiler which he has been building is finished and lies on the shop floor, an inactive mass of metal, with no pressure or power visible in or around it, it is very probable that the workman would begin to inquire as to how the boiler would work afterwards and furnish the power for which it was designed. After the boiler has left the shop, before it can perform its functions there must be constructed the furnaces for burning the fuel, the stacks for furnishing the draft, the coverings of the boiler for preventing the radiation of heat and the steam and water connections to supply the water and take away the steam for its use in engines or for other engineering purposes. After the boiler has been in operation for a certain period of time the action of the heat on the outside of the boiler and the deposits from the water within begin to have some effect upon the material from which it is made, and some of the parts might, through negligence and deterioration, begin to fail. Again the boiler maker is summoned with his tools and helpers to look the boiler over and make repairs. Unless he has a good knowledge of the performance of the boiler, the questions of expansion and contraction of the metal, due to the heat to which it has been subjected, corrosion and incrustation from the chemical action of the contents of the boiler, the stresses on the different parts due to the internal pressure, and the methods of figuring the sizes and proportions, he cannot be expected to do the most efficient kind of repair work. In fact, engineering plays an important part in the boiler-making trade, and the successful boiler maker must turn his attention to this subject before he can realize the possibilities before him.

COMMUNICATIONS.

Talks to Young Boiler Makers.

EDITOR THE BOILER MAKER:

In my last talk I said a little about steel. It is a very large contract to attempt to tell all about it; there are many books which go into the subject with great care, but I am only going to talk about it as something you see in your everyday life in plates and bars.

It is usual to say "It is as hard as steel," yet, in the shape it comes to boiler shops, it is not very hard; it can be worked with ease into almost any shape, but it has to be carefully handled or its quality can be easily injured.

If you tear a piece of paper you will get a rough edge, but if you cut it the edge will be sharp; the tearing wrenches the fibers apart, just as breaking a piece of wood does. Now punching and shearing boiler plates does exactly the same thing, the fibers are torn apart; it is evident, then, that to punch or shear a plate injures it to a certain extent, but this injury is only local, as it is called; that is, the damage is only just around the punched hole and a little back from the sheared edge, otherwise the plate or bar is not hurt.

If now you drill a hole, or plane or mill the sheet apart, you will not disturb the fiber to anyway near the extent that punching and shearing does; therefore, in many cases, the specification for a boiler demands that the holes should be drilled, or that if punched they should be reamed. By reaming, the fibers which have been disturbed by punching are taken away. I never saw a specification which demanded that plates should not be sheared apart, but such a demand may have been made.

Experiments have been made which do not seem to prove that a drilled hole is better than a punched one, and I have tested cylinders made in both ways and did not find any difference in either their tightnness or strength; but I think that in some ways the tests made by me and others were misleading, and to-day most first-class boiler work requires reamed or drilled holes.

It is sometimes claimed that it is better to punch and ream rather than drill, as in punching, while the fibers are injured just around the holes, the metal of the plate back a little ways is somewhat compressed, thus making the section of metal between the rivet holes stronger, and this theory is fairly well proved correct by tests.

It is generally supposed that punching a hole is cheaper than drilling it. I am not at all sure of this being so. The idea is almost universal, I think mainly because the operation of punching is so much quicker and is therefore considered cheaper. Tests were shown that to drill a 1-inch hole in .40 carbon steel, with an advance of 1 inch per minute, takes about one-twentieth of a horsepower. A drill press to drill such a hole will cost very much less than a punch to punch it; but it would hardly take more than 2 seconds, though the power exerted for those 2 seconds would be very great. In drilling the holes are left sharp on the edges, and there is less burr kicked up; with punched holes the burr is quite high, but in either case the burrs have to be removed or the plates would not draw up tight.

The quality of the plates used in boiler work was at one time more of a problem than it is to-day. Good steel is the rule, not the exception now, and the quality is usually marked on each sheet. This has come about by the desire of steel makers to sell their goods and not have them returned; and, further, by the competition. But no matter how good the metal may be it can be ruined in the fire, and a very poor boiler can be made out of very good material. It is rather strange to think that steel can get tired, and, like men, give out; but such is a fact, although it is not quite in the same way. A man gets tired and takes a rest and is as good as ever; not so with steel, it stays tired. We can understand this by taking a dumb-bell and swinging it until tired out; an hour's rest, and we can swing the dumb-bell again. But if we took a piece of steel and bent it back and forth it would become weaker and weaker until it broke, and if we stopped bending it when almost broken a rest would not restore it.

We can, however, rest steel after bending or rolling it by annealing; that is, heating it up to a dull red and letting it cool slowly. This process is one which can be done in several ways and is most interesting and will be gone into later; but just now I will say that usually plates that have to be annealed in boiler shops are brought up to a dull red and covered thickly with ashes. Often powdered charcoal is first put on the plate and then the ashes; and this is a good thing to do, as it results in a better anneal, which means the steel is more rested.

You know that if you take a hammer and try to push a nail into a piece of wood you will not succeed, but a few smart, quick blows will send it home. This is to be remembered in working steel; you must not try to do it too quickly or you will break and not bend the material. The softer the steel the quicker you can work it without injury. You can bend a piece of lead pipe, but a pipe stem breaks if you try to bend it; just so with hard and soft steels. It is clear, then, that material that has to be turned or flanged must be better than the rest of a boiler sheet. The sudden cooling of steel makes it brittle. Some steels, known as "cast steels" (not steel castings), on being cooled very quickly are made so hard that they are used for cutting metals; but when cooled or quenched, as it is called, they become very brittle indeed, and if struck a blow will fly to pieces. By partly annealing the steel after quenching, usually called drawing, the hardness can be decreased as well as its brittleness, and it can be made to stretch and bend like a spring, and this elasticity can be made to meet any requirements. Many men will assert that steel that has been overheated can be restored; beware of any such and never put a burnt piece of steel in a boiler.

One can not tell whether a piece of steel is very hard or not until it is worked, but in using tools or boilers, that is, taps and reamer or drill, a good amount of oil should be always used, and it should be good oil. Pure lard is the best, but it is very expensive. There are many cutting oils which are much used, and with satisfaction; but even a poor oil is better than none, and the poorer the oil the more of it should be used.

Such tools as reamers and taps are generally used by hand and should not be "yanked" around with a single-end wrench, but turned with an even motion with a double-handled wrench. The jerking breaks the teeth out of the taps and pieces out of the blades of the reamers. Too few boiler shops have means to grind their reamers and taps; in fact, I have been told by good boiler makers that you could not sharpen a tap. But you can, and it pays as well to do so as it does to keep any other tool sharp.

Pittsburg, Pa. F. ORMER BOY.

A Hint.

EDITOR THE BOILER MAKER:

Have just been reading "F. Ormer Boy's" letter entitled "Something for the Boys in the Shop to Read," page 305, October number of the paper.

It seems to me that many of the advanced "boys" can profitably read that letter as well as the 'prentices, for the writer of it has "said his say" in a very interesting and instructive manner, that leaves very little else to be desired as far as he has gone with his subject. By all means have him continue, for he has made his explanation clear as requested by contributors, by the fellow who signed himself "Kicker" not long ago. "Kicker's" letter was taken notice of by many readers and writers as well, although no one so far except "F. Ormer Boy" has made any mention of the fact. Keep the boiler question "a boiling," and let the unsatisfied inquirers "come back" on the writers until they do get the information they seek. CHARLES J. MASON.

Some Personal Experiences.

EDITOR THE BOILER MAKER:

Among the numerous letters written by master boiler makers on various subjects we have noticed that none have touched the subject, "The storage of vitality to the man that handles the sledge." There are a number of shops where they do hand-work yet, such as cutting of rivets and flanging. If there is a large number of rivets over 5/8 inch in diameter to be cut, put on two good helpers with a good boiler maker that understands how to take the advantage of shearing rivet heads off with tools. Let one helper strike until his vital power begins to decrease, then let the other take the sledge, and he can knock the rivet heads off with the average amount of blows while the first man stores up fresh vitality to take another turn at it. Likewise, with flanging and setting sheets they can accomplish more with two men. When a man is compelled to exert himself it is not economy for the employer or the man himself. I have tried this out and find that the company gains by it; also I have taken notice that a man to be a good, handy man with a sledge or mall does not have to be a wood chopper, but he must start at trying to learn and master the loose shoulder swing before he is twenty-five or then he will be shoulder bound, and it will be so much harder for him to be a good "swinging mechanic," as a helper by the name of Jack McCarty always termed it—and he was really the best I ever saw for a hard blow, high or low, right or left, swing up on one side and bring down on the other side.

I remember back in the early seventies, when I worked for my father, who was of the old Staffordshire bulldog style, "never give in," and he wanted his boys to be of the same caliber. He had me on the flange fire, and for a long time I knocked down flanges all alone. He would not allow my helper to hit any of the flanges, but when there were corners to be knocked down he would help me, and would go off whistling after a brisk movement with the hammer that would have ordinarily tired anybody. My father would allow me to use nothing but charcoal to heat the steel; of course, that was just the fuel to keep the nature in the metal, but a coal or coke bed in the forge would heat quicker with fewer blisters on my neck and hands. Afterwards in my travels and through experience obtained from one shop and another, I adopted the plan of using the heavier fuel more solid in body with a greater heat, and also the above plan of storage of vitality with extra help. In these up-to-date times it sounds ancient to talk "hand work" and "charcoal" when we have oil furnaces to heat with that can heat a whole sheet in less time than we could take one heat in times past, but it takes a large portion of the nature out of the metal by heating with oil, and with such quick heating to high temperature that there are few fire-boxes which run a year without cracking on the flanges. I have seen them run seven years on the Burlington road without cracking on the fire-boxes that I heated at that time with charcoal, not heating the steel sheets over a cherry red. Father then would not let us use a flatter or bare sledge, but we had to use hardwood malls to straighten the sheets with. His idea was that the more anyone would hit a hot sheet with a steel flatter or sledge the sooner it would crack afterward in service. Hammering the fire-box steel crystallizes it.

In talking about up-to-date boiler makers, in those days there were more men that were general workmen than now. Most of them now are specialists at one particular thing or a gun man, and some do not even know enough to hammer up the lap before driving a rivet; they may be termed specialists, and they are all right where there is a large shop. Being in everyday practice will make them more perfect in their particular work than a general man. There are lots of men call themselves boiler makers, but to be a boiler maker a man should understand the nature of all metals and how to work the metal to make it keep its average tensile strength, take any size or class of boiler, figure and construct it according to horsepower desired with a uniform circulation to avoid having unequal expansion and contraction as much as possible.

A young man learning the boiler maker trade should fire on a locomotive, a stationary or marine boiler awhile to be convinced of what he wishes to get out of a boiler. If there is any fault in the construction he can readily find it out when the boiler is crowded over its capacity, having had this experience myself besides having charge of steam plants.

Los Angeles, Cal. JOE HOLLOWAY.

Rules for the Care of Locomotive Boilers.

EDITOR THE BOILER MAKER:

Following is a set of rules I formed, and which have been in force since May, 1911. I get excellent results, have less leaks and use less boiler makers:

1. Never let out steam in any engine when engine has more than 55 pounds of steam.
2. Never let out steam through the cylinders.
3. Never let out steam too quickly through the valve on dome; open valve very little.
4. When engine is not needed let steam go down by itself.
5. When engine is needed very quick do not let out steam too quickly.
6. When washing out boilers wash thoroughly with warm water.
7. When letting out steam too suddenly it has a serious effect upon the boiler in general, on account of contraction and expansion being too sudden.
8. Any infraction of above rules will be dealt with accordingly.
9. Never offer an engine until it is in condition to do service.

These rules apply to round-houses at different points along the line.

The following rules and suggestions were tried and then approved:

1. When engineer reaches terminal have him see that he has three full gages of water before leaving his engine.
2. Have engineer see that fireman has a good, bright fire under the flues; have the fire-door and dampers and slides closed tightly.
3. In all oil-burning engines keep a bright fire and gradually close off oil so as not to cause engine to cool off too quickly.
4. When cleaning fires have the cleaners clean ash-pan first, then shake grates thoroughly, turning on ash-pan sprinkler, with dampers and slides closed; then clean ash-pan thoroughly; close the dampers and slides; open fire-door and loosen all clinkers, etc., using blower very little and as short a time as possible, and then run the engine to round-house.
5. Have the round-house boiler maker's helper, after engine has cooled down considerably, clean out fire-box thoroughly and blow out flues with air.

In the past, before we tried these suggestions and had them adopted, every engine leaked badly after entering the house. An engine which had a new set of flues would leak badly, but now they only leak on account of an indifferent engineer or because the water and scale begin to leave their effect.

D. L. AKERS, General F. B. M. of N. de M.

TECHNICAL PUBLICATION.

Official Proceedings of the Fifth Annual Convention of the Master Boiler Makers' Association. Size, 6 by 9 inches. Pages, 246. Numerous illustrations. New York, 1911: Harry D. Vought, 96 Liberty street.

The subjects discussed at the Master Boiler Makers' convention this year included apprentice systems, radical departures in boiler work, circulation in marine boilers, brick arches and arch tubes, oxy-acetylene repairs, care of flues at terminals, applying tubes, steel versus iron tubes, staying the front portion of crown sheets. Most of these subjects were presented by committee reports which were compiled by members of the association from information gathered during the year. A few of the subjects were presented by outsiders who were intimately acquainted with the work under discussion, and gave much valuable information which was beyond the range of committee work. With this material as a basis, the volume containing the official proceedings becomes a book of great value to the average boiler maker.

PERSONAL.

MR. GEORGE P. FLINN has been placed in charge of the Boston office of the Oil City Boiler Works, Oil City, Pa.

CLYDE E. PRING has been promoted to be boiler inspector of the Isthmian Canal Commission, with headquarters at Empire, Canal Zone.

JOSEPH MOLINEK, formerly of Truro, has taken the position of foreman in charge of the structural department of Browns Machine Company, New Glasgow, Nova Scotia.

P. H. O'DONNELL, assistant foreman Pioneer Iron Works, Brooklyn, N. Y., and formerly connected with the Newport News Shipbuilding & Dry Dock Company, Newport News, Va., and the Columbia Engineering Works, Brooklyn, is now foreman boiler maker for the P. H. Fitzgibbons Boiler Company, Ogdensburg, N. Y.

The following have been appointed district inspectors for the division of locomotive boiler inspection of the Inter-State Commerce Commission: W. F. Holton, Danville, Va.; G. W. Bennett, Albany, N. Y.; A. C. Breed, Chicago. Ill.; E. G. Simms, Chicago, Ill.; W. S. Jackson, Cleveland, Ohio. The following have also been selected for appointment: James B. Hartigan, at Rutland, Vt.; J. Frank Brady, East Hartford, Conn.; Herman B. Thurston, St. Mary's, Pa.; J. McManamy, Grand Rapids, Mich.; Franklin W. Fritchey, Sandusky, Ohio; G. Hayes Coleman, Columbus, Ohio; James A. Shirley, San Antonio, Tex.; Elbridge L. Gibbs, Kansas City, Mo.; Alonzo G. Pack, Colorado Springs, Col.; Harvey Boltwood, Denver, Col.

IN THE OCTOBER issue of THE BOILER MAKER it was stated that Mr. R. E. Jackson had been appointed supervisor of boilers of the New York Central Lines at West Albany, N. Y. This is an error, for the position has been filled by Mr. G. B. Usherwood.

ENGINEERING SPECIALTIES.

Cleveland Corner-Drill.

Fig. 1 shows an interior view of the Cleveland corner drill for close-quarter drilling, which is manufactured by the Cleveland Pneumatic Tool Company, Cleveland, Ohio. The machine is designed to drill or ream within 1⅛ inches of side

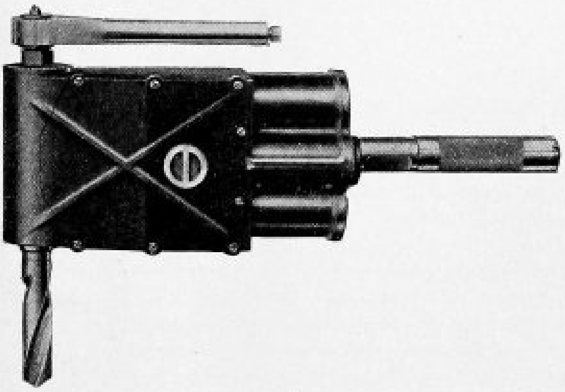


FIG. 1.

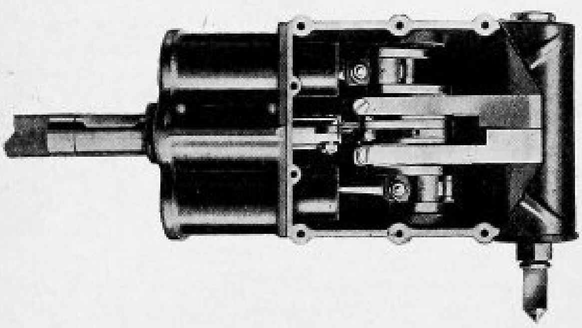
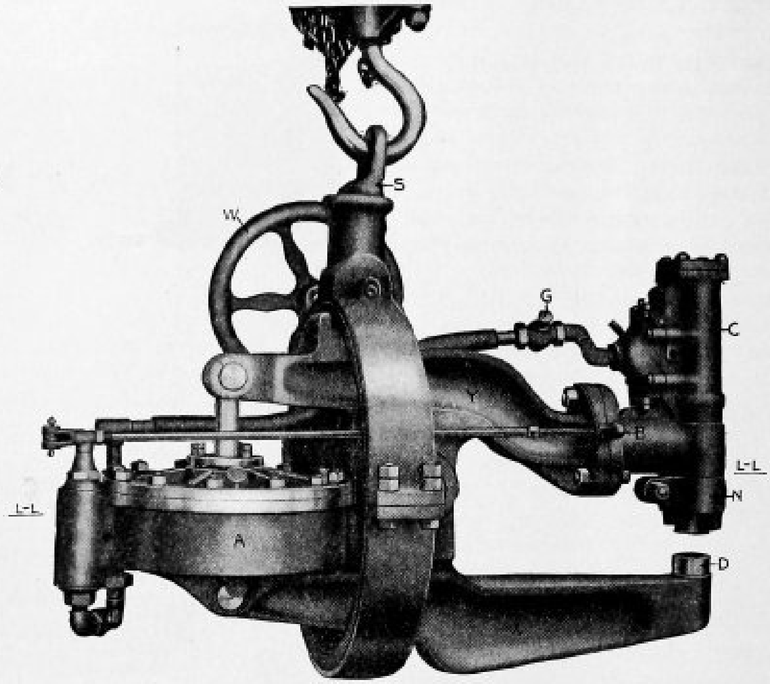


FIG. 2.

wall or corner. Fig. 2 shows the interior construction. The motor consists of two double-acting pistons connected to a crankshaft mounted upon annular ball bearings and provided with eccentric discs, which are connected by eccentric straps to the two piston valves which control the two cylinders, each valve controlling one cylinder. Power is transmitted from the driving crank to the spindle of the machine by ratchet arms, which are connected to opposite wrists of the driving crank, their opposite ends alternately engaging ratchet teeth cut on the spindle. The body of machine is a single-piece steel casting, with piston and valve cylinders cast integral. The single-piece construction insures perfect alinement of working parts. The body of the machine is provided with large hand-holes, conveniently placed to reach all working parts and to insure thorough lubrication.

A New Allen Hammer Riveter.

A notable addition to the line of hammer riveters built by the John F. Allen Company, 370 Gerard avenue, New York City, is shown in the engraving on the following page. This riveter, on account of its shorter reach and lighter weight, is intended for work that is beyond the scope of the regular Allen boiler riveting machines and should have a wide application. Its reach is 15½ inches, and it is sufficiently powerful to drive rivets from ⅜ inch to 1 inch diameter. In operation the work to be riveted is placed so as to bring the rivet head on die *D* with the free end of the rivet pointing toward the axis hammer cylinder *C*. Upon moving handle *B* toward *C* air is admitted to cylinder *A*. This closes arms *X* and *Y*, and with a pressure of about 4,000 pounds firmly secures the plates to be riveted between die *D* and nozzle *N*. When button *G* is pressed air is admitted to cylinder *C*. This causes the hammer to strike the end of the rivet a series of swift blows, heading the rivet in a few seconds. Upon releasing the pressure upon button *G*, the motion of the hammer is arrested. Moving handle *B* toward the rear of the riveter immediately opens



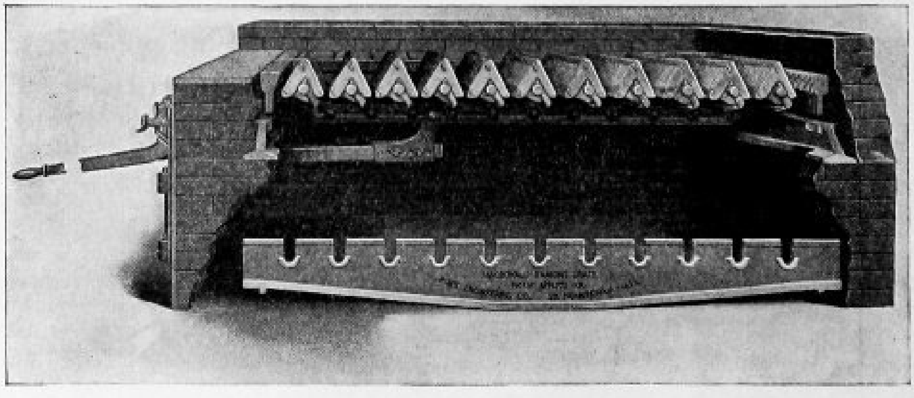
arms *X* and *Y*, and releases the plates, which are moved immediately upon inserting the rivet into position and the riveting operation repeated. The machine is in balance when suspended from hook *S*, and can be swung in any direction. It turns on its long axis *L-L* by means of the handle-wheel *W*, which operates a worm engaging a worm wheel enclosed in the supporting ring *R*. This riveter operates on air at a pressure of from 60 to 100 pounds.

Macdonald Shaking Grates.

The Macdonald shaking grate, made by the Robb Engineering Company, Ltd., South Framingham, Mass., is so designed that the tilting of the sections improves combustion by giving maximum irregularity of surface for breaking up clinker and the mass of unburned fuel, yet does not open up wide spaces which would allow unburned coal to fall into the ash-pit. The detachable top sections may be changed easily for altering air openings or for renewal at minimum expense. When in operating position the grate is flat, locked in place. The surface cannot be left uneven with points projecting into the fire, for only when the grates are level can the lever be disengaged.

In most shaking grates the unevenness of surface when the rocking bars are operated is not sufficient to thoroughly break up the mass of unburned fuel; only a small portion of the lower ash surface is rasped off and deposited in the ash-pit, consequently the fuel remains so massed that the air cannot properly reach it. To give greater irregularity of surface in the Macdonald grates the points of the triangles are made to penetrate deeply into the body of the fire, allowing proper air circulation; the depth is said to be nearly twice as much as in ordinary shaking grates. The mechanism is so arranged that when the lever is operated the top surface of the triangular sections are 60 degrees from the horizontal, and the lever can be swung through an arc of about 60 degrees. Because of this equilateral triangle construction of the sections, and the fact that the tilting of the sections is entirely in one direction, the spaces between the grate sections at the end of the stroke are exactly the same as at the beginning, and during the whole movement there is practically no variation in the size of the spaces.

The Macdonald grates are made up of small removable



sections which securely fit the rocking bars. These sections can be furnished with any desired air space and can be replaced, when it is advisable to change the grade of coal used, without altering the rocking and supporting bars or operating mechanism. When necessary a few sections may be replaced without renewing the whole grate when perhaps only a small part is burned out. This design is claimed to minimize the cost of repairs and permit keeping the grates in their best working condition.

The locking device of the Macdonald grates does all the thinking for the operator. They are locked in a horizontal position and cannot be moved until the shaking lever is inserted and locked in place, which movement unlocks the grate. Unlocking the bell crank so that the grates may be shaken locks the operating lever, and the only position in which the cam may be thrown down so as to disengage the operating lever is when the grates are level.

These grates are adapted to any style of fire-box, rectangular, circular or the corrugated furnaces of internally-fired boilers.

Convenient Means for Determining Flue-Gas Temperatures.

At the basis of all scientific management are quantitative measurements, and one of the most notable developments in modern steam plant practice is the introduction of all kinds of meters for weighing the coal, measuring the boiler feed-water, determining the flow of steam, sampling the gases of combustion, recording the temperature of the water entering the boiler, measuring and recording the draft in the ashpit and in the chimney, and measuring the many other quantities that enable a steam plant engineer to compare his plant intelligently with other plants of the same class, and to determine the magnitude of losses and the possibilities of improvement.

In the operation of a steam boiler, one of the most important quantities is the temperature of the gases passing to the chimney, since, other things being equivalent, this temperature is a direct measure of the portion of the heat of the fuel which is wasted or not utilized. Indicating and recording thermometers and pyrometers are sometimes put in for measuring the temperature of flue gases, but their use is not general, due partly to their cost and also to the fact that many types of instruments are not reliable or break down in service. There is therefore a demand for cheap and efficient means of determining flue gas temperatures, which the Green Fuel Economizer Company, of Matteawan, N. Y., has met by devising so-called temperature pendants. These pendants consist, as may be surmised, of fusible alloys of the proper composition to indicate the desired temperatures.

It is an interesting fact that the melting points of such metals were found to be too uncertain and evasive to be used as temperature tests. That is, it is difficult to tell the exact point at which the metal melts, since it does not change suddenly from a hard solid to a liquid, as does water, but goes through an intermediate softening stage similar to iron and many other substances. Even after the metal is completely melted a hard skin of oxide is usually found to have been formed upon its surface, which prevents the metal running easily, and therefore is apt to confuse the determination of the exact temperature. The manufacturers, therefore, devised the expedient of using the tensile strength of the metal, instead of the melting point, as the true indication of temperature. In other words, the pendants are made with a large body, having a certain definite weight, suspended from a narrow neck, and the composition of the metal and cross section of this neck are adjusted until the body of the pendant will pull the neck in two and fall at some desired temperature.

In actual use the pendants are hung upon a small hook made upon the end of a long wire, which is introduced into the flue so that the pendant will be at the desired point. The best way is to begin with the lowest temperature pendant and proceed until the one is found which will not fall off after five or ten minutes' exposure. The temperature will then lie somewhere between the temperature marked on the last pendant and the next to the last pendant used. In doing this it is quite essential that several different points in the flue be tried, as it very frequently happens that one part of the flue is occupied by gases much hotter than the gases in other parts of the flue.

At present pendants have been perfected for three temperatures, *i. e.*, 425 degrees, 500 degrees and 550 degrees F., representing, respectively, the temperature at which the use of the economizer is justified with coal at commercial prices, the temperature at which an economizer is a good investment in all cases, and the temperature at which neglect to install an economizer becomes an inexcusable waste.

For use in connection with these pendants three tables have been calculated, which show, first, the percentage of heat escaping in chimney gases at various flue temperatures; second, the minimum temperature to which it pays to cool the gases by means of boiler surface only, and, third, the minimum temperature to which it pays to cool the gases by means of an economizer. These tables can be obtained from the manufacturers of the pendants, as can also sets of the pendants free of charge.

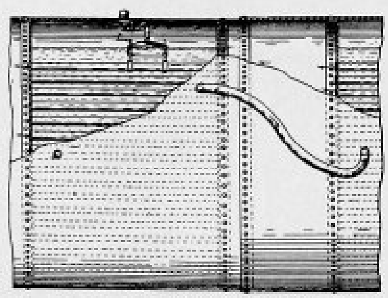
SELECTED BOILER PATENTS.

Compiled by
DELBERT H. DECKER, ESQ., Patent Attorney,
Loan and Trust Building,
Washington, D. C.

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

1,001,761. FEED-WATER HEATER. CHARLES HERSCHEL KOYL, OF NEW YORK, N. Y.

Claim 1.—The combination with a steam boiler of a closed feed-water heater and a feed-water outlet leading therefrom to the boiler, said



heater being provided with a space above its feed-water outlet for the accumulation of liberated gases, a valve controlled vent through which the thus accumulated gases can escape, and means for operating said valve. Three claims.

1,001,741. SHAKING AND DUMPING GRATE. THOMAS SIDLEY DOWNHAM, OF TORONTO, ONTARIO, CANADA.

Claim 1.—In a shaking and dumping grate, the combination with the side bars thereof provided with open-mouthed bearing slots each having a horizontal flat sill, and upward-inward curved walls formed at each end of said sill, of a grate-bar section provided at each end with a trunnion resting in one of said slots, each trunnion being provided in its underside with a recess or groove forming two shoulders positioned on opposite sides of the axis of said trunnions, and each normally resting upon said sill, the sides of each trunnion being rounded and extending upward from said shoulders; the horizontal diameter of said trunnions being less than the horizontal diameter of said slots thereby normally providing a clearance so that as the grate-bar section is rocked on its axis there will be a simultaneous change in position of this axis eccentric to its normal position by reason of each trunnion being bodily shifted and adapted to alternately contact with either side of the slot. Four claims.

1,002,725. SMOKE PREVENTER FOR FURNACES. WILLIAM E. McGRAW, OF CLEVELAND, OHIO.

Claim 2.—The combination with a furnace having a port for the admission of air, aid a furnace door, of a fluid supply pipe, an injector carried by said pipe and projecting into said port, a valve in said pipe, a valve for said port, a bell crank lever, a link connected at one end to the said air port valve and at its opposite end having a loose connection with one arm of the bell crank lever, stops upon the said link and upon opposite sides of the arm of the bell crank lever with which said link engages, a connection between the second arm of the bell crank lever and the fluid supply valve whereby the valves may be operated simultaneously, and means for operating said valves. Three claims.

1,001,075. STEAM SUPERHEATING APPARATUS FOR LOCOMOTIVE BOILERS. JOHN PRIMROSE, OF NEW YORK, N. Y.

Claim 4.—The combination with a steam boiler of the locomotive type having a smoke-box and boiler tubes discharging hot gases thereinto, of a superheater in the upper part of the smoke-box, an exhaust nozzle for the engine exhaust extending upwardly through the superheater, said superheater having superheating tubes surrounding the exhaust nozzle, and deflecting rings or plates on the exhaust nozzle at the top and bottom of the superheater, the superheating tubes being arranged relatively to each other and the exhaust nozzle whereby to cause a thorough distribution of the hot gases among the superheating tubes, as set forth. Four claims.

1,001,336. STEAM-BOILER FURNACE. GEORGE HALE BARRUS, OF BROOKLINE, MASS.

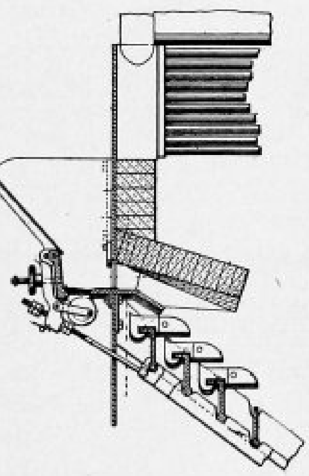
Claim 2.—A pair of boilers set side by side, each having its own furnace, a longitudinal division wall having a front opening and a rear opening, transverse partition walls dividing the space in the setting into passes, the front opening in the longitudinal division wall connecting the two front passes and the rear opening in the longitudinal division wall connecting passes to the rear of the front passes, and a baffle in each of said furnaces above the said front opening and extending outwardly from the said division wall whereby the direction of the unburned gases which pass through said front opening is controlled. Three claims.

1,001,456. UNDERFEED STOKER. FRANKLIN G. SAYLOR, OF QUINCY, MASS.

Claim 1.—A fire-box having a trough shaped fuel retort and a rotary shaft extending lengthwise through the retort, said shaft having two spiral blades running lengthwise thereof, the spirals of the two blades being radially opposite to each other and parallel with each other, one of said blades being throughout its length of greater radial sweep than the other blades. Three claims.

1,000,587. FURNACE STOKER. PAUL L. CROWE, OF JERSEY CITY, N. J.

Claim 1.—In a stoker mechanism a furnace similarly positioned, inclined supporting plates mounted at opposite sides of and within said furnace, rocking grate bars transversely arranged with respect to and



mounted on said inclined supporting plates, each of said rocking bars having its upper supporting portion inclined toward its ends from a point intermediate its ends and grate sections mounted on said grate bars. Three claims.

1,000,489. LOCOMOTIVE. WILLIAM F. BUCK, OF CHICAGO, ILL.

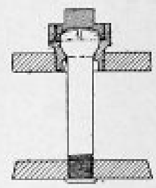
Claim 1.—A locomotive provided with a superheater, a throttle located intermediate of the superheater and the cylinders, and means located to the outside of the boiler-shell whereby the steam is conveyed from the throttle to the valve chambers of the cylinders. Fifteen claims.

999,187. STEAM GENERATOR. SYDNEY HOWARD SHEPHERD, OF LONDON, ENGLAND.

Claim 2.—In a steam generator a combustion chamber casing and a single steam generating and superheating tubular conduit consisting of a series of straight and substantially horizontal tubes all spaced apart horizontally and vertically in staggered arrangement within the casing and connected by U-shaped unions external to said casing and consisting of a bottom horizontal set, a water inlet thereto external to the casing and at the same level as the said horizontal set, and above said set a series of vertical sets so as to form a path in which fluid circulates zigzag fashion first through said horizontal set and afterward alternately and gradually recedes from and approaches such set. Two claims.

1,002,229. STAY-BOLT FOR LOCOMOTIVE BOILERS. THEODORE H. CURTIS, OF LOUISVILLE, KY.

Claim.—The combination with a stay-bolt having a rounded head, of a socket member having an externally screw threaded inner end and a rounded seat to receive the rounded head of the stay-bolt, and provided



with a hollow internally screw-threaded wrench head at its outer end for holding the socket member as described, and an externally screw-threaded plug member having means at its outer end for engagement by a wrench. One claim.

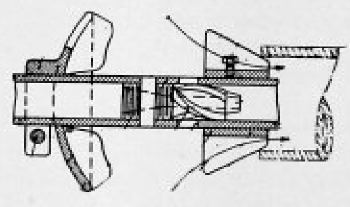
1,002,230. STAY-BOLT FOR STEAM BOILERS. THEODORE H. CURTIS, OF LOUISVILLE, KY.

Claim 1.—The combination of inner and outer boiler sheets at an angle to each other, the said sheets being tapped respectively with bolt

holes opposite to each other and on different axes, and a stay-bolt having an inner member and an outer member flexibly connected together, and an externally screw-threaded sleeve member engaged by the outer bolt member. Five claims.

1,002,255. TUBE CLEANER. ALFRED FRAISSINET, OF CHEMNITZ, GERMANY.

Claim 2.—A tube cleaner of the character described, comprising a nozzle having at its rear end a shoulder and screw-threaded portions at both sides of said shoulder, pipe ends of a diameter equal to that of the



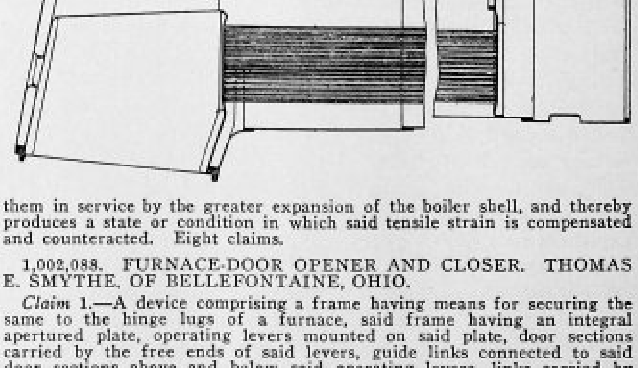
shoulder screwed against the latter from opposite sides, a collar having forwardly tapering spirally arranged ribs adjustably fitted on the pipe for holding the apparatus in position in the nozzle of the tube to be cleaned, means for admitting air into the front pipe, and means for shielding the air inlets from cold air. Five claims.

1,002,392. BLAST-FEED STOKER. WILLIAM T. HANNA, OF CINCINNATI, OHIO.

Claim 1.—In fuel feeding mechanism for stokers, the combination of means for separating the coarse from the fine fuel, and means for applying a comparatively powerful blast to the coarse fuel and a comparatively weak blast to the fine fuel. Four claims.

1,002,413. MANUFACTURE OF STEAM BOILERS. DONALD R. MACBAIN, OF CLEVELAND, OHIO.

Claim 1.—The improvement in the manufacture of steam boilers which consists in the act of mechanically imposing a compressive strain upon the boiler tubes which opposes the tensile strain imposed upon



them in service by the greater expansion of the boiler shell, and thereby produces a state or condition in which said tensile strain is compensated and counteracted. Eight claims.

1,002,088. FURNACE-DOOR OPENER AND CLOSER. THOMAS E. SMYTHE, OF BELLEFONTAINE, OHIO.

Claim 1.—A device comprising a frame having means for securing the same to the hinge lugs of a furnace, said frame having an integral apertured plate, operating levers mounted on said plate, door sections carried by the free ends of said levers, guide links connected to said door sections above and below said operating levers, links carried by said operating levers and a fluid operated slidably mounted block connected to said last-mentioned links. Ten claims.

THE BOILER MAKER

DECEMBER, 1911

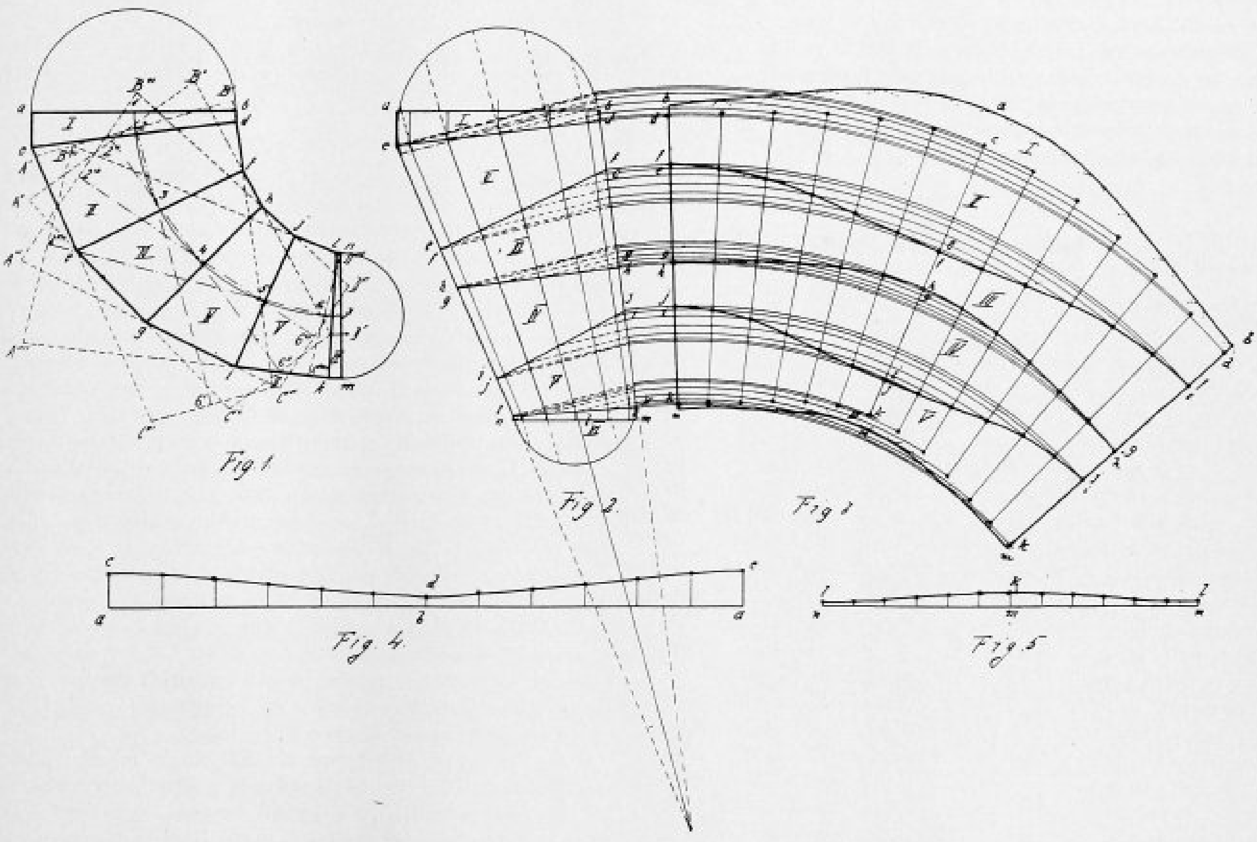
LAYOUT OF A CONICAL ELBOW.

BY JOHN JASHKY.

Sometimes in sheet metal work a conical elbow must be built and the layouts must be made. This is simple work if the elbow is well constructed, but it might be difficult if the method of laying out was not understood. Fig. 1 shows a conical elbow and its construction, and as can be seen both the construction and layout are very simple, saving time and money. It is stated that the elbow sections always must be circular. If properly constructed the two ends *I* and *VI* should be cylinders intersecting the cones *II* and *V*, these cones intersecting the cones *III* and *IV*, which intersect each other.

For constructing the elbow, first divide the arc 2-6 into any number of equal parts, the greater the length of the arc the greater should be the number; 1-2 and 6-7 are the axes of cylinders and may be short if the parts *I* and *II* and *V* and *VI* are made of one sheet. Having divided the arc 2-6 and located the points 3, 4 and 5, draw straight lines through 2 and 3, 3 and 4, 4 and 5, 5 and 6. On the line passing through 2 measure from 3 to 6′ the whole length of the divisions 3-4, 4-5 and 5-6. Erect perpendiculars at 2 and 6, and on the perpendicular going through 2 measure the major diameter, thus locating *A′* and *B′*, and on the square going through 6′ measure the minor diameter, thus locating *D′* and *C′*. After having drawn the lines *A′-C′* and *B′-D′* the first cone is found. On the line going through 3 and 4 measure from 3 to 2″ one division, equal to 3-2, and from 4 to 6″ two divisions equal to 4-5 and 5-6. After squaring on the ends at 2″ and 6″ measuring the diameters and having drawn the lines *A″-C″* and *B″-D″*, the second cone is completed.

In the same manner the other two cones are found. These cones and the two end cylinders are intersecting each other,



A SIMPLE METHOD OF LAYING OUT A CONICAL ELBOW.

and all the intersecting lines are straight lines, but none of these lines passes through the points 2, 3, 4, 5 or 6. If such construction is made, the layout of the conical parts is very easily found. For this purpose draw Fig. 2. First draw the cylinder *I* and the cone *II*, so that the points *a*, *b*, *c* and *d*, are found, and also the first intersecting line from *c* to *d*. With *c* as a center draw an arc with *c-e* from Fig. 1 as a radius and locate the point *e*. With *d* as a center draw an arc with *d-f* from Fig. 1 as a radius for finding *f*. Now with *e* as a center draw an arc with *f-h* from Fig. 1 as a radius, thus finding *h* and *e*, *e* becoming also the point *f*. With *f* as a center draw an arc with *e-g* from Fig. 1 as a radius, finding *g* and *f*, *f* becoming the point *e*. This can be done till all intersecting points are found. After connecting the corresponding points, the intersecting lines and the conical parts *II*, *III*, *IV* and *V* are found.

The layout of each of the parts is found in the usual manner and will not be described. Figs. 2 and 3 show the method clearly. The parts *I* and *II* are each made of one piece of sheet; the cylindrical part must be flanged out for the cone and the necessary layout is found simple. Take *c-a* in Fig. 1 and draw an arc with *c* in Fig. 3 as a center. Continue with all other points and lay a curve, which is tangent to all these arcs, and the layout is found. By the same method the layout of the cone and cylinder *V* and *VI* is made.

That the parts *II* and *III* and *IV* and *V* in Fig. 2 are the same as in Fig. 1 is shown by drawing these parts on tracing paper and superimposing the corresponding parts, therefore *II* from Fig. 1 coincides with *II* in Fig. 2, *etc.* The allowances for lap joints are not shown.

A Bulged Back-Flue Sheet.

EDITOR THE BOILER MAKER:

I have noticed the inquiry of "Flue Sheet" in your September issue regarding causes for the buckling or bulging of the back flue sheets in locomotive boilers where the very best clear water is being used in the boiler. In my opinion the cause for this action cannot very well be determined until more details are given regarding the size and construction of the boiler. If clear water is being used it is not likely that the flue sheet will become heavily coated with scale or dirt, and, therefore, there probably would not be much chance of overheating the sheet. The main reason is probably the expansion and contraction of both the flues and the fire-box. Without further details of the boiler it is pretty difficult to accept this reason without many reservations. It would be easier to give a more definite reply if the exact position of the spots where bulging and buckling occurred had been given. The expansion and contraction of the flues bring a great strain on the thin and unsecurely braced flue sheet, and unless the flanges of the sheet have been so designed as to give some relief from those strains, it is not unlikely that the parts of the sheet which are most securely held by the tubes will bulge after considerable service.

To straighten out sheets which have buckled or bulged in this way would depend upon the exact nature of the deformation in the plate. If the plate had been overheated, and thereby caused the bulging, the plate itself would have become thinner and could not be straightened by heating and pounding without distorting the flue holes, unless the metal in the sheet was upset. Where the bulging and buckling has not thinned the plate but has simply twisted it, it could be straightned by heating and pounding, providing great care was used. This would undoubtedly elongate some of the adjacent flue holes and they would have to be reamed out.

F. T. JOHNSON.

COMBUSTION IN BOILER FURNACES.

BY J. F. SPRINGER.

Just what do we mean by combustion? When an oil lamp is burning we say that combustion of the oil is taking place. When a splinter is lit and a more or less bright flame results, accompanied by smoke, we say that combustion of the wood is going on. If we inquire of the chemists as to what is taking place they will tell us that the material which we say is burning is being broken up, and that the oxygen in the air is combining chemically with its particles. In consequence of this combination heat and light become manifest. This is what is ordinarily termed combustion. But a visible flame is not essential. What is essential is the chemical combination and the consequent evolution of heat. When we breathe combustion takes place. Air is taken into the lungs, where it is brought into contact with blood which has become laden with impurities. A chemical breaking up takes place, resulting in carbon from the blood uniting chemically with oxygen from the air. When we exhale, the combination passes off as carbon dioxide CO_2, and more or less heat is evolved. Apart from the spectacular bright flame, this is just what occurs in a furnace: Carbon set free from the coal unites with oxygen from the atmosphere and so forms CO_2, which passes out and up the chimney. Oxygen is eager to combine with hydrogen, sulphur and other substances as well as with carbon whenever the opportunity is offered. In any case we call the process combustion.

INSUFFICIENT OXYGEN CAUSES WASTE.

It sometimes happens that there is not enough oxygen available to result in the formation of carbon dioxide. Imperfect combustion then results. That is to say, carbon and oxygen unite and form carbon monoxide CO. You see, only half as much oxygen is required to form CO as is required for CO_2. This may not seem important at first sight, but it is quite so. Carbon monoxide is a poisonous gas, while carbon dioxide is merely a suffocating gas. But this is by no means all. The heat evolved when CO is formed is much less than when the complete combustion to CO_2 is effected. When 1 pound of carbon unites with sufficient oxygen to form carbon monoxide 4,400 heat units result. If, however, a pound of carbon is supplied with enough oxygen to result in the formation of carbon dioxide 14,500 thermal units are produced. That is to say, if air is supplied in sufficient quantity we shall obtain instead of a poisonous gas one which is of advantage to the vegetable world, and more than three times the amount of heat. When hydrogen combines with oxygen, forming water, there is a tremendous production of heat, for the burning of 1 pound of hydrogen results in 62,000 British thermal units. One pound of sulphur unites with oxygen to form SO_2 and liberates 4,000 British thermal units.

When we supply insufficient air and obtain merely CO instead of CO_2 from the combustion of 1 pound of carbon, we have lost in heat units the difference between 14,500 and 4,400. That is, there have been wasted 10,100 British thermal units, enough heat to raise the temperature of 101 pounds of water 100 degrees F. Of course, it may cost something to supply the extra oxygen under suitable conditions, but allowing for this there is still an enormous loss entailed when only incomplete combustion takes place.

OXYGEN IS NECESSARY.

It is instructive to remember that in endeavoring to secure heat by the process of combustion nothing will take the place of the oxygen. If we supply a furnace with too little air, so that we are only getting CO with a limited amount of heat, we can correct the difficulty only by supplying the necessary amount of oxygen. To conduct the CO over a highly heated bed of coals, with the hope of burning it to CO_2 through the agency of the high temperature without adding more oxygen, is absurd. This will become clear when we consider the two symbols CO and CO_2. There is just twice as much oxygen indicated by one as by the other. Heat is not oxygen, so it cannot, of itself, cause CO to become CO_2. There is no substitute; sufficient oxygen must be present in order that complete combustion may take place.

It is the same if that which is being separated from the fuel being burned is hydrogen, or a compound of hydrogen and carbon, instead of simple carbon. The result of the burning or combustion will be heat. Heat is what we want. In order to get it, we must supply oxygen. If we do this, and other conditions are right, heat will be developed in great quantity.

The great difference between anthracite and bituminous coals is that the former coal contains little or no hydrogen (in combination with carbon), while the latter has a very considerable percentage. If bituminous coal be heated without a supply of air, there will be given off one or more of the hydrocarbons, such as methane (marsh gas, CH_4), ethylene (olefiant gas, C_2H_4) and acetylene (C_2H_2). A great deal of heat is lost when such gases are allowed to pass out of the chimney. But if sufficient oxygen is supplied and other conditions are right, the carbon atoms will separate from the hydrogen atoms, the carbon will unite with the oxygen to form carbon dioxide (CO_2), and the hydrogen will combine with the oxygen to form water (H_2O). This is perfect combustion. These chemical changes will produce a great amount of heat. Nothing can adequately take the place of oxygen, so if we want the best results we must supply it in sufficient quantities.*

OIL LAMP EXAMPLES.

Consider the illustration furnished by the ordinary oil lamp. Turn up a lighted wick to a certain point. There is no smoke and no bad odor. Turn it up somewhat further and there is smoke and a disagreeable odor. In the former case hydrocarbon is given off, no doubt, just as in the latter; but in the one the air supply is sufficient to furnish the hydrogen and carbon with as much oxygen as they can combine with. The results are water and carbon dioxide. But in the second case the oxygen supply is insufficient, and, despite the high temperature, the hydrocarbon passes off to be chilled and to cause an evil smell and black smoke. The introduction into the flame of a cool rod causes a deposit of soot to form upon it. The checking of the combustion of the hydrocarbon exhalation by a lowering of the temperature results in only the hydrogen combining with the oxygen, while the carbon refuses so to combine and separates as soot. In further illustration of the part which the temperature plays, we may take another example. A lamp which is burning perfectly may be made to smoke by raising the chimney and admitting cool air at the bottom.

We may supply a sufficient total amount of oxygen, we may have the temperature sufficiently high, and we may still fail to get perfect combustion. Each atom of carbon needs two atoms of oxygen and a proper temperature. But of what avail are the atoms of oxygen and the heat if these oxygen atoms are not on the spot? That is to say, to get perfect combustion, the oxygen supply must be distributed thoroughly. The want of this is the controlling reason why a bonfire smokes. There is the whole ocean of air with its inexhaustible supply of oxygen, but it is not where it is wanted. So with a furnace; it is not enough that a sufficient total of air be introduced, and that a sufficiently high temperature be maintained, the air must be thoroughly mixed with the hydrocarbons as they pass off from the fuel.

In order to understand combustion and successful stoking, it is necessary to understand the functions of three factors:

(1) Oxygen.

(2) Temperature.

(3) Mixture.

COLORLESS BUT WASTEFUL SMOKE.

Some additional remarks may be added as to the detection of imperfect combustion. First, if the stack smokes we know that a quantity of carbon has failed to combine with oxygen, as it is usually the carbon that makes the exhalation from the stack visible. The failure of the chemical combination means that combustion, with its valuable attendant disengagement of heat, has not taken place. Second, if carbon monoxide (CO) is being emitted from the stack, we know at once that not sufficient oxygen is combining with the carbon. Imperfect combustion is taking place. Since carbon monoxide is colorless we may have imperfect combustion going on and no visible signs of the fact at the mouth of the stack. The stack may be smokeless and the combustion anything but perfect. On the other hand, a given fuel will produce, when completely burned, a pretty definite quantity of waste gases, and that the carbon dioxide ought to constitute a certain definite amount. And, further, whether a larger or smaller quantity of fuel be burnt, the ratio of the CO_2 ought always to be the same. So there is a very good reason why we seek to determine this ratio. When the ratio remains constant from hour to hour, as the boiler is now pressed and now relieved, it indicates a regularity of combustion.

A great thing to remember in connection with chemical combinations is that they require time for their consummation. This time is usually so short that we are apt to neglect its consideration altogether. For example, the coal gives up its hydrocarbons, a sufficient heat is at hand for ignition, sufficient oxygen is being supplied, and finally there is an adequate mixing operation going on. Will combustion take place? Indeed it will, for all the necessary conditions have been complied with. Yes, it will burn, unless, of course, some change takes place before the combustion has been fully completed.

What we want is combustion at such a location that the heat evolved will be communicated to the boiler surface. However, we do not want to transfer quite all the heat to the boiler, even if we could, for then we should have no draft. The heat necessary for the purpose of securing a draft and thus getting rid of the products of combustion is not great. Therefore, we are free to transfer nearly all to the boiler surface, if we can. It is obvious that heat, being derived from combustion, is not available until the moment of chemical combination. It may be available subsequently, but it cannot be available before. Hence if the boiler is so placed with reference to the grate that the speed of the rising gases is sufficient to carry a portion of them past the boiler before the combination with oxygen has actually taken place, heat will have been wasted. Not that heat is not generated. It may be liberated, especially if we disregard any chilling surfaces, but at the wrong point. The stack is heated and the outside air is heated, but what we wanted to heat was the boiler. If the gases reach the surface to be heated just after combustion we may expect little or no loss of heat. It is important, then, to be sure that there is a sufficient distance between the grates and the boiler. If the boiler is such that it may be heated at a number of points, then the gases may be guided to these, distances being so regulated that when at last the gases leave combustion will have fully taken place.

*It is true that sulphur, if present, may combine with hydrogen to form sulphuretted hydrogen in case of an insufficient supply of oxygen, and no doubt this chemical combination produces heat. However, as the authors of "Smoke Prevention and Fuel Economy" point out, if sufficient oxygen be available, the sulphuretted hydrogen may burn to SO_2 and H_2O.

TEMPERATURE OF BOILER SURFACE.

A further consideration in connection with our subject concerns the temperature of the boiler surface. In so far as the thermometer is concerned, this may be taken as about 350 degrees F. or less. It may, therefore, be regarded as a cooling surface as compared with the burning gases. Now if we recollect the effect of a cool rod introduced into the flame of a lamp, we will perhaps better understand the significance of the statement that the comparatively cool boiler must not be allowed to check combustion that is still going on. Gases about to unite with oxygen and so liberate heat will fail to do so if just at the critical moment they and the oxygen have their temperatures lowered. So here is an additional reason for having a considerable distance between the bed of coals and the boiler surface. Combustion should take place before the cool surface is reached. Once there it may not take place at all, on account of the temperature falling below the ignition point.

It will be seen, then, that it is a matter of importance where we place our boiler with reference to the grate. It is probably impossible at present to define a relation with a comprehensive rule applicable to all cases. There are too many factors entering into the problem. It is sufficient just now if we realize the importance of the correct placing of boiler and grate.—*Power.*

PIPE THREADING DIES.*

The greatest difficulty in threading pipe, no matter of what composition, lies in the use of dies which oftentimes are inadequate to perform the duties expected of them. The fact that practically all pipe must be threaded justifies those interested in pipe and its use in thoroughly studying the question of threading dies.

The experience of pipe manufacturers and others who do their threading by machinery, and use the improved form of die, shows that steel pipe can be threaded just as rapidly as iron, with less wear on the dies, and is preferred by the operator. The same may be said as to dies used in ordinary hand stocks.

*From a bulletin issued by the National Tube Company.

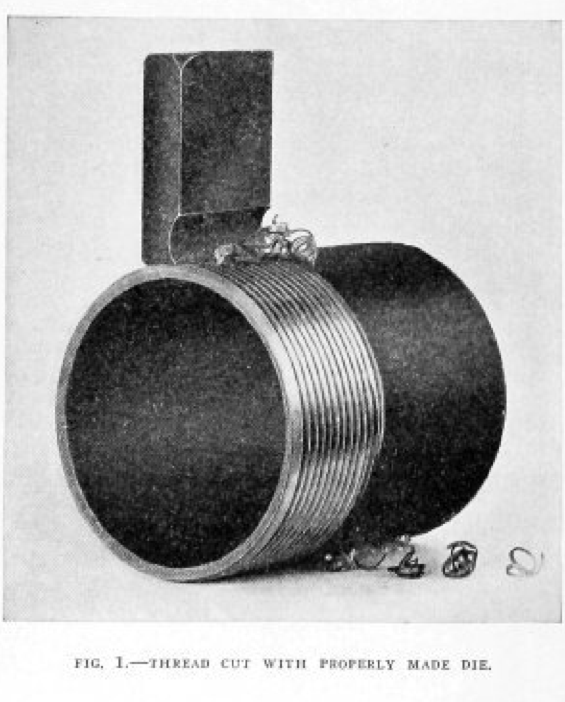


FIG. 1.—THREAD CUT WITH PROPERLY MADE DIE.

To insure a good threaded joint between the pipe and fitting it is necessary to have a clean, smoothly cut thread, and in order to secure such a thread it is necessary to have a good die, consisting of a frame or holder and a set of chasers, made with proper consideration for the following points: Lip, chip space, clearance, lead, sufficient number of chasers.

The lip is also known as hook or rake, and is the inclination of the cutting edge of the chaser to the surface of the pipe.

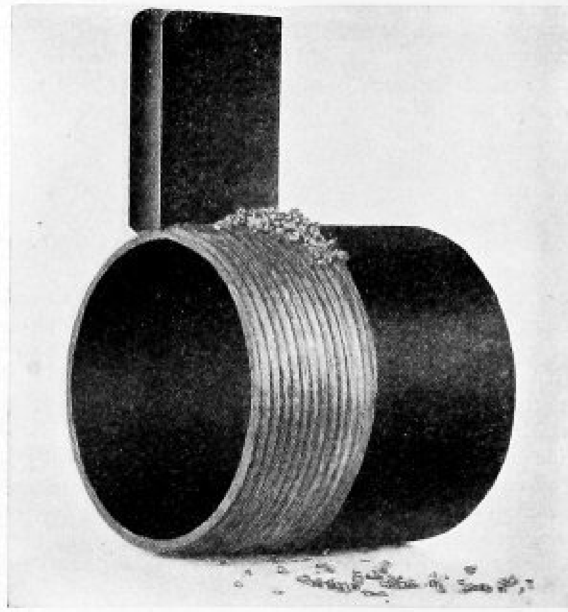


FIG. 2.—SAME WITH IMPROPERLY SHAPED AND COMMONLY USED DIE.

The lip may be secured by milling the cutting face of the chaser, or by inclining the chaser.

The lip angle should be from 15 to 25 degrees, depending upon the style and condition of the chasers and chaser holders. In Fig. 1 is shown a chaser of a properly made die. The chips curl off clean and leave a smooth thread. In Fig. 2 is shown a chaser of an improperly made die. The square cutting edge pushes the metal off, leaving a ragged, torn thread. This style of die not only makes a poor thread, but also causes excessive friction and is less durable.

Chip space is the space required in the holder in front of the chaser to allow room for the accumulation of chips, and also provides means for lubricating the chasers. A lack of chip space will cause the chips to clog and tear the threads.

Clearance is the angle between the threads of the chasers and the threads of the pipe. This clearance may be secured in various ways, depending upon the position in which the chasers are held in the frame. The position of the cutting edge of the chaser, in relation to the center line of the pipe while working, determines whether the chasers shall be set "out" or "in" while the teeth are being machined.

Lead is the angle which is machined or ground on the front of each chaser to enable the die to start on the pipe, and also to distribute the work of making the first cut over a number of threads. The lead may be machined on or, as is more frequent, it may be ground on after the chasers are tempered. The proper amount of lead is about three threads. As the heaviest cutting is done by the lead, it should have a slightly greater clearance angle than the rest of the threads on the chaser. When regrinding a chaser that has become dull on the lead, care should be taken to give each chaser the same length of lead, as otherwise the work will be unevenly distributed between the chasers in the set.

To get good results in threading at one cut, experience shows that a die should have a suitable number of chasers; the approximate number being determined by the size of the die. Our experience shows that the dies up to 1¼ inches should have four chasers.

One and one-quarter to 4 inches should have approximately six chasers.

Four to 7 inches should have approximately eight chasers.

Seven to 10 inches should have approximately ten chasers.

Ten to 12 inches should have approximately twelve chasers.

Twelve to 14 inches should have approximately fourteen chasers.

Fourteen to 18 inches should have approximately sixteen chasers.

Eighteen to 20 inches should have approximately eighteen chasers.

Good lard or crude cotton seed oil should be used in liberal quantities. The best die made will not produce good results with poor oil.

A die which is made with regard to these points by an experienced tool maker will thread both wrought iron and steel pipe with equally good results.

Steel pipe is naturally softer and tougher, and consequently somewhat more difficult to thread with the old form of dies having the cutting edge on the center, as shown in Fig. 2. Such a die pushes the metal out or "tears it up by the roots." A better shape is shown in Fig. 1, having sufficient front rake and relief to cut the metal out with a clean finish without waste of power or unnecessary friction, similar to the working of a lathe tool.

Applying these principles to hand dies it is possible for one man to do the work of two. In a paper by T. N. Thomson, read before the American Society of Heating and Ventilating Engineers in 1906, certain tests are described on the power required to thread pipe with hand dies of the common pattern, and with the same type of dies correctly made. The author says:

"It shows that the power required to thread mild steel pipe with the new die is not much more than that required to thread wrought iron with the same die, and much less than the power required to thread wrought iron pipe with the common die."

Notice to Manufacturers.

The Supplymen's Association of the American Boiler Manufacturers' Association at the convention held in Boston, July 10, 11, 12, and 13, decided to compile a complete list of all of the manufacturers of boilers, tanks and stacks in the United States and Canada, as well as other concerns using steel plate in their process of manufacture, and it is requested that all concerns building boilers, tanks, stacks and using steel plate, would immediately send their names and addresses to the undersigned for insertion in this book.

F. B. SLOCUM, Secretary.

Supplymen's Association of the American Boiler Manufacturers' Association, West and Calyer streets, Brooklyn, N. Y.

The D. Connolly Boiler Company, of Cleveland, Ohio, has moved to new quarters at East Cleveland, occupying one of the most complete and up-to-date boiler shops in the country, capable of handling a great variety of boiler and sheet metal work. A representative of THE BOILER MAKER, on a recent visit to this plant, was shown through the various departments by Mr. C. E. Schafer, superintendent of the works, and found many new features in the arrangement of the plant tending toward efficiency and accurate and rapid production of the work.

A STUDY OF THE BOILER BLOW-OFF.

BY J. C. WILLIAM GRETH.

All waters fed into steam boilers contain some impurities, which are either soluble or insoluble, or both. These impurities may be divided into two classes—incrusting and non-incrusting. The former is made up of the suspended matter, lime and magnesia salts, silica and the oxides of iron and alumina; the latter includes only the sodium salts.

The impurities in the feed-water accumulate in the boiler by the action of heat and the concentration due to evaporation. Heat drives off the soluble carbonic acid, and thus reduces the solubility of the carbonates. By the evaporation of the water into steam all the impurities, including the suspended matter, are left behind, and eventually supersaturation of the soluble scale-forming impurities is reached, when these impurities crystalize, and with the suspended matter deposit as scale or sludge. Sometimes the combined effect of heat and concentration causes chemical reaction, with a consequent precipitation.

Operating a boiler with water containing any impurity will, by heat and concentration, cause any or all of the following, depending on the amount and kind of impurity:

Accumulation of suspended matter.

Formation of scale or sludge.

Corrosion.

Concentration of non-incrusting substances.

These in turn may cause any or all of the following, which are objectionable from the viewpoint of economy and safety:

The overheating of plates and tubes.

Loss by waste of fuel due to scale, reducing the efficiency of the boiler.

Reduced heating surfaces in watertube boilers and decreased water space in all types of boiler.

Necessity for cleaning and repairs.

Priming and foaming.

Loss due to the investment in spare boilers to put into commission when it is necessary to take boilers out of service for cleaning or repairs.

Loss of fuel due to heat lost on cooling a boiler for cleaning or repairs and that required again to bring it into service.

Cost of tube-cleaning machines, repairs to them, interest and depreciation on the money invested and labor and power required for operating them.

Loss of efficiency in earning power of improved furnaces and stokers; these are installed to increase evaporation, which correspondingly increases the concentration of impurities, thus forming a greater deposit of scale or producing more active corrosion, and hence a great reduction in the efficiency and life of the boilers.

All types of steam boiler are subject to the same general condition of water contained in them after they have been under steam for a time. That is, on account of the concentration and precipitation of impurities the water becomes foul, and to eliminate some of the impurities and keep down sludge a part of the water is blown off while the boiler is in service. The introduction into the boiler of any chemicals or boiler compounds increases the amount of impurities, both soluble and insoluble, and increases the frequency of blowing off.

Blowing off is generally done from the lowest point on the boiler, on the assumption that all impurities in suspension will settle with the heavy suspended matter, such as the mud or silt of the feed-water; hence the name "mud-drum." This settling may occur in certain types of boiler, especially in the return-tubular, but it is doubtful if such is the case in many of the watertube boilers.

Heat will force out of solution practically all those incrusting solids which make up the temporary hardness, namely, the carbonate of lime and magnesia held in solution by the carbonic acid, which is expelled by boiling. These precipitated carbonates may be carried to the mud-drum or part of the boiler designed to receive them, or may be deposited on the heating surfaces.

The permanent hardness, made up of the sulphates, chlorides and nitrates of lime and magnesia, is not acted on by heat alone, as its being forced out of solution depends on the temperature and the amount in solution; so that no appreciable precipitation of these substances occurs unless a concentration is effected, and concentration in the mud-drum or leg is possible only to a very limited extent. The chloride and nitrate of magnesia will, however, suffer partial dissociation and precipitation, even much below boiler temperature.

The non-incrusting solids are rarely if ever present in feed-water to such an extent as to reach supersaturation by evaporation and thus be forced out of solution. Furthermore, the solubility of the non-incrusting solids, as a rule, increases with the rise in temperature.

The circulation of the water in the return-tubular boiler is such that there is a considerable deposit of sludge in the bottom of the boiler. At the waterline there is also a considerable accumulation of suspended matter, and no matter from what part of the return-tubular boiler water is taken it shows practically a uniform diffusion of the soluble impurities.

In the watertube boiler an entirely different state of affairs exists, varying with the type of boiler. Some watertube boilers are provided with mud-drums, others with legs from which the blow-off is taken; in others the blow-off is located at the lowest point with no special provision for collection of sludge; in some the feed-water enters the steam drum, mixes with the water in the boiler and passes down a bank of tubes, where it is heated to boiler temperature, which is supposed to bring about the precipitation of the scale-forming matter and carry it, together with the suspended matter in the feed-water, into the mud-drum, to which the bank of tubes is connected and through which all the water entering the boiler circulates.

In other types the mud-drum is not in the direct path of the circulating water, but is a dead end; in this type the water in the mud-drum is practically static. In other types of the watertube boiler the water is fed through drums, tubes, pans, etc., in the boiler, so as to heat the water to boiler temperatures before mixing with the water in the boiler, and depending upon the circulation to carry the suspended impurities in the feed-water, or those forced out of solution, to the lowest point of the boiler or the blow-off opening. The mud-drum or blow-off is usually located in the coolest part of the setting, or, in other words, where there are the least circulation and evaporation.

The blow-off is intended not only to remove suspended matter and deposited sludge, but to reduce the concentration of the soluble impurities; therefore, it should be so located that a minimum quantity of blow-off water will remove the greatest amount of suspended matter and that portion of the water showing the greatest concentration of soluble salts. The greatest concentration of soluble impurities occurs in that part of the boiler where the evaporation is most rapid, and not in the coolest part, where little or no evaporation takes place.

The blow-off from the mud-drum or lowest part of any boiler does not carry out all the matter deposited, but simply that in the immediate vicinity of the opening, so that in those boilers having a dead-end drum or leg, the greater part of the deposited suspended matter remains in the water. In those boilers where there is a circulation of the water through the mud-drum or leg, it must necessarily prevent the deposition of all of the suspended matter, and much of it will be carried into the boiler proper, where, with the scale-forming matter forced out of solution, it adds to the scale formed.

There are many theories about ebullition in a steam boiler, but just what changes in the impurities in the water take place in the boiler are not known, nor can they be positively determined. The analysis of the feed-water shows the impurities it carries into the boiler; the analysis of scale shows what has been deposited as a result of heat and concentration; the analysis of water taken from various parts of the boiler will show that reactions have taken place; just how, when or under what conditions they take place is a matter of conjecture.

Those reactions I shall cite as having taken place are conclusions reached from the analyses of many hundreds of samples of boiler-feed water, blow-off water and scale; samples taken of almost every possible water supply, raw, softened, etc.; blow-off water from nearly every type of boiler operating under every conceivable condition. There are, however, some reactions cited that do not seem to have always taken place. This can only be accounted for by the presence or absence of other salts and the difference in boiler-operating conditions.

For instance, to precipitate calcium sulphate which, at boiler temperatures, is soluble to about 25 grains per United States gallon, it is necessary, if a water which contains only three grains per United States gallon is fed into the boiler, to have the temperature and concentration to the point at which it will be forced out of solution for that particular water. This point is a variable one, and depends on the nature of the other substances in solution in the water, as well as the temperature at the pressure under which the boiler is operating.

An increase of impurities is shown in any boiler after being in operation for only a few hours, and there will be a continual increase in the amount as long as the boiler is making steam, irrespective of the amount blown off. (See the writer's article "The Effects of Superheating Moist Steam," *Power*, July 7, 1908.) This point is illustrated by the following analyses, showing the raw water and the boiler water after four days' operation, with regular blowing off:

	Grains per U. S. Gallon.	
	Feed Water.	Concentrated Boiler Water.
Volatile and organic matter	0.25	7.40
Silica	0.35	0.65
Iron and alumina oxides	0.05	Trace
Calcium carbonate	4.50	3.77
Calcium sulphate	0.68	10.13
Magnesium sulphate	1.98	21.15
Sodium sulphate	0.44	25.40
Sodium chloride	0.45	30.00
Total solids	8.70	98.50
Suspended matter	0.90	130.60
Incrusting solids	7.56	35.70
Non-incrusting solids	0.89	55.40

The foregoing analyses also illustrate the difference in concentration of the different salts and the effect of heat on forcing out of solution some of the salts, depending on their solubility at the temperature and the other substances in solution. The sodium chloride (salt) in the raw water shows 0.45 grain; in the boiler water 30 grains, showing over sixty-six concentrations.

Sodium chloride may be used as a basis for determining the concentration, as practically no chemical change takes place between the sodium chloride and the other salts in solution;

also, because the solubility of sodium chloride increases with the temperature, so that at no time will there be any material reduction in the sodium chloride on account of chemical change or precipitation, as the boiler would not steam with the concentration of the sodium chloride at a point where it would be forced out of solution. Some of it may be mechanically carried down with the scale-forming matter and be deposited with the scale; but the amount is usually extremely small, as scale analyses rarely show any appreciable amount of sodium chloride. Of course, measuring the concentration of the impurities by means of any soluble salt is liable to error on account of variations in the feed water.

Sodium chloride will sometimes react with magnesium sulphate, especially at the higher temperatures and pressures and after considerable concentration, forming sodium sulphate, precipitating magnesium hydrate, which is very insoluble (less than 1 grain per United States gallon), and liberating hydrochloric acid, which will combine with the calcium carbonate if present; if not, it will attack the iron of the boiler. This is not the case in the foregoing analyses, as there is no calcium chloride present, and the sodium sulphate shows less concentration than the sodium chloride.

Sodium sulphate may also be taken as a measure of the concentration on account of its great solubility, and its not being subject to chemical change, except in concentrated solutions. In the foregoing analyses the sodium sulphate only shows fifty-eight concentrations, as against sixty-six for the sodium chloride. Ordinarily this concentration should be the same, but slight changes in the impurities in the feed-water may account for the difference. There is not a sufficient quantity of either one present to cause a precipitation and the scale from this boiler does not show either, except as traces.

Calcium carbonate at boiler temperatures varies in solubility from about ½ grain to 8 grains, depending on the other salts in solution.

Calcium sulphate, as already explained, is soluble to about 25 grains, and in this particular water shows only 10.13 grains (probably its solubility for this particular water and temperature), or about fifteen concentrations as against sixty-six for the sodium chloride, so that in all probability a considerable amount of it has been precipitated, either as suspended matter or as scale-forming sludge.

The magnesium sulphate, which at boiler temperature is quite soluble, also shows about eleven concentrations.

The volatile and organic matter has a decided influence on the solubility of various salts, but in most water supplies the quantity present is not such as will affect the solubilities of other salts until after concentration. Volatile and organic matter is usually present to some extent in scale, but it does not necessarily follow that it will cause scale in the absence of lime and magnesia salts. Silica and iron and alumina oxides are usually present in most waters in small quanties, and they deposit as scale in the boiler.

The large quantity of suspended matter is undoubtedly due to the impurities forced out of solution, and to the concentration of the suspended matter introduced with the feed-water. The sodium chloride shows sixty-six concentrations, while the suspended matter shows about 145 concentrations.

Other substances in solution in boiler feed-water may, under heat and concentration, become insoluble, such as magnesium carbonate, which is quite similar to calcium carbonate as to solubility, but it is usually dissociated into magnesium hydrate and carbonic acid; the magnesium hydrate being precipitated and the carbonic acid going off with the steam.

Magnesium chloride and magnesium nitrate are easily dissociated, beginning at 200 degrees F., into magnesium hydrate and hydrochloric acid or nitric acid, as the case may be. Both acids are very soluble at all temperatures, but they will recombine with calcium carbonate if it is present. If no calcium carbonate is present these acids will attack the iron of the boiler, forming the corresponding iron salts, which react like iron sulphate, which will be discussed later.

The following analyses will illustrate the decomposition of magnesium chloride, the hydrochloric acid formed combining with the calcium carbonate and the carbonic acid going off with the steam, and the magnesium hydrate precipitated forming either scale or sludge:

	Grains per U. S. Gallon.	
	Feed Water.	Concentrated Boiler Water.
Volatile and organic matter	0.35	2.90
Silica	0.35	0.45
Iron and alumina oxides	0.10	Trace
Calcium carbonate	1.02	2.02
Calcium sulphate	2.14	7.68
Calcium chloride	....	1.19
Calcium hydrate	....	0.33
Magnesium sulphate	0.93	....
Magnesium chloride	0.32	
Magnesium hydrate	....	0.32
Sodium chloride	0.10	12.77
Total solids	5.31	27.66
Suspended matter	0.05	0.80
Free carbonic acid	0.33	None
Incrusting solids	4.86	11.99
Non-incrusting solids	0.10	12.77

From the preceding analyses, which show what is usually considered a good natural water supply, there have been, based on the sodium chloride, about 120 concentrations. This water also shows the decomposition of the calcium chloride and the formation of calcium hydrate, and the presence in solution of some magnesium hydrate. This water has a decided caustic reaction. The boilers are operated at a pressure of about 175 pounds.

A similar state of affairs exists also in the following analyses; being rather a bad water. From the analyses of the water it would seem that a greater dissociation should have taken place compared with the preceding analyses. The water in this case also has a caustic reaction:

	Grains per U. S. Gallon.	
	River Water.	Concentrated Boiler Water.
Volatile and organic matter	0.85	4.90
Silica	0.30	0.25
Iron and alumina oxides	0.10	Trace
Calcium carbonate	6.47	1.50
Calcium sulphate	5.64	26.66
Calcium chloride	6.96	52.41
Calcium hydrate		0.45
Magnesium chloride	3.42	....
Magnesium hydrate	....	0.23
Sodium chloride	18.81	239.73
Total solids	42.55	326.13
Suspended matter	2.55	14.50
Free carbonic acid	0.11	None
Incrusting solids	22.89	81.50
Non-incrusting solids	18.81	239.73

Magnesium sulphate in itself will not usually form scale. There is, however, a reaction between the magnesium sulphate and calcium carbonate, in which the magnesium hydrate is formed and precipitated, carbonic acid going off with the steam and a corresponding amount of calcium sulphate being formed. This calcium sulphate will, of course, form scale after concentration to the limit of solubility for the particular water.

The following analyses will illustrate the formation of the calcium sulphate from the magnesium sulphate, also the decomposition of the magnesium chloride. It will be noted in these analyses that the concentrated boiler water still shows some magnesium chloride but no magnesium sulphate. This reaction is quite common in nearly all boiler waters:

	Grains per U. S. Gallon.	
	Raw Water.	Concentrated Boiler Water.
Volatile and organic matter	1.40	2.80
Silica	0.35	0.45
Iron and alumina oxides	Trace	0.15
Calcium carbontae	6.25	1.50
Calcium sulphate	3.64	16.35
Magnesium sulphate	1.02	....
Magnesium chloride	1.01	0.28
Magnesium hydrate	...	0.15
Sodium chloride	4.68	146.44
Total solids	18.35	168.12
Suspended matter	0.25	15.90
Free carbonic acid	0.33	None
Incrusting solids	12.27	18.88
Non-incrusting solids	4.68	146.44

Iron sulphate is sometimes present as a result of drainage from coal mines and manufacturers' waste, also sulphuric acid, which, with the iron of the boiler, forms iron sulphate. The iron sulphate is decomposed at boiler temperatures, liberating sulphuric acid, precipitating the iron as the oxide, the acid taking up a new supply of iron, again forming the iron sulphate, which in turn is again dissociated. This cycle continues indefinitely with an increased corrosion of the boiler iron, corresponding to the increase of acid resulting from the iron sulphate introduced in the feed-water.

In the return-tubular boiler, samples of water taken from the blow-off of a 72-inch by 18-foot boiler, the blow-off located about 18 inches from the back head, and from a floating surface blow-off, gave the following analyses:

	Grains per U. S. Gallon.	
	Blow-off Water.	Water from Surface Blow-off.
Volatile and organic matter	3.60	3.30
Silica	0.85	0.75
Iron and alumina oxides	0.15	0.85
Calcium carbonate	3.00	3.54
Magnesium hydrate	0.17	0.25
Sodium sulphate	94.15	96.44
Sodium chloride	69.05	70.20
Sodium nitrate	0.31	0.39
Total solids	171.28	175.72
Suspended matter	0.15	192.25
Incrusting solids	4.17	5.39
Non-incrusting solids	163.51	167.03

In this case water taken from a floating skimming blow-off shows practically the same analysis as from the bottom blow-off, except that the amount of suspended matter shows about 192 grains per United States gallon, showing that a surface blow-off is more efficient in this type of boiler than the bottom blow-off, on account of the reduction of suspended impurities.

A watertube boiler of standard make (which I shall designate as "Type A"), with a mud-drum, was fed with a softened water of the following analysis:

SOFTENED WATER.

	Grains per U. S. Gallon.
Volatile and organic matter	0.85
Silica	0.25
Iron and alumina oxides	Trace
Calcium carbonate	1.25
Magnesium carbonate	0.88
Magnesium hydrate	0.44
Sodium carbonate	0.77
Sodium sulphate	12.21
Sodium chloride	6.76
Sodium nitrate	0.55
Total solids	23.96
Suspended matter	0.05
Incrusting solids	2.82
Non-incrusting solids	20.29

After being in operation for about 700 hours the blow-off showed water of the following analysis:

BLOW-OFF WATER.

	Grains per U. S. Gallon.
Volatile and organic matter	0.10
Silica	1.25
Iron and alumina oxides	Trace
Calcium carbonate	1.43
Magnesium hydrate	0.46
Sodium carbonate	9.06
Sodium sulphate	258.08
Sodium chloride	107.02
Sodium nitrate	5.10
Total solids	382.50
Suspended matter	17.80
Incrusting solids	3.14
Non-incrusting solids	379.26

On the other hand, water drawn from the gage column at the same time analyzed as follows:

WATER FROM GAGE COLUMN.

	Grains per U. S. Gallon.
Volatile and organic matter	0.15
Silica	2.45
Iron and alumina oxides	Trace
Calcium carbonate	0.71
Magnesium hydrate	0.58
Sodium carbonate	9.85
Sodium sulphate	438.07
Sodium chloride	175.50
Sodium nitrate	8.50
Total solids	635.81
Suspended matter	41.90
Incrusting solids	3.74
Non-incrusting solids	631.92

No sample was obtainable from the surface, as the boiler in question had no surface blow-off, but if the suspended matter shown in the analysis of water from the surface blow-off of the return-tubular boiler cited is used as a basis, the water at the surface would show the greatest concentration of both suspended matter and soluble impurities. This would be in the steam drum and not in the mud-drum.

The analyses of samples from the feed, bottom blow-off and water column in another type of watertube boiler ("Type B") also provided with a mud-drum but of a totally different construction, and where an entirely different set of conditions existed, are as follows:

	Grains per U. S. Gallon.		
	Feed Water.	From Blow-off.	From Water Column.
Volatile and organic matter	0.05	14.00	17.00
Silica	0.55	0.45	1.05
Iron and alumina oxides	Trace	Trace	Trace
Calcium carbonate	2.02	6.43	7.32
Calcium sulphate	0.65	2.80	3.80
Magnesium sulphate	0.29	4.36	6.17
Sodium sulphate	2.17	132.20	141.72
Sodium chloride	0.99	108.77	120.30
Sodium nitrate	0.31	6.12	6.13
Total solids	7.03	275.13	303.49
Suspended matter	0.05	5.75	16.45
Incrusting solids	3.51	14.04	18.34
Non-incrusting solids	3.47	247.09	68.15

Not such a marked difference exists between the two blow-off samples in this case as in the preceding example with boilers of "Type A," yet an appreciable difference exists both in the suspended matter and in the soluble impurities; showing a greater concentration in the water from the water column, also a larger amount of suspended matter than from the regular blow-off.

Any number of similar analyses might be cited to show the same condition of affairs, and in nearly every case the analysis of water taken from the gage column shows a larger amount of soluble impurities than does the water from the blow-off. The amount of suspended matter, except in a very few instances, shows higher from the water column than from the blow-off, and where samples could be obtained from the surface the suspended matter was still higher, and in the case of all watertube boilers the greatest concentration of both soluble and suspended impurities is found to be in the water in the steam drum at the waterline.

The location of the blow-off at the bottom of the boiler is on the assumption that the suspended matter would settle out. This would undoubtedly be true if the water were static, but the circulation of water in a boiler in operation must necessarily be very rapid, and very little, if any, settling can take place while the boiler is steaming, so that the suspended matter introduced in the raw water, together with that formed by those substances which are forced out of solution, is swept along with the water, some of which deposits as scale, the remainder eventually as sludge.

There seems to be a tendency for the suspended impurities to collect at the surface as a sort of scum. This scum may be more or less broken up by the steam leaving the water, but the upward current of the steam and water tends to carry the suspended matter to the surface, where much of it is held by the surface tension. All these forces tend to make the waterline the collecting place for suspended matter rather than the mud-drum.

Taking everything into consideration, the waterline is the more rational location for the blow-off for the removal of impurities than the so-called mud-drum or bottom of the boiler. A blow-off at the bottom of the boiler is absolutely essential, but the intelligent use of a blow-off at the surface of the water in addition to the bottom blow-off would result in improved operating conditions, by reducing the amount of suspended impurities as well as the concentration of the soluble substances, thereby reducing scale formation and increasing economy in fuel and boiler maintenance.

It is, of course, essential that the water fed into the boiler should be of the best possible quality obtainable; that is, free from suspended matter, as soft as possible and low in sodium salts. If natural water, practically free from lime and magnesia salts, cannot be obtained, nearly all natural supplies can be softened, purified and filtered at small cost, thereby preventing scale formation; but the blow-off is still necessary, as concentration will take place, and this must be reduced by blowing off, and that at the point of greatest concentration to remove the greatest quantity of impurity, soluble and insoluble, with a minimum quantity of blow-off water. However small the amount of incrusting and non-incrusting solids may be in any natural or purified water, concentration cannot be prevented, but a slight diluting effect can be brought about by blowing off and replacing with fresh feed-water.

Blowing off, then, is necessary to improve the conditions under which a boiler is to make steam, and therefore every boiler should be supplied with properly located blow-off valves and an intelligent engineer to use them.—*Power.*

PROCESS SPEEDS.

BY JOHN ROSS.

Attention has lately been directed in an unusual degree to the matter of speed in manufacturing. Many and able arguments have been advanced for and against what is known as "speeding up" as a means of reducing costs and increasing production. Time studies have shown how a lathe or planer or punch could be made to produce so much more work in a given time under certain prescribed conditions. These researches are valuable, not so much perhaps for the actual saving accomplished in specific cases as for the resulting critical attitude they have engendered among the manufacturing hosts. They have brought about to a large extent the present spirit of observation and investigation that is constantly on the watch for methods of improving and shortening processes.

While speed studies have undoubtedly accomplished much in themselves, they have too often been circumscribed in scope. Too much attention has been paid in many cases to individual links and not enough to the entire chain of processes entering into the making of a product, considered as a unit. If the finished work is of such a character that one, two or three processes only enter into its manufacture, the individual method can undoubtedly accomplish important results. But suppose the article of manufacture is a boiler, an engine or an automobile, it is patent that a study of the *relation* of different process speeds is of paramount importance. Where several thousand units must be made, shaped, fitted and assembled, as in the case of the automobile, the goal of the management should be a schedule of machines, routing and speed such that with every part of the plant operating at its highest efficiency, exactly enough parts of each kind will be finished in time to reach the assembling floor as soon as the other parts. That is, highly specialized effort in any department or process will avail little in the long run if the remaining departments or processes cannot keep pace with it.

This truth applies with especial force to the boiler shop. Here many different processes and numerous different parts have a share in the finished product. Considering one boiler as the unit, what process limits the speed of production? Every boiler maker can review in his own mind the course of manufacture in the shop he knows best and answer the question for his special case. For every shop has a different ratio of process speeds, due to the character of the product, the physical equipment, ability of the men and the methods of handling, routing, etc.

But let us suppose that each man has determined for his own case where the narrow point in the channel is, the point that backs up the water above and thins it out below. Is it not evident that here is the place to begin the study of process speeds? Is there any great use in speeding up a process which from its nature already takes but little time and consequently is in use perhaps half the time? Having found the slow process that is choking the production of the plant, ways must be devised for speeding up at this point. For the sake of illustration, assume that the boiler maker has concluded, from observation, that the flange presses are idle part of the time, that the punches are not always busy, but that there are always punched and rolled plates standing on the floor waiting to be riveted, and the bull riveters never get a moment's rest. He concludes that the bulls are the narrow neck in which the boiler flood is getting jammed. The riveters, let us say, are going at their maximum capacity, speeding up is impossible unless quality is sacrificed. Evidently the answer in this case is more riveters. But how many more?

At this point a little time study will come in very handy. It will take but a short time to figure out the maximum capacity of the riveters per day (in this case the shop's capacity also). In order to have some concrete facts to work with, suppose this proves to be eight. Then figure out, by timing one boiler through, the capacity of each principal process. Find out how many complete sets of castings the foundry can turn out, if there is a foundry. Note the speed of punches, drills, reamers, presses, rolls, etc., and then set these down in a table similar to the imaginary figures below. The outputs shown are merely chosen for convenience and to illustrate the method. It is understood, of course, that capacities represent the boiler shop as it *is*, not as it *might be*; that is, with its present machines and methods and number of men.

TABLE OF CAPACITIES.

Process.	Boilers Per Day.
1. Laying out	20
2. Rolling	36
3. Punching	60
4. Reaming	50
5. Shearing	60
6. Flanging	18
7. Smithing	18
8. Staying	25
9. Calking	30
10. Machine riveting	8
11. Hand riveting	16
12. Expanding	16
13. Testing	20
14. Handling (crane)	40
15. Foundry	35
16. Machining	10

Our boiler makers' researches having resulted in such a table, the next step is simple, and depends upon the company's ability to sell its boilers. Will the sales justify the shop in doubling its capacity? If so, the table shows that but two processes are below this figure in daily capacity, and two are exactly at this figure—sixteen per day. So in the case illustrated, doubling the machine riveters' capacity by doubling the number of machines and increasing the machine-shop capacity 60 percent by installing additional lathes, drills or planers, will increase the capacity of the entire shop 100 percent. Probably no actual shop contains such glaring inconsistencies in capacities as the case cited, but a study of this kind in any shop will show where the tight place is, and means for remedying the trouble are usually easy to apply. Furthermore, it takes but small differences in capacity to choke up a whole shop. Ten or 15 percent difference in capacity of two important processes is sometimes the reason for aggravating delays and higher costs.

Nothing of human origin is perfect, and no product of man's brain or hand is past improving. We are all apt to think that the things we are familiar with are all right because they do well enough. But just a little systematic investigation of the kind outlined will usually show where still more improvements may be introduced. Every process may be in itself correct, but the "balance" of true co-ordination is lacking. Once the proper relation of speeds is established real efficiency can be attained.

The Brick Arch and the Superheater.

The *Railway and Engineering Review* in its editorial columns has consistently favored the use of the firebrick arch for locomotives, both on account of the economy which it represents and as a means of preventing smoke; which, by the way, is only another way of saying the same thing for fuel economy, means more perfect combustion, and more perfect combustion invariably results in a diminution of the smoke. In its present state of perfection the brick arch has overcome practically all of its imperfections inherent in the early stages of its development. It no longer causes trouble with side sheets, which with the old-style heavy arch was a continual source of trouble on account of the repairs made necessary by the abrasion of the side sheets by the arch. The reduction in weight of the arch has also done away with many of the arch tube troubles which formerly existed, and the sectional feature has reduced materially the maintenance cost of the arch. These features, together with the results that have been obtained within the past few years by those who are using arches, substantiate the stand that we have taken in reference to the arch, and we have no hesitancy at this time in saying that as a factor in locomotive economy the brick arch cannot be overlooked.

Along with the brick arch the locomotive superheater is another factor in the fuel economy of the locomotive which has won its way to the front by its merits. Its remarkable savings in fuel shown in tests have been substantiated in actual service conditions, and by its aid some feats in locomotive operation are being accomplished which would have been thought impossible five years ago.

From the results of many tests that have been made to show the value of the brick arch and superheater it is conservative to say that on an average there is a saving of about 10 percent effected by the arch and about 25 percent by the superheater. At first thought this means a saving of the equivalent percentage of the fuel consumption of the road, and with this big item in view we are very apt to overlook the real significance of these savings of 10 and 25 percent. In order to bring out this point let us take a hypothetical example. Assume that we are burning, on a locomotive equipped with neither brick arch nor superheater, 6,000 pounds of coal per hour, and that this is the limit of the fireman's capacity. Assume, also, that with every 4 pounds of this coal we are developing 1 horsepower-hour. (The figure of 4 pounds of dry coal per horsepower-hour has been established by tests.) We are then developing 1,500 horsepower-hours. Now suppose that we equip this locomotive with a superheater, and find that we can save 25 percent of this fuel by so doing; we are then generating 1,500 horsepower-hours at the cost of 3 pounds of coal per horsepower-hour. In other words, we are burning 4,500 pounds of coal and getting the same results that we did previously with 6,000. But we found that 6,000 was the capacity of our fireman, so why not let him shovel 6,000 pounds and increase the hauling capacity of our engine 500 horsepower per hour, giving us 2,000 horsepower-hours, an increase of 33 1/3 percent, at the full capacity of the fireman instead of 1,500 horsepower? Suppose, now, that the engine is equipped with a brick arch, which, conservatively, is good for about 10 percent saving, we would develop 2,000 horsepower-hours with 5,400 pounds of coal, while if we still burned the 6,000 pounds of coal we will develop 2,222 horsepower-hours, or an increase over the superheater condition of 11.1 percent. Hence by the use of the superheater and the brick arch we have increased the capacity of the locomotive from 1,500 to 2,222 horsepower-hours, or 48 percent. The notable and valuable feature of this increase lies in the fact that it has in no way affected the capacity of the fireman, for he fires no more coal than he did on the engine without the superheater and brick arch.

As to what this means to the railroad. Many times it is necessary to double-head trains in order to get them over the road on schedule time. The economy of the superheater and brick arch then rests in the fact that it is possible to design locomotives which will within the capacity of the fireman take present trains, now being double-headed with saturated locomotives, over the road with one superheated engine. This, of course, is a saving in operating cost of one engine crew and a reduction in the necessary investment in power.

POINTERS FOR THE SELECTION OF BOILERS.*

The choice of a boiler will usually lie between the ordinary horizontal firetube and one of the many forms of watertube boilers. No particular rule can be followed in the selection of a boiler, as much will depend upon the maximum price to be paid, pressure to be carried, available space, etc. Generally speaking, when boilers of any of the well-known types are equally well designed and proportioned for the work to be done, and are operated with the same skill, and provided with the same quality of fuel, one type will give about the same economy as another. This leaves the owner free to choose a boiler best suited to his own taste and to any local requirements which may exist.

If the plant is of considerable size, carrying a high-pressure, and the boilers are located in or near a building containing a large number of operatives, the matter of safety should be given especial weight. Here the watertube boiler has the advantage, as the water is divided into small masses, which tends to prevent serious results in the case of rupture. Among other features of the watertube boiler may be mentioned a large amount of fire surface, causing a more rapid circulation of the water, with a decrease in the liability of both overheating and the accumulation of sediment and scale; or large draft area through the tubes, resulting in a slower movement of the gases and a greater absorption of heat; the losses from the accumulation of soot and ashes are less than in the case of firetube boilers, as they do not adhere so readily to the outside of the tubes as to the inside. All of these features tend to economy.

* From an article on the selection of equipment for the shop power plant, in *The Iron Age*.

Probably the greater majority of the machine shops throughout the country use the horizontal firetube boilers. They cost less, have a greater water capacity, which gives a less rapid fluctuation of the waterline and thus require less careful attention, and when properly designed and cared for and inspected at regular intervals are comparatively safe against explosion.

In selecting a tubular boiler the manufacturers' tables of dimensions for different capacities should be used with caution. Boilers of this type used for power purposes are usually rated on a basis of 1 horsepower for each 12 square feet of heating surface. This makes it a temptation on the part of the manufacturer to crowd as many tubes as possible into a shell of a given size to give it the maximum rating at the least cost. To get the best results there should be a good space above the tubes for the separation of the steam from the water to secure dryness, and there should also be ample room for the circulation of water between the shell and tubes, and also between the tubes themselves. In general, there should be a clear space between the tubes in both directions of 1 inch, with a 2-inch vertical space at the center, and at least 3 inches between the tubes and the shell at the sides.

Figs. 1 and 2 are each sections through a 100-horsepower boiler. They are of the same diameter (60 inches), but the first contains ninety-four 3-inch tubes, 12 feet long, while the second has seventy-two tubes of the same size, 15 feet long. The proportions of the second boiler are better, because there is a larger steam space and more room for the circulation of water between the tubes, and the greater length of the tubes will give better economy in the use of fuel, as more opportunity is allowed for the absorption of heat. The defects in the first boiler would become more pronounced should it be forced above its nominal rating.

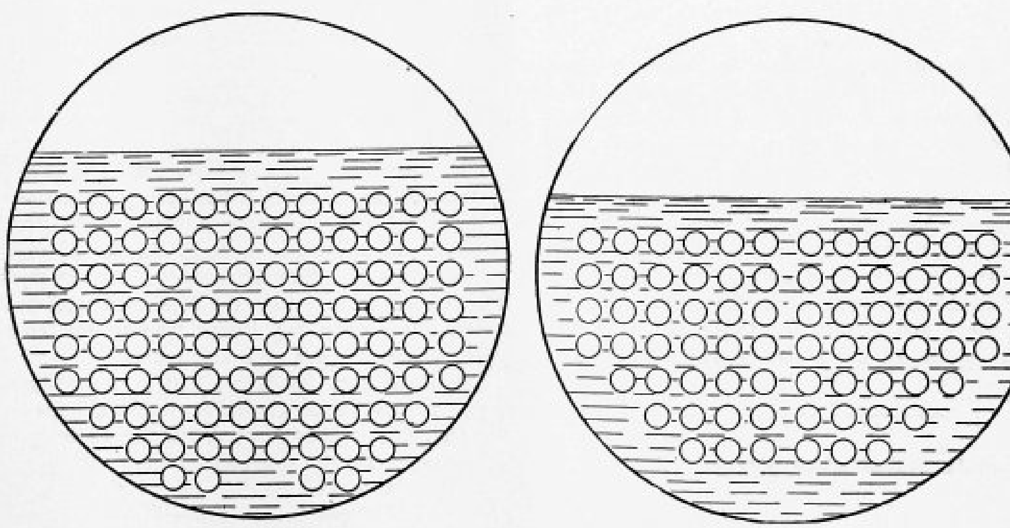


Fig. 1. Fig. 2.
SECTIONS THROUGH TWO 100-HORSEPOWER BOILERS.

The number and size of tubes for boilers of different diameters, as recommended by the Hartford Steam Boiler Inspection & Insurance Company, are given below, and will be found useful in checking up catalogue ratings:

Diameter of Shell.	Diameter of Tubes.	Number of Tubes.
36 inches	2½ inches	34
42 "	3 "	34
48 "	3 "	44
54 "	3 "	54
60 "	3 "	72
	3½ "	46
66 "	3 "	90
	3½ "	64
72 "	3 "	114
	3½ "	98

The type of bracing is important. Through bracing is of advantage from the standpoint of strength, but is objectionable in all but the largest sizes, as it makes the boilers more difficult to enter for inspection. A good plan is to compromise by using diagonal bracing in the smaller sizes, say from 36 inches to 48 inches, a combination of diagonal and through bracing for 54-inch and 60-inch boilers and all through bracing for 66-inch and 72-inch boilers. Figs. 3 and 4 show the usual arrangement of combination diagonal and through bracing. The pressed steel diagonal braces now in use are preferable to the older form of crowfoot braces with fork and pin, as they are free from welded points and therefore more reliable.

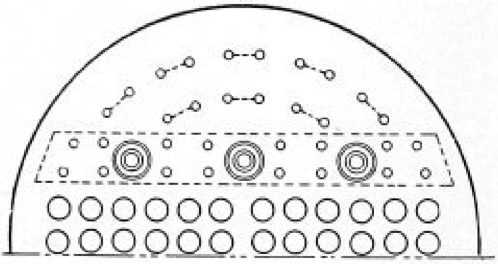


Fig. 3.

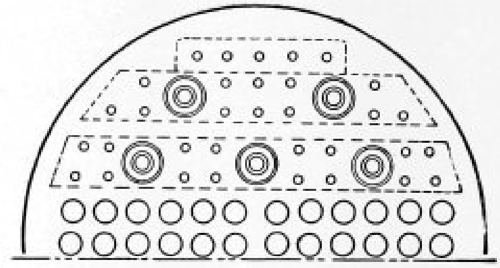


Fig. 4.

USUAL ARRANGEMENT OF COMBINATION, DIAGONAL AND THROUGH BRACING.

The longitudinal seams should be of the butt-joint type, with either double or triple riveting, according to the pressure carried. Lap joints will give sufficient strength when new, but are apt to become weakened by constant expansion and contraction. The thickness of shell will depend upon the diameter of the boiler and the pressure carried. For a working pressure of 100 pounds per square inch, with a factor of safety of 6, and double riveted butt-joints, shell plates of best quality of mild steel, 3/8 inch thick, may be used up to and including 54 inches diameter; 7/16-inch plates may used for 60 and 66-inch boilers, and 1/2 inch for 72 inches. If higher pressures are to be carried the plates should be thickened accordingly.

Tubular Boiler Construction.

NEW EUROPEAN DEVICE FOR FORMING FLANGES ON THE TUBES.

Consul Thomas H. Norton, of Chemnitz, furnishes the following information concerning a new device in the construction of tubular boilers, viz., the turning over of the flange on tubes when introduced in their proper positions:

In Chemnitz, a leading center of locomotive construction in Germany, much interest has been shown in the device of the French engineer, M. Gallon, now employed on the Western Railway of France. This ingenious piece of mechanism serves not only to bend over the flange on the ends of boiler tubes, but also to force the metallic packing rings of such tubes into place.

It consists essentially of a strong steel axis, upon which a massive collar can be screwed up and down by means of a lever arm, with ratchet attachment. Conical rollers are attached to the lower part of the collar, with an axial inclination of 45 degrees. The lower end of the steel bar is of a conical shape and threaded. A sectional toothed collar can be screwed up and down on this conical end, its diameter diminishing or increasing according to the direction of the movement.

If the end of a tube which has been inserted into its place in a boiler is to be turned over so as to form a close-fitting flange, the lower end of the apparatus is introduced into the tube. It is then turned until, by the action of the conical screw, the terminating collar is forced tightly against the walls of the tube immediately adjacent to the boiler shell. By working the lever and ratchet the upper collar is forced slowly downward, the conical rollers impinge upon the rim of the slightly projecting tube, and it is gradually pressed outward and downward until it forms a flange in tight contact with the encircling boiler plate.

EASE IN MAKING REPAIRS.

When the apparatus is employed for the fastening of packing bushes in the holes of a boiler, as so frequently occurs in case of repair, the conical screw at the lower end is replaced by a spherical cap. This rests against the inner flange of a bush, the descending rollers press the upper rim into the flange form, and a perfectly tight joint is assured by the use of sheet copper for packing. The surface of the rollers can be altered so as to produce a flange of any desired form.

The process of repairing leaky boilers is notably simplified by this device. Hitherto it has been the practice to introduce a steel bush provided with a thread, upon which a disk is screwed, and a joint is made by the use of copper washers, 2 millimeters (1 millimeter = 0.0394 inch) in thickness. Now it is possible to turn over the edge of a steel bush 2½ millimeters thick upon the copper washer and effect a tighter joint than by the use of a screw disk.

Experience thus far shows that by the application of this device not only is there a distinct technical improvement in the character of the joints secured, but also a pronounced economy is attained. By the old method each packing, as above described, cost $2.30. By the aid of the new appliance the expense is reduced to 60 cents.—*Daily Consular and Trade Reports.*

Steam Boiler Inpectors' Meeting.

The second semi-annual meeting and banquet of the American Institute of Steam Boiler Inspectors was held at the American House, Boston, Mass., on Tuesday, Oct. 24, and was largely attended. The educational committee secured the services of Mr. H. M. Feldman, representing Chandler & Floyd Company, who gave a very interesting talk on the manufacture of Pittsburg Pure Brand American Ingot Iron manufactured by the Allegheny Steel Company.

Mr. A. M. Loydd, representing the Central Iron & Steel Company, gave a very interesting as well as humorous talk. Mr. Frank S. Allen, chief inspector for the Hartford Steam Boiler Inspection & Insurance Company, was the next speaker, and his relation of his experiences in forty years at boiler inspecting was immensely enjoyed by all present. This organization is for educational and social purposes, and has had a rapid growth, having among its members boiler inspectors from the United States, Canada and Alaska. The secretary is Thomas G. Ranton, 112 Water street, Boston, Mass.

ANSWERS TO QUESTIONS IN THE NOVEMBER ISSUE.

Reinforcing for a Manhole.

EDITOR THE BOILER MAKER:

Concerning the question, "Reinforcing for a Manhole," as asked in your November, 1911, edition, the remarks hereinafter will answer said inquiry as well as touching upon other important subjects in connection with the same.

In Figs. 1 and 2 are shown the plan and side elevations, and to determine how to reinforce the manhole is but mere calculation. The size of the manhole in the inquiry is given as 11 inches by 15 inches, and thickness of plate as ½ inch; thus the letter *A*, Fig. 1, represents 11 inches and *B*, Fig. 2, represents ½ inch. The width *D*, Figs. 1 and 2, depends upon the thickness *C* of the liner and the diameter *E* of the rivet. See Fig. 2.

As a general proposition the thickness of the liner is as great as the thickness of the boiler shell to which the liner is attached, and thus with *B*, Fig. 2, ½ inch in thickness, the

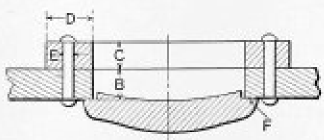
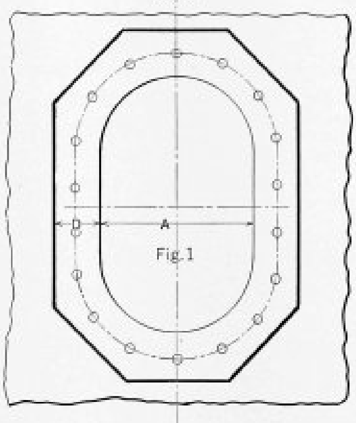


Fig. 2



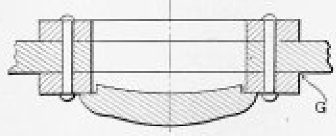


Fig. 3

thickness of the liner will be at least ½ inch. The basis for reinforcing a manhole is to supply a strength equal to the strength removed, and thus the area removed, figured on the longitudinal plan, is 11 × ½ = 5½ square inches. To reinforce the manhole the area of the liner must be at least 5½ square inches, and as the liner surrounds the manhole, one-half of the area of the liner must be located on each side.

Then 5½ ÷ ½ = 11 inches total width of liner, and 11 ÷ 2 = 5½ inches width of liner on each side, plus the diameter *E* of the rivet holes, and assuming the rivet holes to be 1 inch, then the width in this case would be 5½ + 1 = 6½ inches. The number of rivets to be used would not depend upon single-riveted and double-riveted, but whether the rivets were in single or double shear. For instance, in Fig. 2 the liner is shown on top of the shell, which is the proper way to apply the liner, and the liner so applied would generally have the rivets in single shear, and whether they should be placed single-riveted or double-riveted depends upon the number of rivets used.

Now in Fig. 3 the rivets are placed single-riveted, but due to an inside and an outside liner—very poor practice—the rivets are in double shear, yet spaced single-riveted. Rivets in double shear are rated in shearing strength as about 1.85 times the shearing strength, single shear; therefore it will be seen that if eighteen rivets are required to secure the liner, as shown in Fig. 2, not so many rivets will be required to secure the liner as shown in Fig. 3. The objection to Fig. 3 is largely that steam can secure an outlet at the joint *G*, while in Fig. 2 the packing *F* is between the boiler shell and the manhole plate, and the steam does not come in contact with the liner.

The number of rivets depends upon how they are placed, their size and their shearing strength. The first question to determine is the strength removed, and that requires that the tensile strength of the plate be known, which will be assumed in this case to be 60,000 pounds. Then the strength removed is 11 × ½ × 60,000 = 330,000 pounds. It has already been assumed that the rivet holes are 1 inch in diameter, and now it will be assumed that their shearing strength in single shear is 42,000 pounds per square inch, and hence the shearing strength of a 1-inch rivet will be 1 × .7854 × 42,000 = 32,986.8 pounds. Then the number of rivets required would be 330,000 ÷ 32,986.8 = 11 rivets. However, the number of rivets is usually more than eleven, which would mean the use of a rivet of less diameter than 1 inch, and, further, it is regular practice to make the shearing strength of the rivets attaching the liner to the boiler shell considerably in excess of the strength of the liner.

H. S. JEFFERY.
Washington, D. C.

EDITOR THE BOILER MAKER:

I note questions which appear on page 330 in the November issue of THE BOILER MAKER, some of which I will try to answer. First, with regard to the question concerning size of manhole ring, the question specifies but *one* ring. (Sometimes two rings are used.) Here is the rule when one ring is to be used: To find the width of a reinforcing ring multiply the length of opening in the shell in the direction of the length of the boiler by the thickness of the shell. Divide the product so found by twice the thickness of the reinforcing ring, and add the diameter of the rivet to the quotient if one row of rivets is to be used, and if the ring is to be double-riveted then add twice the diameter of the rivets.

When a single ring is to be used it should be from 1.25 to 1.5 times the thickness of the shell plates. Therefore we will assume for our question a ring ⅝ inch thickness, and further assume that 1-inch rivets are to be used to secure the ring to the boiler plate. Now, applying the rule before given, we have a statement like this:

$$\frac{11 \times \frac{1}{2}}{2 \times \frac{5}{8}} + 1 = 5.4$$

inches width of ring required for *single* rivets. For *double* rivets it becomes

$$\frac{11 \times \frac{1}{2}}{2 \times \frac{5}{8}} + 2 = 6.4$$

inches width of ring.

The number of rivets required, first, for *single* riveting will be: Multiply the net section of the ring by four times the tensile strength of the material in the ring, and divide this by the product of the shearing strength of the rivet and its area. In our example the net section of the ring is (5.4 — 1) × ⅝ = 2.75 square inches. Applying this to the rule just given we have this statement:

$$\frac{2.75 \times 4 \times 50{,}000}{38{,}000 \times .7854 \times 1^2} = 18 \text{ rivets required.}$$

I have assumed the plate value to be 50,000 pounds per square inch section, and the rivet value to be 38,000 pounds per square inch section.

If the ring is to be *double* riveted then the width, as before found, will be 6.4 inches, and $(6.4 - 2) \times \frac{5}{8} = 2.75$ square inches net section of the ring as before, and

$$\frac{2.75 \times 4 \times 50{,}000}{38{,}000 \times .7854 \times 1^2} = 18 \text{ rivets minimum required.}$$

CHARLES J. MASON.

EDITOR THE BOILER MAKER:

When one ring is used the thickness should not be less than one and one-quarter times the thickness of the shell plate; when two rings are used each ring should be at least equal in thickness to the shell plate.

To find the size of rivets, add 7/16 inch to the thickness of the shell for a trial diameter, in this case they would be 15/16-inch rivets useing one ring; for two rings add 5/16 inch to the shell thickness, which would give us 13/16-inch rivets. To find the necessary information needed to apply reinforcing rings use the following formulæ:

Let T^s = tensile strength of ring per square inch of section, say 50,000 pounds.
S = shearing strength of rivets per square inch of section, say 38,000 pounds.
a = net section of ring. One side of opening only.
l = length of opening in shell parallel to the length of the boiler.
n = number of rivets (minimum).
w = width of ring.
t = thickness of ring.
T = thickness of shell plate.
d = diameter of rivet hole.

Then $w = \frac{l\,T}{2\,t} + d$ when single riveted.

$w = \frac{l\,T}{2\,t} + 2\,d$ when double riveted.

$t = 1\frac{1}{4}\,T.$

$d = T + \frac{1}{2}$ when one ring is used.

$n = \frac{4\,a\,T^s}{S\,d^2 \times .7854}$ when one ring is used.

In this case the opening is 11 by 15 inches and ½ inch thickness of plate. We will let the 11 inches run parallel to the length of the boiler. In locomotive boilers we figure 50,000 pounds tensile strength when we are not sure of its test strength, and 38,000 pounds shearing strength of rivets. For single riveted ring:

$$w = \frac{11 \times \frac{1}{2}}{2 \times \frac{5}{8}} + 1 = 5.4 \text{ inches.}$$

$$a = (5.4 - 1) \times \tfrac{1}{2} = 2.2 \text{ square inches.}$$

$$n = \frac{4 \times 2.2 \times 50{,}000}{38{,}000 \times 1 \times .7854} = 14.75 \text{ nearly, or 15 rivets.}$$

For double riveted ring:

$$w = \frac{11 \times \frac{1}{2}}{2 \times \frac{5}{8}} + 2 \times 1 = 6.4 \text{ inches.}$$

$$a = (6.4 - 1) \times \tfrac{1}{2} = 2.7 \text{ square inches.}$$

$$n = \frac{4 \times 2.7 \times 50{,}000}{38{,}000 \times 1 \times .7854} = 18.1 \text{ nearly, or 19 rivets.}$$

In case the ring is placed on the inside, this pitch may be too great to calk. If such is the case put in more rivets. As these rules give the minimum number of rivets they also give the point where the rivets and the reinforcing ring are equal in strength, and where the ring will stand the extra strain due to the cutting away of material for the opening.

CLARENCE REYNOLDS.

Shearing Strength of Rivets.

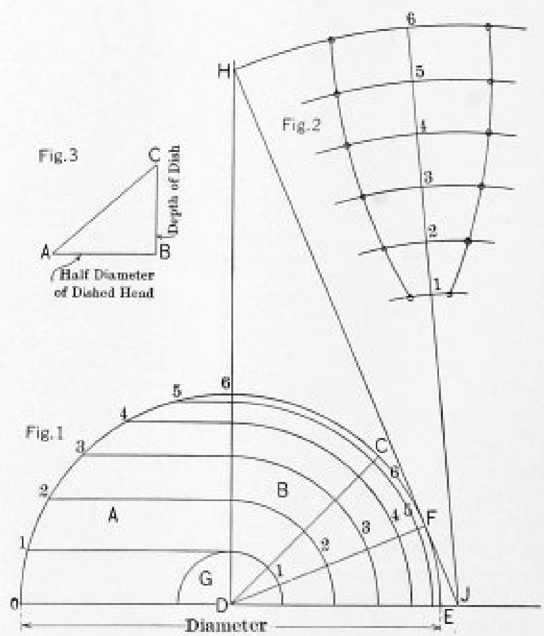
In answer to the second question in the list, relating to the shearing strength of rivets and how the values 38,000, 40,000 and 42,000 were obtained, I would say that the material of which rivets are made is subjected to an actual shearing or cutting off in a testing machine for that very purpose, and the numerical values quoted represent the number of pounds of force actually required to cut off the samples, respectively, on the basis of 1 square inch cross-sectional area. Some material will shear at 38,000 pounds, while others will require as high as 44,000 pounds to cut off a bar equivalent to 1 square inch cross-sectional area. It depends upon the nature of the material as to just what it will shear at, but those values are fairly representative and may be safely used. When in doubt use 38,000 pounds for safety.

CHARLES J. MASON.

Layout for Hemisphere Head for Tank.

EDITOR THE BOILER MAKER:

In the November issue of THE BOILER MAKER inquiry is made for the "best" rule for laying out this piece of work. I would say that much depends upon the manner in which the different sections of the head are worked up. Where the sections are heated and pressed to shape in dies, a pattern can



be struck out for the sections with a good degree of accuracy. Where the sections are worked up by hand it would be a difficult matter to bring out each section alike. Another point to be considered is the number of sections forming the head. The greater number of sections you have the better uniformity the finished head will present.

The writer has chosen a circular head for this problem; the same method can be applied where the height of head is the same as the diameter. Strike up diameter of head as at *E* and *O*; erect center line, dividing into two parts *A*, *B*. Part *A* can be assumed as elevation of head. Divide the arc in part *A* into equal parts, in this case six, and number as shown. Strike lines from these points to center line, as shown. Now, with dividers, set to where these lines intersect center line, and at point *D* strike arcs to line *O, E*. Part *B* can now be taken as a plan view of head. As the head is made up of eight sections, divide *B* into two parts. Bisect the angle *C, D, E* by the line *F, D*. *C, D, E* will give us the section from which to develop pattern. Set square to line *F D* at point *F*, and strike line to base line as shown. Extend this line upward to intersect center line at *H*. Now erect any line from *J*, as shown; then with trams set to points *J* and *H* strike an arc across line *J*. Where arc intersects line step off the distances 6-5-4-3-2-1 from part *A* along line *J*. Now from point *J*, with trams set to the different points, strike arcs as shown. Going back to section *C, D, E*, measure the length of each arc and transfer half of distance on each side of line *J* at their respective numbers. A line traced through these points will give the pattern, lap to be allowed.

The length of the different arcs can be verified by taking the different radii in part *B*, and figuring the circumference of the circle of which they form part and dividing by eight, this should give you the same distance as found on the arcs in section *C, D, E*.

Care should be taken to strike up neutral diameter of head. Quadrant *G* represents dished plate at top of tank. The allowance for dished heads can be obtained easily without going into figures. Erect right-angle *A, B, C*, as in Fig. 3, upon *A, B*. set off half diameter of head desired; on line *B* and *C* set off depth of head required; at center of head strike a line intersecting points *A* and *C*. The length of this line will give you the radius required for marking off the circular plate. This rule has been figured to allow for shrinkage in shaping plates to shape. J. SMITH.

Lorain, Ohio.

Layout of Dished Plates on a Round-Top Tank.

EDITOR THE BOILER MAKER:

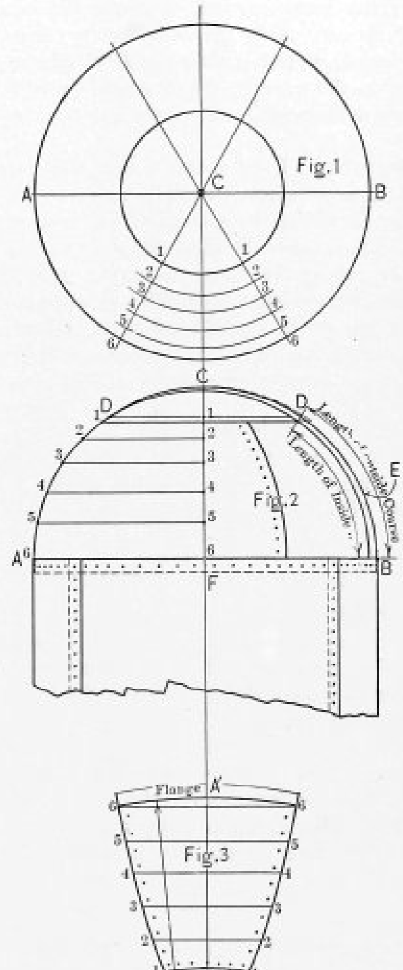
In answer to the question published in the November issue, "What is the rule for allowing for shrinkage in dished plates on a round-top tank, and what is the rule for laying out the plates for such a tank?" I submit herewith an article showing the layout, which I know to be absolutely correct, having had four such tanks to build recently. We punched all the holes and sheared the plates before bending except at the bottom of the plate, which had to be flanged after being assembled, and then the whole top was put in the top course of the tank and these holes were marked off.

The dimensions for the roof plate or dished head are found in the following way: Divide one quarter of the circumference of the head into three parts, as shown in the elevation, Fig. 2, at *C, D, E, B*, and take the top points *D D* as the diameter of the dished head, which will be an outside course. When laying out the plate the radius equal to the length of *C D* must be used, which will give the correct diameter of the plate after it is dished. I have not drawn the sketch to scale, nor divided it into eight parts, as the inquirer requested, but for convenience I divided it into six parts, since the number of sections does not affect the laying out.

First lay down the neutral diameter of the top course, as *A B*, Fig. 2. Bisect it at *C* and erect the perpendicular *C A'* of indefinite length. Mark off inside *A B* the thickness of the material for the top courses, using the neutral diameter all through. Then with *F* as a center set the trams to the points just found, and strike the semi-circle *A C B*, Fig. 2. With the same radius and at a convenient distance strike another semi-circle as *A C B*, Fig. 1, for the plan view. It is not necessary to show the whole plan, as half will do just as well. After this has been drawn divide it into as many sections as necessary, drawing lines from these points to *C*, as *C*-6-6, Fig. 1, will be the portion to be developed.

Having found points *D D*, divide the arc, *A D*, Fig. 2, into any number of equal parts; in this case there are five. Through the points of division draw the lines 1-1, 2-2, etc., parallel to *A B*. On the plan, Fig. 1, from *C* as a center, with the radius 1-1 taken from Fig. 2, draw the arcs 1-1, 2-2, etc.

We are now ready to lay out the templet. Draw the line *A'*-1, Fig. 3, making it equal in length to *A D*, Fig. 2, and on



LAYOUT OF DISHED HEADS.

it set off the same number of equal spaces. At the division points draw perpendiculars to *A'*-1, and number them in the same manner as in Fig. 2. Measure the length of the arc 1-1 in Fig. 1, and set off half of it on each side of *A*-1 on line 1-1, etc., and so one with each arc, including 6-6. A line traced through the points thus found will give the curve for the rivet lines, to which must be added the amount for the lap. To draw the curve at 6-6, take one and one-half times the diameter as the radius, and from 6-6 as centers describe arcs cutting *A'*-1 at *G*. Then from *G* as a center, with the same radius, draw the arc 6 *A'* 6, to which must be added the flange. To draw the curve at 1-1, take one-quarter of the circumference as a radius, and from 1-1 as centers describe arcs cutting *A'*-1 at *H;* then with *H* as a center, and with the same radius, describe the arc 1-1-1, which is the edge of the plate on the sketch.

We had our plates made of inside and outside courses. The outside plates being scarfed, of course the length will be different, which can easily be obtained by drawing down another line for the inside curve as at *D B*, Fig. 2, in making the allowance on the templet, which would be laid out in exactly the same manner and with the same lines as the large course.

I would like to state I tested this layout with various other methods and found this one the most correct. For instance, the method of obtaining the curve on the side of the plates by one and one-half times the diameter gave ¾ inch too much camber, and by getting the curve at 1-1, Fig. 3, by the one and one-half radius method gave 3/16 inch too much camber. This method was published in THE BOILER MAKER March, 1908.

Toronto, Can. S. HARRIMAN.

Converter Top.

EDITOR'S NOTE:—Solutions of the question regarding the layout of a converter top will be found in the August issue of THE BOILER MAKER.

Slope of Locomotive Fire-Box.

EDITOR THE BOILER MAKER:

The back end of a locomotive fire-box is usually 2 to 4 inches lower than the front end of the back flue sheet, so that the crown sheet will slope donwards from the front end of the fire-box toward the back end. This is done to lessen the danger of the back end of the crown sheet becoming uncovered of water in running down a steep grade. There is not so much danger of the front end of the crown sheet becoming uncovered either in going up or down a grade, for the reason that is nearer the center of the length of the boiler.

WILLIAM BARNARD.

Length of Base Line of Triangle.

EDITOR THE BOILER MAKER:

I am not worth much on figures, and I do not see why "Subscriber," on page 330 of November BOILER MAKER, wants to would set a pair of dividers just a little scant of this last measurement, and step around the 24-inch circle, adjusting the dividers until I got exactly ten divisions. You see the curved part of the circle is, of course, greater than a straight line between the ten points of division.

I would then take a boiler plate, or a large table would answer, if it was good and flat, and with one leg of my dividers on the lower left-hand corner *A* I would strike a quarter of a circle A^1 A^2; that is, from the left-hand edge to the lower edge of the plate. Where the circle strikes the lower edge of the plate I would put one leg of my compass, that is one-tenth of a circle, and strike a circle *K* K^1, which would cut the 24-inch circle, and where the two lines cross *O* I would make a prick punch mark. I would take a straight edge, lay it up against this mark, and to the lower left-hand corner of the plate, and draw a line 75 inches to *M*. I would set my trams 75 inches, and from the end of the 75-inch line *M* I would strike another arc *C C*, which would cut the lower edge of the plate, and from this point I would with the straight edge draw another line from the point *M* to the edge of the plate at *C*, and there I would measure from the lower left-hand corner of the plate to where my 75-inch circle cut it, and I would have the distance, or length, which "Subscriber" wants, and in this case it would be 121½ inches.

What's the matter with doing the work this way? Of course, this could be worked out by figures, but for a man who is just a "doer" in a shop my way is O. K. "DOER."

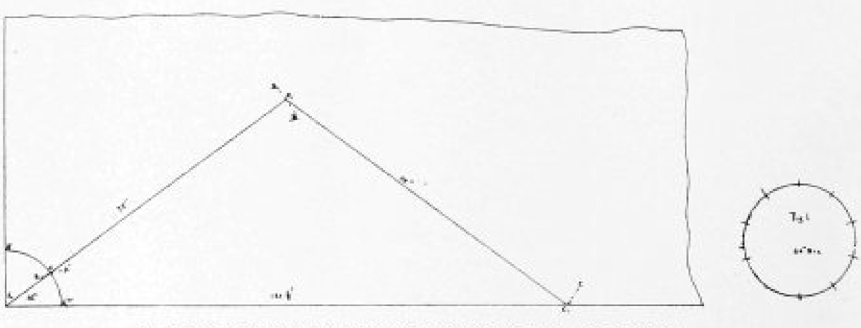
Scranton, Pa.

EDITOR THE BOILER MAKER:

To solve the triangle problem asked for in the November issue of this journal a knowledge of trigonometry is essential. From trigonometry we learn that when three parts of any triangle are known, and one of these parts is a side, the remaining parts can be found. In this case two sides and an angle are given.

We will mark off a sketch of the problem as shown, and drop a dotted line (*b*) from *B* perpendicular to and intersecting the base line *A*-*C* at *D*. This will divide the triangle into two right triangles. The parts of these right triangles can be computed and then the required part of the triangle *A, B, C* found. In any right triangle there can be but one right angle, and the sum of all the angles in the triangle equals two right angles, or 180 degrees.

The angle $A = 36$ degrees, and the angle on either side of the dotted line (*b*) at *D* equals 90 degrees. The sum of these two angles is $90 + 36 = 126$, and as all the angles in the triangle are equal to 180, then the angle on each side of the



GRAPHICAL METHOD OF FINDING LENGTH OF BASE OF TRIANGLE.

use them on his work. This is my way to get the length of the base line:

I would strike out on a sheet a 24-inch circle, Fig. 1. A circle has 360 degrees, so "Subscriber's" angle is one-tenth of the circumference of this circle, and the circumference is 75.398 inches. Divide this by ten and you get 7.54 inches. I

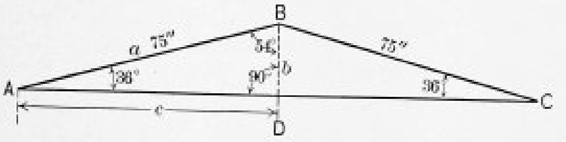
dotted line (*b*) at *B* must be $180 - 126 = 54$ degrees.

We can get at the same result in another way: Subtract the sum of angle A + angle C from 180, and the remainder is angle *B*.

If angle *B* is divided by 2 we have as before 54 degrees on each side of the dotted line (*b*).

$$A = 36 \qquad 180 \qquad \frac{108}{2} = 54.$$
$$C = 36 \qquad \underline{\;72\;}$$
$$\overline{\;72\;} \qquad 108$$

The line (*a*) in the sketch is called the hypotenuse, the dotted line (*b*) is the side opposite; that is, opposite to the angle *A*, and the line (*c*) is the side adjacent to the angle *A*. $\frac{c}{a}$ is the cosine of the angle *A*, but as we do not know the length of the side (*c*) we must consult a table of natural



DIMENSIONS OF TRIANGLE.

trignometric functions to find the cosine, which is .80902; then to find the length of the side (*c*) multiply the side (*a*) by the cosine of the angle *A*.

$$\cos A = .80902$$
$$\text{side } a = 75$$
$$60.67650 = \text{side } (c).$$

As (*c*) is only half of the base line *A-C* multiply 60.6765 by 2 and that equals 121.353 inches.

Had the height of the triangle (which is the dotted line *b*) been known the problem could have been solved by arithmetic, as

$$c = \sqrt{a^2 - b^2}.$$
$$b = a \times \text{sine } A.$$
$$b = 75 \times .58779 = 44.08425.$$
$$a^2 = (75)^2 = 5625.000$$
$$b^2 = (44.084)^2 = 1943.421$$
$$3681.579$$
$$\sqrt{3681.579} = 60.676$$
$$2$$
$$121.352 \; A\text{-}C.$$

Princeton, Ind. WERNER G. VOGEL.

Dimensions of Triangle.

EDITOR THE BOILER MAKER:

The length of the long side in the triangle submitted by "Subscriber" in the November issue of THE BOILER MAKER can be found the shortest possible way as follows:

$$.809 \times 75 \times 2 = 121.35 \text{ inches.}$$

As for the reasoning involved in this solution, it may be said that in this triangle, having two sides equal, the two angles would be equal also. The third angle will equal 180 — 2 × 36 = 108. The two angles being equal, it follows that the vertical line *CD*, Fig. 1, bisects the base, or *AD* = *DB*. The cosine of 36 degrees = .809, and in any right-angled triangle the base equals the hypotenuse times the cosine of the angle at the base. Hence *AD* = *AC* × cos 36 degrees.

Problems relating to triangles can be solved with wonderful simplicity by the use of the tables of sines, cosines and tangents. As some of the readers may not understand this useful system the following explanation, written in simple language, is given for their benefit:

SINES, COSINES AND TANGENTS.

The names *sines, cosines* and *tangents* are those which have been given to the relations between the sides of a right-angled triangle. Thus in Fig. 2, *ABC* is a three-sided figure called a triangle, with side *BC* drawn square to the side *AC*, forming at *C* an angle of 90 degrees, also called a *right angle*, hence the name *right-angled triangle*.

An angle is the opening between two lines, and a triangle has three angles; these angles may be called angle *A*, angle *B* and angle *C*. The size of an angle is given in *degrees* and

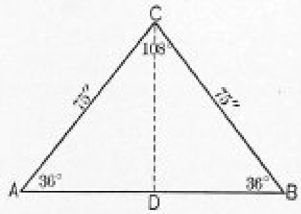


FIG. 1.

fractions thereof, called *minutes* and *seconds*. The method of writing the value of an angle is as follows: 27° 30′ 25″, which is expressed in words as 27 degrees 30 minutes and 25 seconds. Sixty seconds make one minute and sixty minutes make one degree.

The three sides of a triangle may be spoken of as side *AC*, side *BC* and side *AB*. The longest, or sloping side *AB*, is sometimes called the *hypotenuse*, the side *AC* is called the *base*, and the side *BC* the height, or *altitude*.

If the side or altitude *BC* opposite the angle *A* be divided by the slope line, or hypotenuse *AB*, the quotient will be the *sine* of angle *A*. Likewise, if the side or base *AC* next to angle *A* be divided by the hypotenuse *AB*, the quotient will be the *cosine* of angle *A*. Also, if the altitude *BC* be divided by the base *AC*, the quotient will be the *tangent* of angle *A*. The values of the sines, cosines and tangents of angles for each degree and minute are given in tables called *tables of natural*

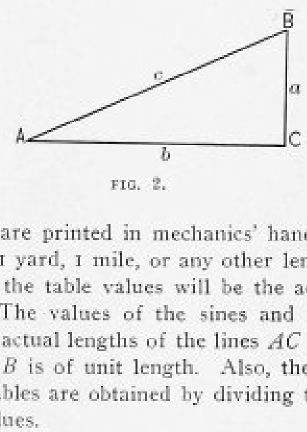


FIG. 2.

functions, which are printed in mechanics' handbooks. Thus, if *AB* be 1 foot, 1 yard, 1 mile, or any other length taken as a unit of measure, the table values will be the actual values in the same unit. The values of the sines and cosines in the tables will be the actual lengths of the lines *AC* and *BC* where the hypotenuse *AB* is of unit length. Also, the values of the tangents in the tables are obtained by dividing the sine values by the cosine values.

The tables are used when working out problems to find the angles or the lengths of the sides of a triangle.

Example.—In the triangle, Fig. 2, suppose the length of *AC* be 8 feet and of *BC* 6 feet, what is the size of angle *A*?

Solution—

$$\text{Tangent of } A = \frac{BC}{AC} = \frac{6}{8} = \frac{3}{4} = .75000.$$

We add three ciphers so as to have five places in the decimal. Looking in the table we find that a value of .75000 corresponds nearest to the tangent of 36° 52′, hence angle *A* = 36° 52′ nearly. In the tables the angles are written at the top and the bottom of the columns, and the minutes are given in the columns at the edges of the pages. The column of minutes at the left-hand edge of the page reads down and belongs to the angles at the top of the page; the right-hand column reads up, and belongs to the angles at the bottom of the page.

Example.—In the triangle, Fig. 2, suppose the angle A is 26° 35′ and the length of the hypotenuse AB is 12 feet. What is the length of the altitude CB?

Solution.—Looking in the tables we find that the sine of 26° 35′ is .44750. Hence we have sine $A = \frac{CB}{AB} = \frac{CB}{12} =$ .44750. Therefore, $CB = 12 \times .44750 = 5.37000$.

Example.—Suppose in Fig. 2 that the angle A is 37° 25′, and the side AB is 15 feet. What is the length of AC?

Solution.—Looking in the table we find that the cosine of 37° 25′ is .60761. Hence we have cosine $A = \frac{AC}{AB} = \frac{AC}{15} = .60761$. Therefore, $AC = 15 \times .60761 = 9.11415$.

The table of tangents also gives the values of the *co-tangents,* which are found by dividing one by the tangent values. In order to find the lengths of the sides from the angle B in Fig. 1, proceed the same as when using angle A. Thus the sine of $B = \frac{AC}{AB}$, cosine $B = \frac{BC}{AB}$, and tangent $B = \frac{AC}{CB}$.

F. WEBSTER.

Size of Stack.

EDITOR THE BOILER MAKER:

In answer to the inquiry of J. J. M. in the November issue regarding the size and height of a stack for a stationary boiler, I would say that in chimney design two things must be considered, viz.: draft and capacity to carry off the waste gases. The draft depends upon the difference in weights of the column of hot gas in the chimney and the air column outside of it. Hence the calculation for height must be made to get the draft. The size and number of boilers determine the volume of waste gas to be removed, and the calculation of the chimney area is based on this volume. Besides these two fundamental considerations there are other features that enter into the problem and sometimes make it very complicated. Thus the kind of fuel, the rate of combustion per square foot of grate area, the height of surrounding buildings and the size of the plant have something to do with determining the chimney height.

To get the height of stack for any given draft use this formula:

$$H = \frac{P}{\frac{7.6}{T} - \frac{7.9}{t}}$$

In this formula P is the draft pressure in inches of water, t is the absolute temperature of the chimney gases, and T that of the air. The absolute temperature is used because the pressures and volumes of gases are reckoned on this basis. The absolute temperature is found by adding 460 to any reading on the Fahrenheit thermometer.

The draft is usually measured by the suction effect on a column of water. Thus a draft of 1½ inches means that the suction will lift a water column 1½ inches.

Example.—Required, the height of a chimney to give a draft of 1½ inches of water, the flue gases being 540 degrees and the air 40 degrees.

Solution:

$$H = \frac{1.5}{\frac{7.6}{460+40} - \frac{7.9}{460+540}} = \frac{1.5}{\frac{7.6}{500} - \frac{7.9}{1{,}000}}$$

$$= \frac{1.5}{.0073} = 205 \text{ feet.}$$

Having given the horsepower of the boilers and the height for the required draft, the effective area of the stack may be calculated by this formula:

$$A = \frac{H.P.}{3\tfrac{1}{3}\sqrt{H}}.$$

Example.—What should be the area of a 100-foot chimney for 500 horsepower of boilers?

Solution—

$$A = \frac{500}{3\tfrac{1}{3}\sqrt{100}} = \frac{500}{3\tfrac{1}{3} \times 10} = \frac{1{,}500}{100} = 15 \text{ square feet.}$$

The actual area should be greater than the effective area, so as to allow for losses. Adding about a fifth is necessary, hence $15 + \frac{15}{5} = 18$ square feet, and for a round stack $D = 13.54\sqrt{18} + 4$, or $D = 61$ inches.

Tables have been prepared giving the proportions of stacks for different horsepowers of boilers operating under various conditions. These tables, which will be found in mechanics' handbooks, with the formulas for chimney calculations, save making laborious estimates.

F. W. BRADY.

EDITOR THE BOILER MAKER:

It may be well to consider the up-take first. The area should be about one-eighth to one-seventh of the grate area. Suppose this up-take can only be 12 inches wide, due to the length of the smoke-box, and is to have an area of 432 square inches, what is the length, provided it has a radius of 6 inches at each end?

Let $a = 12^2 \times .7854$.
$b = 432$, or area of up-take.
$c = 12$ inches width of up-take.

Then $\frac{b - a}{c} + c =$ length.

$$12^2 \times .7854 = 113.098.$$

```
        432
        113.098
    12)318.902(26.575
        24         12.
        --       ------
        78       38.575
        72
        --
         69
         60
         --
          90
          84
          --
           62
           60
           --
            2
```

Then the up-take should be 12 inches by 38.575, and change from this oblong section to a circular section of the same area, which would be 23½ inches diameter nearly.

The rules here given are not exact, but will give fairly close results, as it all depends on the temperature of the gases inside and the temperature of the air outside and also the surrounding objects. The stack should be well above all such objects, but in case you wish to increase the capacity, and there were no such tall objects near, it would be better to increase the diameter than to increase the height, as the capacity increases with the square of the diameter and only as the square root of the height. The area of the stack should be the area of the up-take.

Let a = grate area in square feet.
x = height of stack in feet.
A = area of stack in square inches.
b = constant 120.

$$\text{Then } \frac{a\,b}{\sqrt{x}} = A.$$

To find the value of x proceed as follows:

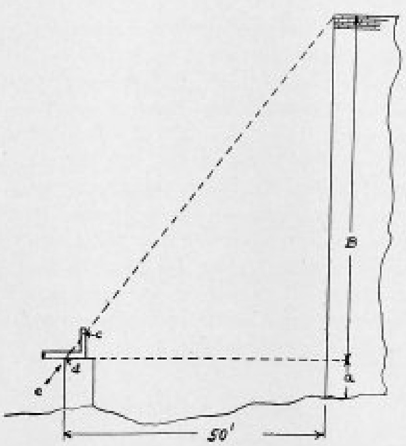
$$\frac{a\,b}{\sqrt{x}} = A; \text{ get rid of the fraction.}$$

$$a\,b = A\,\sqrt{x} \text{ get rid of the } \sqrt{\ } \text{ sign.}$$

$$a^2\,b^2 = A^2\,x.$$

$$x = \frac{a^2\,b^2}{A^2} = \text{height of stack.}$$

In other words, the square of 120 times the square of the grate area in square feet divided by the square of the cross-sectional area of the stack in square inches equals the height,



and one-eighth to one-seventh of the grate area equals the area of the stack.

A great many people take one and one-quarter times the flue area for the area of the stack. If you have the area of the stack and want the height in proportion, then use the equation $x = \frac{a^2\,b^2}{A^2}$; if you have the height and want the area in proportion use the equation $\frac{a\,b}{\sqrt{x}} = A$.

I would suggest that you get the height of the surrounding objects and let the stack be well above the highest. It is not necessary to climb any of these objects to get the height, because it does not have to be so exact. This can be done by the use of a steel square and a level as shown. Get some kind of a box or stool, anything to raise the square up so you can sight the top of the object, as shown at "*e*." The square should be set with the blade at the 12-inch mark at "*d*," or, in other words, at the edge of the box, which is placed at any number of feet from the object, say 50 feet; then level the square and sight in the direction of the arrow "*e*," some point at the top of the object; then run your finger up the tongue of the square until it is in line with the point sighted at the top of the object. We will suppose this distance on the tongue is 15¼ inches, then along the bottom edge of the square to the object and let somebody mark it. The distance from that point to the top, or the distance B, would be $50 \times 15\frac{1}{4} = 762\frac{1}{2}$ inches, then add the distance "*a*," and this will be the height nearly.

CLARENCE REYNOLDS.

PROPER AREA FOR BOILER BREECHINGS.*

BY J. E. TERMAN.

Considerable variation in the amount of area provided in boiler breechings and connections for the same capacity is often found, and such variations are not only noted between breechings designed by different manufacturers, but also between those made by a single firm. This is partly due to the variable conditions met with in each installation, but it is more often due to the lack of ability on the part of the manufacturer to design such connections uniformly, the areas used in many cases being arrived at along lines that practically amount to guesswork.

The boiler manufacturer frequently bases the area of the uptake connection to his boiler on the cross-sectional area of the tubes, if it is a tubular boiler, and the maker of the breeching bases his flue area on that of the uptakes or the tubes. It is readily seen by a moment's reflection that the cross-sectional area of the tubes does not vary directly with the capacity of the boiler, and therefore with the amount of gas to be handled, for the capacity of a horizontal or vertical tubular boiler varies almost directly with the length of the tubes for any fixed diameter of boiler; therefore, with varying lengths of boiler there could be a number of different capacities with one area for the cross-section of the tubes. It is thus seen that the cross-sectional area of the tubes should not be used in arriving at the proper area for the breeching, and the only correct way is to base the area of such connections on the volume and velocity of the gases to be handled, or, what is the same thing, the amount of coal to be burned, making, of course, due allowance for unusual length of connections or for bends in the connections, where surrounding conditions make frequent turns necessary. Prof. William Kent's table for chimney sizes, which is probably the most widely used for design of boiler chimneys, is based on a formula in which the effective area of the chimney varies directly as the capacity for any fixed height, and he recommends that the area through the flues and gas passages be 20 percent in excess of the area of the chimney, as given by his table.

If the flue designer knows the capacity of the chimney to which the flue is to be connected, he can base the size of the flue required on this. However, the writer's experience would indicate that the 20 percent over the chimney area recommended by Prof. Kent for flues is somewhat in excess of the average met with in plants which can be said to represent good practice, and 10 percent would probably represent conditions as they are actually found in good practice.

As stated above, if the chimney size and capacity were known the flue areas could be designed accordingly, but it very frequently happens that these data are not available, and in many cases where the chimney dimensions are known they would not be correct for designing the breeching, on account of not being correct for the boiler capacity served; and in

* From *Power*.

cases where the chimney area was deficient it would be making a bad matter worse to use this area in designing the breeching, for it would result in a contracted breeching attached to a chimney of insufficient capacity.

In the accompanying table the flue or breeching area is given as 10 percent in excess of the chimney area obtained by Prof. Kent's formula, assuming that a boiler capacity of 25 horsepower would be supplied with a stack 50 feet high, 300 boiler horsepower with a stack 100 feet high and 5,000 boiler horsepower with a stack 250 feet high, and that the height of stack for any intermediate capacity between these arbitrary points would vary the same as the capacity. Thus 2,650 boiler horsepower, which would be the capacity midway between 300 horsepower and 5,000 horsepower, would be assumed to be supplied with a stack 175 feet high, which height is midway between 100 and 250 feet. The areas for flues or breeching given in this table may be safely used for all ordinary conditions.

Boiler H. P.	Breeching Area, Square Feet.	Boiler H. P.	Breeching Area, Square Feet.
25	1.9	1600	48.6
50	3.3	1800	53.2
100	6.0	2000	57.7
150	7.3	2200	61.9
200	8.8	2400	66.1
250	10.5	2600	70.1
300	11.9	2800	74.0
400	15.2	3000	78.9
500	18.5	3250	82.5
600	21.7	3500	86.8
700	24.7	3750	91.0
800	27.6	4000	95.4
900	30.5	4250	99.5
1000	33.2	4500	107.6
1200	38.7	4750	111.3
1400	43.7	5000	115.1

MAKING REPAIRS UNDER PRESSURE.

Never do any calking nor make any repairs upon a boiler or a pipe or fitting that is under pressure. Consider, for example, the accident that occurred some months ago at the Merrimac Woolen Mills, Bracut, Mass. According to the information that we have at hand, "Pierre Pelletier was engaged in calking a joint when the accident occurred. It was in the boiler room in the rear of the big mill, and he was 16 or 18 feet from the floor. He used a hammer in the course of his work, and while hammering a pipe that carried somewhere in the neighborhood of 100 pounds of steam, it blew out at the joint that he was calking and hurled him with terrific force against a stone wall. His head struck the wall and death was instantaneous. Even though he had not been killed by the fall he would have died from his scalds." The unfortunate man is survived by a wife and seven children. The fact of leakage shows that something is loose or corroded or wrong in some way, and it is the height of folly, while the steam pressure is on, to pound on the weakened place with a hammer.

In another case two men were engaged in connecting a 6-inch steam pipe to an engine. The men were working about the pipe while it was under pressure, and it suddenly gave way, releasing the steam from the boilers upon them. One of the men was fatally injured, and the other was injured so badly that it was thought to be doubtful whether he could live. In another case of this kind three men were fatally scalded. Our informant says that "it was another case of attempting to make repairs to the pipe while it was under pressure, and was a shining example of things as they ought not to be." "It seems too bad," he continues, "that such accidents can occur in these enlightened times, but in spite of all warning engineers seem to make it a common practice to attempt to tighten joints under pressure, the all too frequent result being that a hurry call is sent for the undertaker."

In a more recent example a man was killed by a steam pipe failure, and his employers were held to be responsible for his death. Naturally they were reticent, under the circumstances, about giving out particulars; but as nearly as we could learn the accident was due to the use of some kind of a patent clamp, in an effort to stop a leak at a joint. The joint itself was said to be a bad one, only a few threads on the pipe having engaged in the fitting. It had been leaking considerably, and we understand that the engineer was endeavoring to tighten the bolts on the clamp when the explosion occurred.

In January of the present year an accident, apparently due to manipulating a fitting while under pressure, occurred in Brooklyn, N. Y. In this case "something went wrong with one of the pipes connected with a boiler, and the foreman with three helpers went down into the basement to repair the damage. He found that there was a leak in the pipe which ran along the floor overhead, and getting a ladder he climbed up to make a closer examination. An explosion followed shortly afterward. The sound was heard in the engine room above, and in a few moments clouds of scalding steam were rolling up the stairway. One of the helpers, though badly burned, succeeded in reaching the engine room alone, and the other two were rescued by fellow employees. Steam was shut off from the pipe at the boiler, and the foreman was then found to be dead on the basement floor. Beside him lay the fragments of a valve that had burst from the pipe."

We should like to say something that would convince every boiler attendant in the land of the grave danger of doing any kind of work upon a pipe or fitting that is under pressure, but if a perusal of such accounts as we have given above will not accomplish this object, we do not know how it can be done Whenever there is a leakage or a sign of weakness of any kind the thing to do, of course, is to shut off the steam from the affected pipe or fitting and investigate the trouble when the pressure is off. All too frequently the difficulty is that some pipe thread has not been made to standard, or has not been screwed into place properly. Poor pipe fitting is unfortunately quite common, and leakage at a joint, when it is due to this cause, indicates that there is liability to failure in the ordinary course of events. The stress on the pipe threads, if the joint is not properly made up, may have caused them to yield a little, so as to allow steam to escape around them. Then a little injudicious hammering, or the application of a pipe wrench or a calking tool, may be like the last straw that broke the camel's back. Never do any calking, nor make any repairs whatever, upon a boiler or a pipe or a fitting that is under pressure!—*The Locomotive.*

A Fireless Locomotive.

Fireless locomotives have been mentioned briefly in previous issues of THE BOILER MAKER, but as their construction and use is not clearly known, we describe this type of locomotive which is built by the Lima Locomotive & Machine Company, Lima, Ohio. The boiler consists of a cylindrical tank, 84 inches diameter, 16 feet long, with a capacity of 530 cubic feet. Steam is generated in the power plant of the works where the locomotive is used, and the locomotive is charged with steam from this plant. The tank is filled about half full of water, and then is connected with the power plant until the pressure in the locomotive and in the stationary boiler is equalized, which is usually about 155 pounds per square inch. As the steam enters the locomotive boiler a considerable amount of it is condensed, and the water in the tank is raised to nearly the pressure and temperature of the steam in the boiler. Steam is discharged from the tank to the cylinders of the locomotive through a reducing valve, which reduces the pressure to about 60 pounds. As the steam is used the pressure falls, causing part of the water to change to steam.

The Boiler Maker

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

Boiler Blow-Offs.

An interesting study of the boiler blow-off is given on another page in this issue. It contains analyses of water taken from the boiler at different places to show the amount of various impurities contained in the water. It has usually been assumed that most of the suspended matter in feed-water would settle to the bottom of the boiler, and, therefore, the blow-off has usually been placed within a few inches of the bottom of the boiler, with the expectation that most of the solids would accumulate at that point and be discharged by frequent blowing off. Somewhat different conditions really exist, however, as shown by the analyses referred to. It was found that a greater concentration and also a larger amount of suspended matter exist in the water from the water column than from the regular blow-off, and where it was possible to obtain samples from the water surface the amount of suspended matter there was still higher. This was particularly true in all watertube boilers, where the greatest concentration of both soluble and suspended impurities was found to be at the water line in the steam drum instead of in the mud drum, as might be supposed. The reason why this takes place is, of course, due to the circulation of the water in the boiler, which in most types is very rapid. Therefore, while the boiler is steaming the suspended matter has little opportunity to settle near the regular blow-off, but it is swept along with the water and deposits in some places as scale or remains as suspended impurities in the water near the steam space. This brings out the conclusion that the water line is the more rational location for the blow-off for the removal of impurities than the mud drum or bottom of the boiler. The ordinary blow-off at the bottom of the boiler is, of course, necessary, and should be used when the boiler is operated; but a surface blow-off or scum blow-off, as it is usually termed, will give much better results and take care of a large percentage of the impurities in the water, both soluble and suspended.

Combustion.

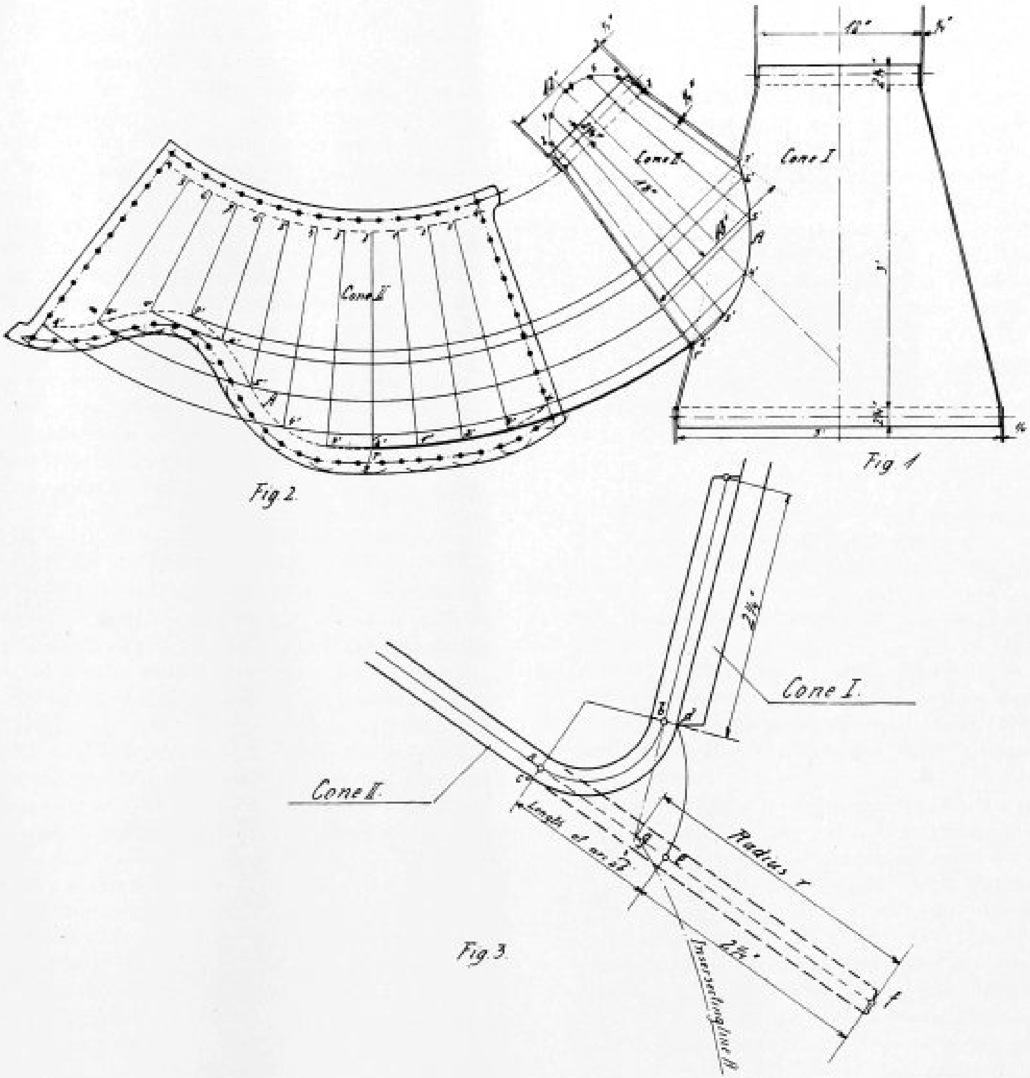
The furnace is one of the most important parts of a boiler when efficiency is being considered. It is a part of the boiler, however, which boiler makers themselves have too little to do with. To thoroughly understand what are the necessary requirements for a good furnace, the nature of combustion must be studied. A very clear and easily understood description of this process is found on another page of this issue, in which simple comparisons are made to show exactly what action takes place when combustion is going on and how the different factors affect it. To understand the functions of a furnace, three factors are pointed out which must be studied; the oxygen, or amount of air supplied; the temperature required for combustion, and the mixture of oxygen with the gases evolved from the fuel. In order to get the greatest efficiency from the boiler complete combustion must take place. Where the combustion is incomplete, losses will occur. For complete combustion oxygen must be supplied in sufficient quantities and at the right temperature and in the proper place in the furnace to thoroughly mix with the gases from the fuel. Such a result might be obtained without much difficulty if only the furnace were considered, but further than this we have the boiler into which should go all of the heat evolved except what is needed for creating draft in the chimney. The temperature of the heating surface of a boiler is so much lower than the temperature of the gases needed for combustion that the heating surface of the boiler really becomes a cooling surface, and has a corresponding effect upon combustion. The position, size and arrangement of the furnace, therefore, must be so proportioned that the process of combustion will take place completely in the furnace, in order to carry the greatest amount of heat to the boiler. Hard-and-fast rules cannot be laid down for such matters, since the type and design of boilers vary widely, and also the kind of fuel makes almost as great a difference as the type of boiler. The various functions for each installation should be taken into account to meet the existing conditions and secure the best results.

COMMUNICATIONS.

Flange of an Intersecting Cone.

Editor The Boiler Maker:

In a recent issue "Norfolk, Virginia," asks to solve a problem in laying out the flange of one of two intersecting cones. I always lay it out as shown in the accompanying figures. In Fig. 1 I show the intersecting line in the usual manner, and in Fig. 2 the layout. My method is described in the April issue. For finding the flange I draw Fig. 3. With *a*, at the middle of the plate, I draw an arc with radius *a-d* and intersect the line *a-f* at *e*. The length *a-e* is equal to the length of the arc *a-b*, or in some cases a little longer; *c-f* is equal to the lap of the joint. Now I take *g-f*, and with it as a radius, and the points 1′-2′-3′-4′, and so forth, in Fig. 2 as centers, I describe the small arcs shown, and by laying a curve tangent to the small arcs the outer line of the flange is given.



METHOD OF LAYING OUT FLANGE OF INTERSECTING CONE.

I have found that this simple way gives good results, but if another boiler maker knows a better method I would be glad to hear it.

John Jashky.

A big percentage of the trouble with some boilers never should have happened. Any boiler will cause trouble if it isn't treated right.

Choking His Hammer.

Editor The Boiler Maker:

The boss was walking round the shop, when he noticed with eagle eye the way in which a recent importation whom he had not seen before was using his hammer.

The young fellow in question was working in a very Weary Willie fashion, choking his blows and having his hand about one-third of the shaft from the head.

In his usual fussy manner the boss hurried up and explained that to make good in "his shop" the newcomer must hold his tools differently. Taking the hammer from the hand of the by now trembling user, the big man explained that if a new workman held his hammer half-way down the shaft he paid him improvers' wages, 26 shillings a week; but to get full rate, 42 shillings, he expected a hammer to be held at the end of the shaft with a good shoulder swing.

The youngster looked up (he was only a big lad, who had made his first start at any kind of work that week), and in a tired voice put the query: "Say, boss, please show me where to hold this for 5 shillings a week?"

Totally discomfited, and catching the scarcely concealed grins on the faces of the men near by, his Nibs sought out the foreman, who caught it hot and warm about quite another matter of trifling importance.

A. L. Haas.

Talks to Young Boiler Makers.

Editor The Boiler Maker:

It is always a satisfaction to me to have anybody notice what I write. Of course, it is pleasanter to have some one speak as kindly as does Mr. Mason in the November issue of The Boiler Maker of my remarks to young boiler makers.

It has struck me, Mr. Editor, what a job it is for you to be always guessing what will meet your readers' wants, and how good you would feel if they would only "speak up" and tell you if what you were publishing was helping them or not, and if not, why. I wonder how often you get letters which would guide you in selecting articles for your pages. I feel sure many could suggest what would be instructive to them and to others.

This has nothing to do with my talks, but I do hope that if what I write is not clear or interesting that those who read The Boiler Maker will be honest enough to write and say so. I can stand a little "knocking" without getting mad. I have given a few punches and taken a few in my day to my own advantage, if not comfort, but I don't know how the other fellow felt, and that is what should be found out.

A boiler is made to make steam, the high brows call it "generating steam," and the idea is to get as much of the heat

Fig. 1.

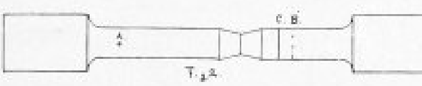


Fig. 2.

from the coal to act on the surfaces of the tubes, flues or shell as is possible.

The parts of the boiler against which the heat acts should be backed with water, or they will become so hot that they will get twisted out of shape and soon become dangerous. By not having water enough in a boiler it will soon "burn out," as it is called.

Heat acting on steel or iron makes it swell up as water does a sponge. The theory is that the particles which go to make up the plates or tubes by the action of heat are forced apart. This swelling up is called "expanding," and in designing boilers the action must at all times be remembered, otherwise serious danger will arise.

In expanding, steel does not move far but with very great force. One of the causes of leaky joints is due to this expanding of steel while hot and its contracting when cold.

The thinner the tube shell or flue the easier it is for the heat to pass through it and the easier steam will be made, but it must be remembered that in making steam, pressure is generated, and we cannot make the material very thin or the boiler would burst.

The rules used for figuring out what is the proper thickness of material are given in many books. They are not difficult to understand, but, unfortunately, all writers do not agree, so people get confused. Later I may write something on this very interesting part of boiler making, but it is more properly "planning a boiler," not boiler making.

I told you in my previous talk that steel between punched holes was stronger than the rest of the sheet; now the surfaces of rolled sheets are stronger than the material between them as in rolling the plates, it is clear that the surfaces are more compressed than is the interior. In making tools of fine cast steel a good workman takes advantage of this fact, and often to get a specially good tool he will take a square bar and mill it into four square bars. In so doing the central part is machined off, leaving the best of the steel. If the machinist had to make a reamer a round piece of steel would be best to use, as here the hardest and best part would be on the outside on which the flutes are to be cut.

Sometimes the greater strength of the surfaces is cut away in making a test piece, and the result of a test does not show the real strength of the average bar. I can make this plainer by explaining how a test piece is made.

A piece of steel is taken and turned up to the shape here shown, Fig. 1; that is, the ends are left about ¾ inch, and the middle is turned down to ½ inch exactly, a prick punch mark is made at *A*, and with a pair of dividers a line is scratched, as shown by the dotted lines at *B*. It is evident that the ½-inch part being in the center and less compressed is less strong than the outside.

This test piece is put in a machine, and by means of a screw is pulled apart, and the strength required is shown on the machine when these test pieces are "pulled"; the break is like the sketch, Fig. 2. As the power is put on to pull the piece apart the ½-inch section begins to grow smaller, and this reduction in size is noted, and when the piece parts one-half is almost always convex or rounding, while the other half is concave or hollow, and also, whether the material is iron or steel the two pieces are found to be magnetic. I have never heard any explanation of why this is so.

Now, after the pieces are brought together as carefully as possible a second scratch is made with the dividers (of course, they have been left set as when the first scratch was made), and one leg of the dividers being placed in the prick punch mark *A*. This second line, represented by the solid line *C*, will be a certain distance from the first dotted line *B*. We measure the distance that the dividers were set at, and say it is 2 inches, and we find that the two lines scratched are ¼ inch apart; we then say that this stretching, or elongation, as it is called, is ¼ inch in 2 inches. The softer or more ductile the material the greater is this elongation.

It can be easily understood that after a boiler is built and of fine material the workmanship may be faulty, or it may not have been properly designed. Therefore, just a test of the material is not sufficient to assure that it is strong enough to stand the working pressure. To test a boiler when finished it is filled with water, and by means of a test pump pressure is put on the boiler. This test is often made with cold water, simply because it is more convenient and cheaper than hot water; but it is better to use hot water, as then the effect of expansion which I have referred to comes into play, and the boiler is nearer working conditions than if cold water is used. Often a boiler tested with cold water will leak, but when the water is warm it will be tight. Sometimes a boiler is filled full of cold water, and then it is heated; this causes the water to expand, which, of course, produces a pressure.

If steam were used to test a boiler, and it was not strong enough to stand, a serious accident would result, but when water is used no damage results if a seam opens up. This hydraulic test is usually carried out so that twice the working pressure is given it to insure a perfectly safe working pressure.

I will go into the reasons which govern hydraulic tests and the appliances which are used in such tests in my next talk.

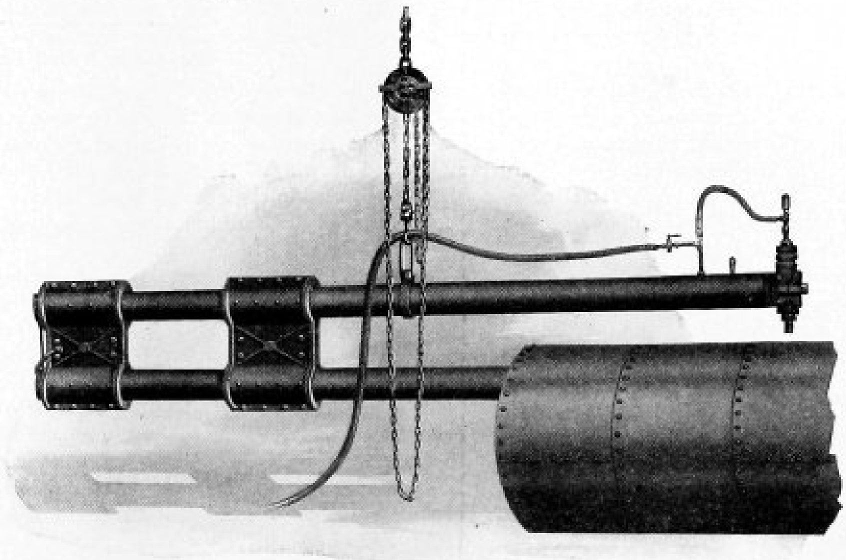
F. Ormer Boy.

The annual meeting of the American Society of Mechanical Engineers was held in New York, December 5-8. The society is undertaking important work of very broad scope at these meetings by appointing over forty committees, each one of which is to investigate some particular industry for the betterment of industrial and social conditions connected with it.

ENGINEERING SPECIALTIES.

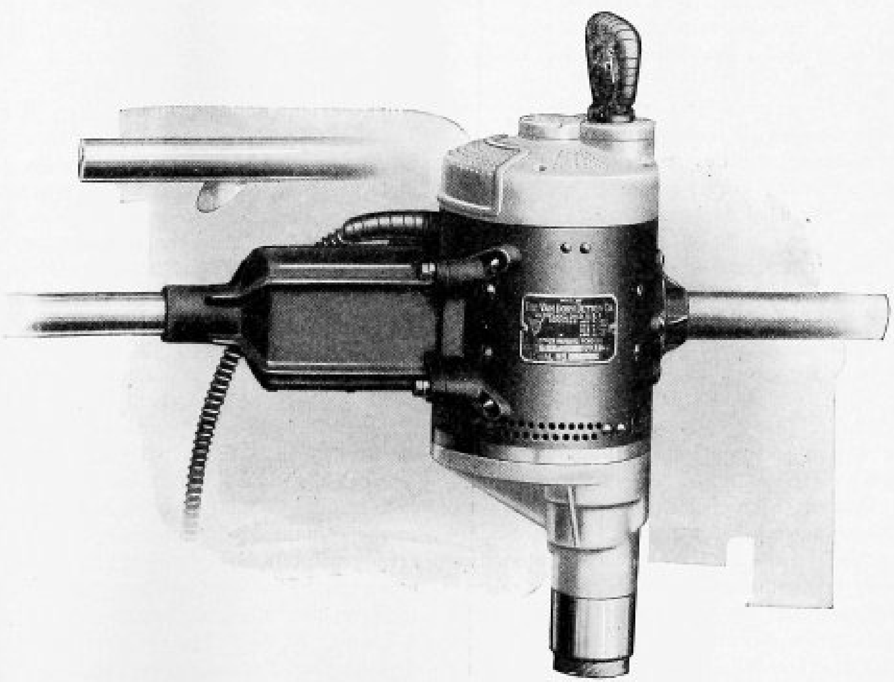
Wonder Riveting Machine.

A new pneumatic riveting machine, specially adapted for boiler, tank and structural work, has just been placed on the market by the Hardsocg Wonder Drill Company, Ottumwa, Ia. As will be seen from the illustration, the machine consists of a solid frame, the gaps of the standard machine being 12, 10, 8 and 6 feet. Special machines are made with shorter gap. The machine has a riveting hammer and a pneumatic holder-on attached to the frame, which, it is claimed, are always maintained in perfect alinement. The machine is suspended from a traveling crane or track, and may be used either horizontally or vertically. It is operated by one man, who merely turns the machine into position and turns the lever to the air valve. There is but one air valve controlling the supply of air to both the riveter and holder-on. The pneumatic hammer that does the riveting is a valveless tool. The capacity of the machine permits driving rivets up to 1 inch diameter. Any size rivet up to ⅜ inch can be driven cold. The rivet may be dropped into position from the upper side of the work, and the machine works within 1½ inches of a boiler head on 1-inch rivets, and within ¾ inch of the head on ⅜-inch rivets. It is claimed to do the work much quicker than it can be done with an ordinary pneumatic gun, and with less labor and with no vibration from the machine.



An Improved Line of Electrically Operated Portable Drills and Reamers.

A new or improved line of "hard-service," portable, electrically-operated drills and reamers was exhibited at the recent M. M. & M. C. B. convention, held at Atlantic City, June 14 to 21, by the Van Dorn & Dutton Company, Cleveland, Ohio. This line consisted of eight different types of machines, as follows: Six sizes, scope 0 to 2 inches, for operation on direct current, either 110 or 220 volts, and two sizes, 0 to ⅜ inch, for operation on either direct or alternating current, 110 or 220 volts. These machines were constantly in operation drill-



ing and reaming in iron and steel and also wood boring. The manufacturer, who has been engaged in the production of tools of this kind for a number of years, does not claim anything radically new in principle in their improved line of tools, but a marked improvement in both electrical and mechanical construction. In the larger machines four-pole construction is employed, whereas the small tools are of the two-pole construction. The design is such that the harder the tool is forced the greater the torque or working power. Straight series motors, developing the greatest factor of power obtainable for size and weight, are used. The armature is of the slotted drum type, built up of soft steel laminations on a hollow shaft, these laminations being made from steel of a special analysis to give the highest efficiency. Each lamination is carefully and uniformly insulated. In the larger machines the field frames are constructed of steel of a special analysis, by means of which the best results are obtained. In the smaller machines the field frames are built up of laminations much in a manner similar to the armature.

In the design of these machines exhaustive consideration has been given to the matter of lubrication and bearings, experience having proved that these two features are of the greatest importance in the construction of tools of this character. The method of lubrication is simple but effective. The gears are enclosed in a gear case, entirely separate from the windings; this gear case serving as a lubricant chamber as well as a housing for the gears. By means of canals lubricant reaches all bearings with the exception of that supporting the spindle, which is lubricated by a receptacle easily accessible. In revolving, the gears force the lubricant through these canals, insuring a proper and sufficient lubrication at all times. The oiling system is so devised that one charge of non-fluid oil in the gear case will answer for several weeks. Ordinary machine oil can be used for lubricating the spindle. The wipe system employed at the spindle is so arranged that the wick is constantly in contact with the spindle, extending into the oil chamber. The bearings are proportioned with an excess factor of safety. The system used was adopted after exhaustive consideration of the subject on the part of experts in this branch of engineering and has withstood the severest tests.

In laying out these bearings consideration has been given to each and every function involved, friction being reduced to a minimum and great wearing qualities secured. At the high-speed members imported ball bearings are used, whereas elephant bronze bushings are used as bearings for the slower speed members.

In the gear construction accurately generated tooth gears are used. These are made from alloy steel, especially hardened and ground to size, great strength and long wearing quality being in this manner obtained. The spindle and socket are of a special design, which is claimed to eliminate slipping and breaking. Steel of a special analysis, hardened and ground, is used. Another feature of interest is the unique cooling system, the design and construction employed being substantial and effective. The switches employed are of the quick-break type; capacity, 50 percent in excess of the duty required. In the larger machines for reaming mechanically-operated automatic switches are used. These will automatically stop the machine, should the operator accidentally release the handles when the tool is in operation. These switches will at all times break the current instantaneously, thus eliminating a heavy and destructive arcing. In the smaller machines switches of a special design are also employed, the design used being strong mechanically. The switch contacts are so designed that when wear is shown they are easily replaced at a very small cost.

The general construction of this line of machine is such that the tools are easily assembled and disassembled, all parts being interchangeable and easily accessible. All machined parts are finished to micrometer measurements, and held absolutely to size to secure interchangeability. Machined parts, such as the spindle, socket and gears, are hardened by the latest scientific methods, ground true to size and smooth, giving an excellent wearing surface. One screw holds firmly in place the cover. When this is removed the brush holders, etc., are readily accessible.

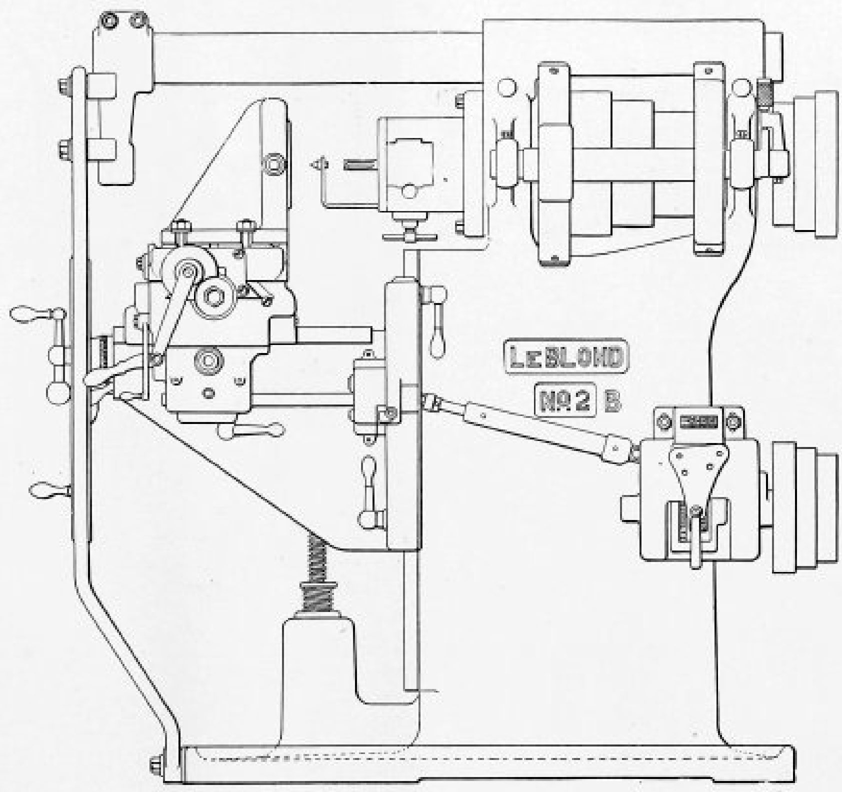
Isometric Ruled Paper.

The Norman W. Henley Publishing Company, New York, has just placed on the market a new form of hand pads, or loose sheets of various sizes, for making isometric sketches and drawings. Isometric perspective or projection has seldom been used in engineering work, because it has always been surrounded with technicalities and involved description which usually resulted in a good deal of trouble. On the isometric ruled paper the drawing may be scaled in three main directions, the axes of which are 120 degrees apart, one being vertical and the others at 30 degrees from the horizontal. All horizontal lines are laid along the 30-degree line in either direction. Thus a cube shown in an isometric sketch will become a hexagon and a circle an ellipse. This form of drawing saves the trouble of making different views of an object when it is desired to show a preliminary scaled sketch for the use of a designer, pattern maker or blacksmith. The paper is sold in lots of forty sheets each, the price varying from 25 cents to $1.00 for the various sizes.

Le Blond No. 2 Combination Miller.

Designers have introduced various devices for boring square holes, consisting usually of independent chucks or attachments attached to regular lathes or milling machines, but these have invariably given trouble on account of the difficulties encountered in the proper mounting and rigid fitting of such attachments to machines of various types and construction. To overcome these difficulties a practical tool for this kind of work has been produced by the R. K. LeBlond Machine Tool Company, Cincinnati, Ohio, and is sold exclusively by the Niles-Bement-Pond Company, 111 Broadway, New York. The machine is constructed along the same lines, and has all the features of the No. 2 plain miller manufactured by the same company, with the additions necessary for operating the machine for drilling round or square holes. The changes, however, do not interfere with the operation of the machine when used for regular milling. Work of this kind was formerly done by broaching, which was limited entirely to a hole clear through the work. With the combination miller, however, holes of any depth up to the length of the drill and the capacity of the machine may be drilled. The operation of drilling is identical to that of drilling a round hole and is accomplished almost as quickly. In this machine the guiding chuck in which the square hole cutters are moved about eccentrically is held in alinement by being fitted over the spindle journal-box and held securely by being bolted directly to the column of the machine by four heavy bolts. By this arrangement it is claimed the possibility of the least movement caused by the jarring eccentric motion of the cutter is entirely eliminated, the upper part of the column is offset 6 inches, to allow for the projection of the squaring hole drilling chuck, so as not to cut down the range of the cross feed of the table. The construction of the machine is very heavy and rigid so as to take up the thrusts in the different directions when drilling square holes.

The operation of drilling square holes is as simple as that of drilling a round hole, and the ease of changing from one to another is a remarkable feature of the machine. No special fixtures are necessary for holding the work, as is necessary with a broaching machine. Provision is also made for drilling round holes without removing the square hole drilling chuck, and a bush and Morse tapered collet are furnished for this purpose. The machine is equipped with two sets of power feeds—one set for regular milling operations, the other for square-hole drilling. The change from one to the other is made by merely dropping a spring plunger into a hole in the feed cone. Both longitudinal and cross feeds are supplied with automatic stops which stop the feed to a line. The range



of the machine is 28 inches longitudinally, 8 inches across and 19 inches vertical. The capacity for square holes is from ⅜ inch to 2 inches round corners; ¼ to 1¼-inch holes with absolutely square corners. There are 12 spindle speeds from 12 to 361 revolutions per minute—all right hand. Two distinct sets of feeds are provided, fifteen for milling ranging from .006 to .143, and fifteen for square-hole drilling ranging from .0012 to .03. The net weight of the machine is 3,500 pounds.

A table of constants for estimating the weight of steel sheets, plates and bars has been compiled by G. A. Schust, M. E., and published by the Industrial Engineering Company, Fort Wayne, Ind. The tables are published on a single sheet, 8½ by 11 inches. The constants are for both black and galvanized sheets and plates of various gages, ranging from No. 28 to 1. In using the tables, as, for instance, that for estimating the weight of steel sheets and plates, either black or galvanized, it is simply necessary to multiply the product of the length and breadth in inches by its corresponding constant given in the table according to the gage or thickness, and the result will be the required weight desired. The weight of flat, round or square steel bars can be found in a similar easy way. The constants for the plates include the usual percentage for over-weight in rolling. Copies of these tables can be obtained from the Industrial Engineering Company upon receipt of one dollar.

PERSONAL.

MR. JOHN GALLIVAN has been appointed Federal locomotive boiler inspector for the State of Indiana.

MR. JAMES B. HARTIGAN, who, as reported in the November issue, was appointed Federal boiler inspector at Rutland, Vt., has declined the appointment, and will remain with the Rutland Railway.

MR. J. F. DEEMS, general superintendent of motive power, rolling stock and machinery of the New York Central Lines, has resigned to become president of the Ward Equipment Company, 139 Cedar street, New York.

MR. T. F. POWERS, foreman boiler maker of the Chicago Northwestern Railway at Chadron, Neb., has been made general boiler shop foreman of the system, to take the place of Mr. J. W. Kelly, first vice-president of the Master Boiler Makers' Association, who has become associated with the National Tube Company.

MR. FRANK T. SAXE has established a new boiler shop at 400 Fountain street, Providence, R. I., under the name of the Providence Boiler Company. Mr. Saxe is president of the company.

JAMES HUGHES has been appointed boiler inspector for the United Fruit Company, with headquarters at Nipe Bay, Preston, Cuba.

MR. JAMES WHITEACRE, formerly foreman boiler maker with the John McDougall Iron Works, Montreal, Quebec, has accepted a position with the Western Dry Dock Company, Port Arthur, Ontario, as foreman boiler maker.

WE ARE INFORMED by Mr. James H. Sheridan, foreman of the boiler shop at the Pioneer Iron Works, Brooklyn, N. Y., that Mr. P. H. O'Donnell, formerly assistant boiler maker of the Pioneer Iron Works, who, as announced in the November number, had accepted a position as foreman boiler maker for the P. H. Fitzgibbons Boiler Works, Ogdensburg, N. Y., was fatally injured by alighting from a moving train at Belleville, Ontario.

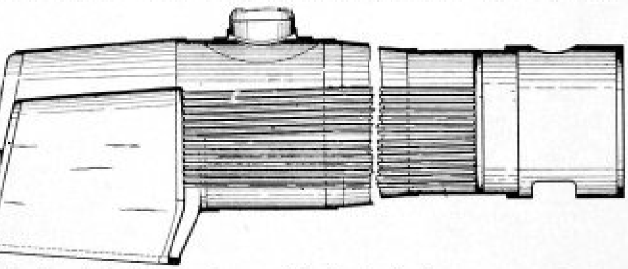
SELECTED BOILER PATENTS.

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

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

1,002,414. MANUFACTURE OF STEAM BOILERS. DONALD R. MACBAIN, OF CLEVELAND, OHIO.

Claim 1.—The improvement in the manufacture of steam boilers which consists in the act of mechanically imposing a compressive strain upon the boiler tubes which opposes the tensile strain imposed upon them in service under the greater expansion of the boiler shell, by



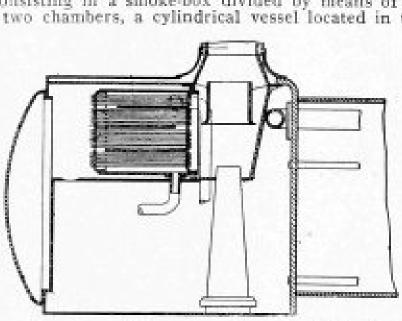
springing the boiler tubes into a slight longitudinal curvature, and, when so sprung, securing their ends into the tube sheets, thereby producing a state or condition in which said tensile strain is compensated and counteracted. Five claims.

1,002,688. BOILER FURNACE. CHARLES G. HENRY, OF CINCINNATI, OHIO.

Claim 1.—A furnace comprising a fire-box, a boiler thereover, a plurality of zigzag mixing passages, alternate air-heating passages therebetween, air duct means leading to the last-named passages, a shield over the passages spaced below the boiler, and a canopy over the fire-box spaced from the boiler, the lower edge being spaced from the shield and slightly therebelow for the purposes described, a mixing chamber, said mixing and air-heating passages leading thereto, and a combustion chamber communicating with the boiler. Two claims.

1,001,712. STEAM GENERATOR OF THE LOCOMOTIVE TYPE. FREDERICK HARVEY TREVITHICK, OF ZEITOUN, CAIRO, EGYPT.

Claim.—In a locomotive or other combined engine and boiler, the herein-described means for utilizing the waste gases in heating the feed-water, same consisting in a smoke-box divided by means of a horizontal partition into two chambers, a cylindrical vessel located in the upper of



said chambers and traversed by tubes, through which the furnace gases pass, and a narrow compartment or pocket disposed beneath the smoke-stack and inclosing the outlet end of said cylindrical vessel, and a blast-nozzle discharging into said narrow compartment.

1,004,403. APPARATUS FOR BLOWING OFF BOILER MUD. ALBERT FONÓ, OF BUDAPEST, AUSTRIA-HUNGARY.

Claim.—Apparatus for blowing off boiler mud or slime at full working pressure characterized by the fact that a chamber is inserted in the blow-off pipe in which chamber a pressure somewhat lower than the boiler pressure is maintained and which is connected with the boiler by means of a yielding pipe. One claim.

1,004,052. BOILER-CLEANING DEVICE. VASIL MACKAY, OF BOSTON, MASS.

Claim 1.—A cleaning device for steam boilers and the like having, in combination, a cleaner, means for moving said cleaner horizontally within the boiler, and other means supported on said cleaner to move relatively thereto and operated by the first-mentioned means for imparting to said cleaner a vertical movement independently of said horizontal movement. Three claims.

1,003,968. FURNACE FOR PERFECTING COMBUSTION. WILLIAM J. PAUL, JOHN H. LYNCH, AND JAMES G. MEYER, OF MATTEAWAN, N. Y.

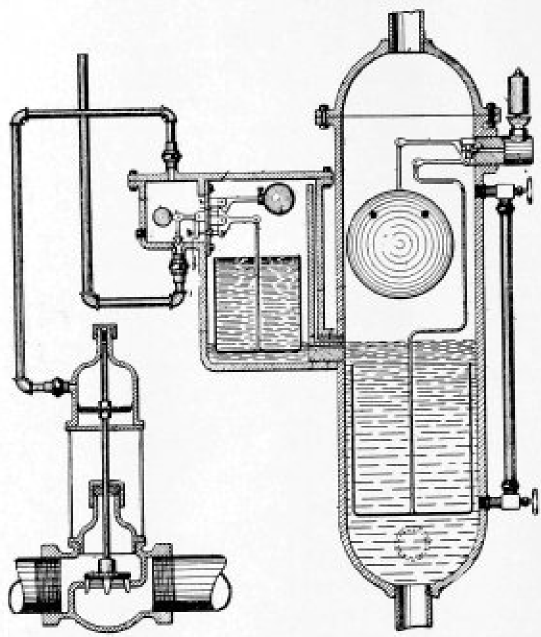
Claim 2.—A furnace or oven comprising, a fire-chamber, a bank of spaced combustion and heat radiating tubes, disposed within the line of draft and in free communication with the said chamber, the tubes being of such length as to insure substantially complete combustion within the area thereof, means for supporting said tubes without materially affecting the temperature or the radiating surfaces thereof, and a body to be heated exposed to the radiant heat from said tubes, whereby said tubes may be maintained at a high temperature and the said body heated by radiation. Four claims.

1,004,764. FEED-WATER HEATER FOR LOCOMOTIVE AND OTHER STEAM BOILERS. JOHN F. FITZSIMMONS, OF TACOMA, WASH.

Claim.—A feed-water heater for boilers, comprising an exhaust steam standpipe located in the boiler smoke-box, a water-circulating coil located in the standpipe to be exposed to the direct action of exhaust steam in the standpipe and having an outlet extension discharging into the boiler, and a receiving tank located in the smoke-box, outside of the standpipe, said tank being connected with the inlet of the water-circulating coil and adapted to contain a relatively large body of water for an injector to act against should steam be generated in the coils located within the standpipe.

1,002,219. AUTOMATIC BOILER-FEED AND WATER-LEVEL ALARM. JAMES J. BURKE, OF HARTFORD, CONN.

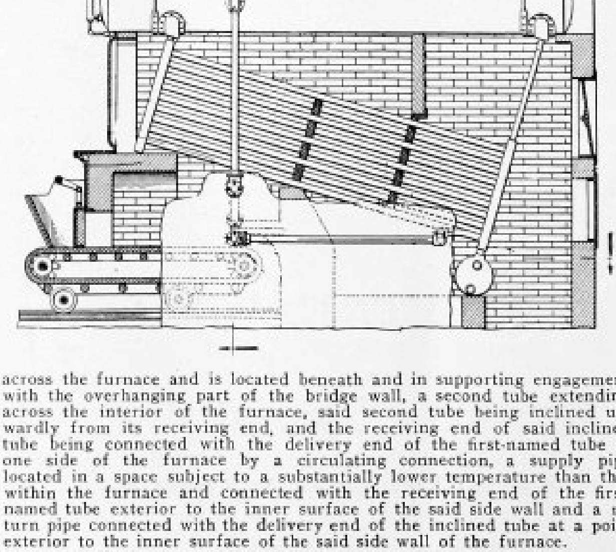
Claim 2.—In a feed-water regulator in combination, a water column adapted to be connected with a boiler, at one end below and at the other end above the water line, a regulator bucket adapted to contain



water and arranged to be immersed in and to have its effective weight varied according to the level of the water in which it is immersed, said water level depending upon the amount of water in the water column, a lever upon which said bucket is hung, a pressure valve connected with said lever, a weighted lever engaged with said bucket lever and adapted to counterbalance the weight of said bucket, a chamber, a weighted lever in said chamber, a screw turning in one end of said lever and adapted to butt against said pressure valve, an exhaust valve connected with the last-mentioned lever and adapted to open and close an exhaust outlet from said chamber, a cylinder connected with said chamber, a piston in said cylinder, a feed water throttle valve, and a connection between the stem of the feed-water valve and the piston. Five claims.

1,003,503. TRAVELING-GRATE FURNACE. HERMAN A. POPPENHUSEN, OF EVANSTON, ILL.

Claim.—The combination with the side walls and bridge wall of the furnace, of a grate adapted to effect movement of the fuel resting thereon rearwardly in the furnace, said bridge wall being provided with a part which overhangs the rear end of said grate, a tube which extends



across the furnace and is located beneath and in supporting engagement with the overhanging part of the bridge wall, a second tube extending across the interior of the furnace, said second tube being inclined upwardly from its receiving end, and the receiving end of said inclined tube being connected with the delivery end of the first-named tube at one side of the furnace by a circulating connection, a supply pipe located in a space subject to a substantially lower temperature than that within the furnace and connected with the receiving end of the first-named tube exterior to the inner surface of the said side wall and a return pipe connected with the delivery end of the inclined tube at a point exterior to the inner surface of the said side wall of the furnace.