

MODEL BOILERS

A booklet devoted to the construction of model boilers may well open with a few cautionary words, as the dangers connected with steam-raisers are very real; and though model-boiler explosions are fortunately rare, if they do occur they may be extremely disastrous.

Therefore the following warnings:

(1.) Do not use tins or thin sheet iron for boilers. One cannot tell how far internal corrosion has gone. The scaling of 1/100 inch of metal off a "tin" is obviously vastly more serious than the same diminution in the thickness of, say, a 1/4-inch plate. Brass and copper are the metals to employ, as they do not deteriorate at all provided a proper water supply be maintained.

(2.) If in doubt, make the boiler much more solid than is needed, rather than run any risks.

(3.) Fit a *steam gage*, so that you may know what is happening.

(4.) *Test* your boiler under steam, and don't work it at more than half the pressure to which it has been tested. (See p. 220.)

In the present chapter we will assume that the barrels of all the boilers described are made out of solid-drawn seamless copper tubing, which can be bought in all diameters up to 6 inches, and of any one of several thicknesses. Brass tubing is more easily soldered, but not so good to braze, and generally not so strong as copper, other things being equal. Solid-drawn tubing is more expensive than welded tubing or an equivalent amount of sheet metal, but is considerably stronger than the best riveted tube.

Boiler ends...

... **may** be purchased ready turned to size.

Get stampings rather than castings, as the first are more homogeneous, and therefore can be somewhat lighter.

Flanging Boiler Ends

To make a good job, a plate for an end should be screwed to a circular block of hard wood (oak or boxwood), having an outside diameter less than the inside diameter of the boiler barrel by twice the thickness of the metal of the end, and a rounded-off edge. The plate must be annealed by being heated to a dull red and dipped in cold water. The process must be repeated should the hammering make the copper stubborn.

Stays...

... should be used liberally, and be screwed and nutted at the ends. As the cutting of the screw thread reduces the effective diameter, the strength of a stay is only that of the section at the *bottom* of the threads.

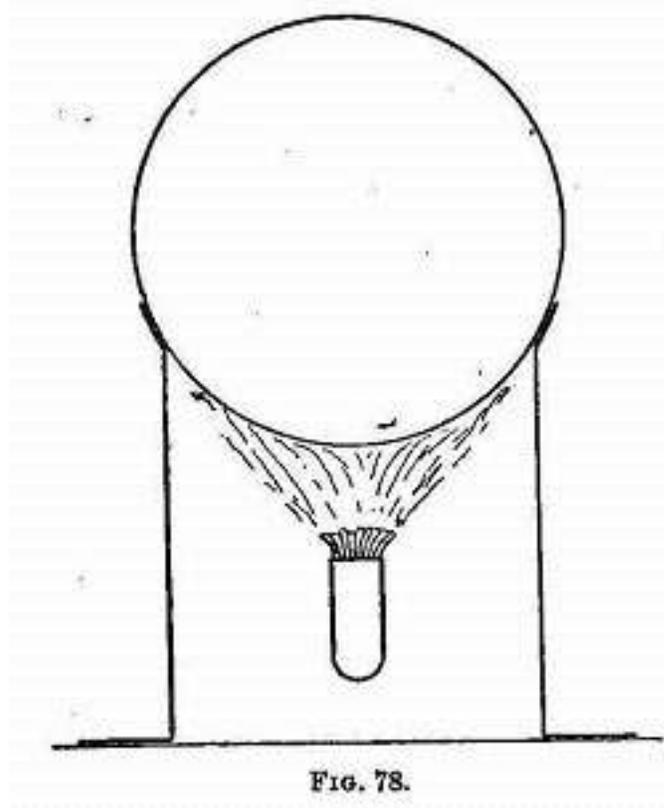
Riveting

Though stays will prevent the ends of the boiler blowing off, it is very advisable to rivet them through the flanges to the ends of the barrel, as this gives mutual support independently of soldering or brazing. Proper boiler rivets should be procured, and annealed before use. Make the rivet holes a good fit, and drill the two parts to be held together in one operation, to ensure the holes being in line. Rivets will not close properly if *too long*. Dies for closing the rivet heads may be bought for a few pence.

Soldering, etc.

Joints not exposed directly to the furnace flames may be soldered with a solder melting not below 350 degrees Fahrenheit. Surfaces to be riveted together should be "tinned" before riveting, to ensure the solder getting a good hold afterwards. The solder should be sweated right through the joint with a blow-lamp to make a satisfactory job.

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All joints exposed to the flames should be *silver-soldered*, and other joints as well if the working pressure is to exceed 50 lbs. to the square inch. Silver-soldering requires the use of a powerful blow-lamp or gas-jet; ordinary soft soldering bits and temperatures are ineffective. *Brazing* is better still, but should be done by an expert, who may be relied on not to burn the metal. It is somewhat risky to braze brass, which melts at a temperature not far above that required to fuse the spelter (brass solder). Getting the prepared parts of a boiler silver-soldered or brazed together is inexpensive, and is worth the money asked.

Some Points in Design

The *efficiency* of a boiler is governed chiefly (1) by the amount of heating surface exposed to the flames; (2) by the distribution of the heating surface; (3) by the amount of fuel which can be burnt in the furnace in a given time; (4) by avoiding wastage of heat.

The simplest form of boiler, depicted in Figure 78, is extremely inefficient because of its small heating surface. A great deal of the heat escapes round the sides and the ends of the boiler. Moreover, a good deal of the heat which passes into the water is radiated out again, as the boiler is exposed directly to the air.

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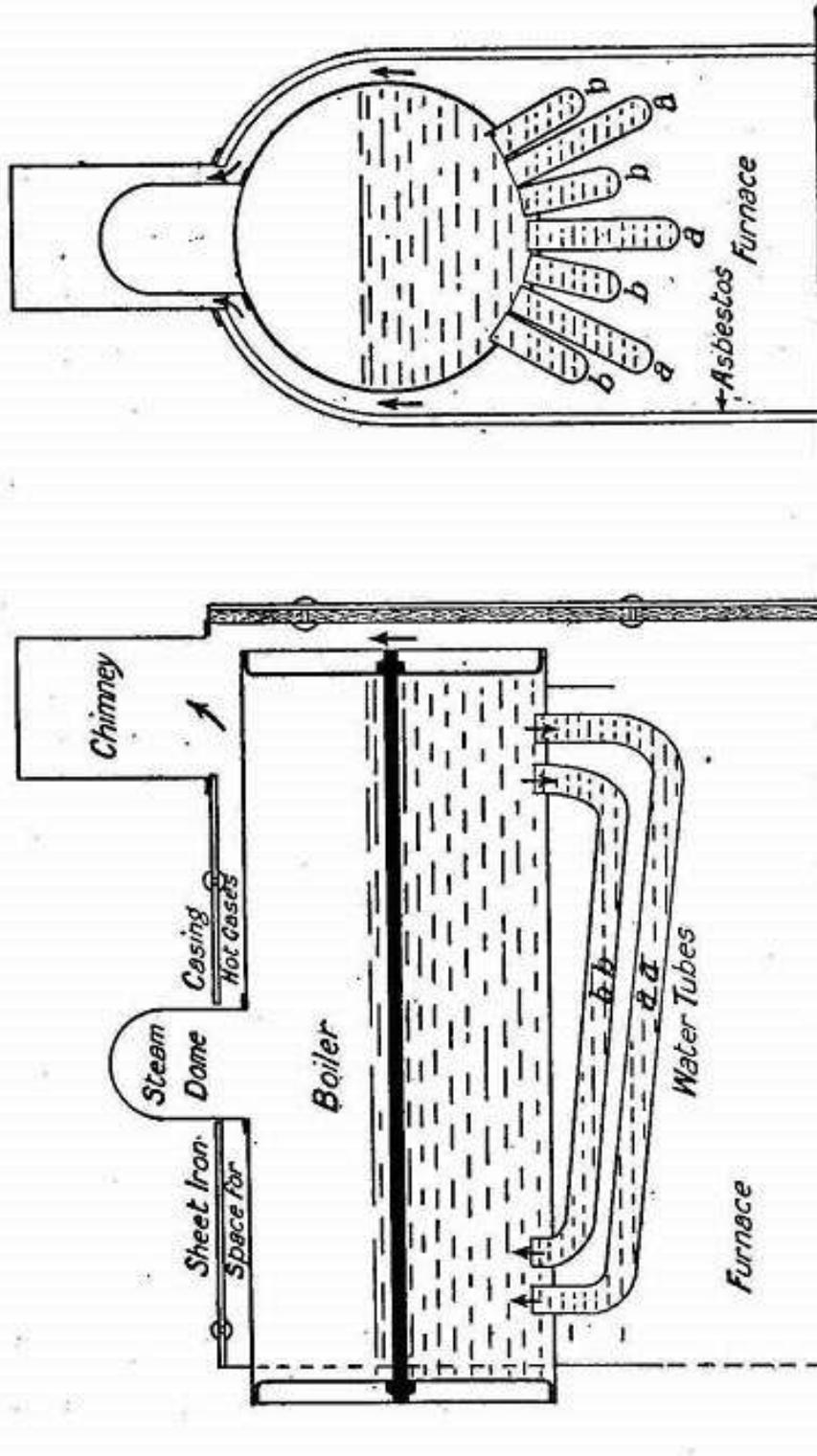


FIG. 79.—Side and end elevations of small water-tube boiler.

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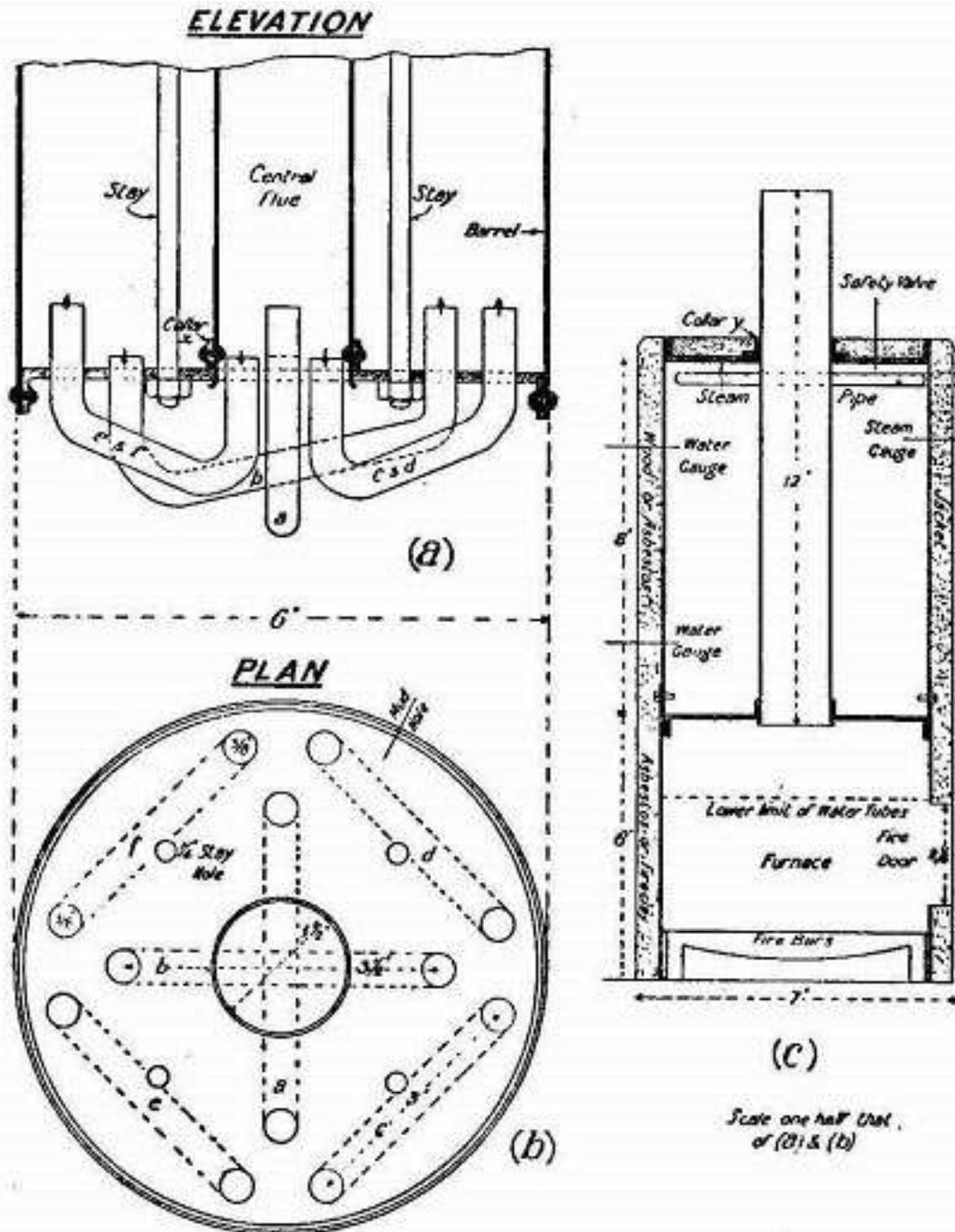


FIG. 80.—Details of vertical boiler.

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Figure 79 shows a great improvement in design. The boiler is entirely enclosed, except at one end, so that the hot gases get right round the barrel, and the effective heating surface has been more than doubled by fitting a number of water-tubes, *aaa*, *bbbb*, which lie right in the flames, and absorb much heat which would otherwise escape. The tubes slope upwards from the chimney end, where the heat is less, to the fire-door end, where the heat is fiercer, and a good circulation is thus assured. The Babcock and Wilcox boiler is the highest development of this system, which has proved very successful, and may be recommended for model boilers of all sizes. The heating surface may be increased indefinitely by multiplying the number of tubes. If a solid fuel-coal, coke, charcoal, etc.-fire is used,

the walls of the casing should be lined with asbestos or fire-clay to prevent the metal being burnt away.

The horizontal boiler has an advantage over the vertical in that, for an equal diameter of barrel, it affords a larger water surface, and is, therefore, less subject to "priming," which means the passing off of minute globules of water with the steam. This trouble, very likely to occur if the boiler has to run an engine too large for it, means a great loss of efficiency, but it may be partly cured by making the steam pass through coils exposed to the furnace gases on its way to the engine. This "superheating" evaporates the globules and dries the steam, besides raising its temperature. The small water-tube is preferable to the small fire-tube connecting furnace and chimney, as its surface is exposed more directly to the flames; also it increases, instead of decreasing, the total volume of water in the boiler.

A Vertical Boiler

The vertical boiler illustrated by Figure 80 is easily made. The absence of a water jacket to the furnace is partly compensated by fitting six water-tubes in the bottom. As shown, the barrel is 8 inches long and 6 inches in outside diameter, and the central flue 1-1/2 inches across outside solid-drawn 1/16-inch tubing, flanged ends, and four 1/4-inch stays--disposed as indicated in Figure 80 (a) and (b)--are used. The 5/16 or 3/8 inch water-tubes must be annealed and filled with lead or resin before being bent round wooden templates. After bending, run the resin or lead out by heating. The outflow end of each pipe should project half an inch or so further through the boiler bottom than the inflow end.

Mark out and drill the tube holes in the bottom, and then the flue hole, for which a series of small holes must be made close together inside the circumference and united with a fret saw. Work the hole out carefully till the flue, which should be slightly tapered at the end, can be driven through an eighth of an inch or so. The flue hole in the top should be made a good fit, full size.

Rivet a collar, *x* (Figure 80, *a*), of strip brass 1/4 inch above the bottom of the flue to form a shoulder. Another collar, *y* (Figure 80, *c*), is needed for the flue above the top plate. Put the ends and flue temporarily in place, mark off the position of *y*, and drill half a dozen 5/32-inch screw holes through *y* and the flue. Also drill screw holes to hold the collar to the boiler top.

The steam-pipe is a circle of 5/16-inch copper tube, having one end closed, and a number of small holes bored in the upper side to collect the steam from many points at once. The other end is carried through the side of the boiler.

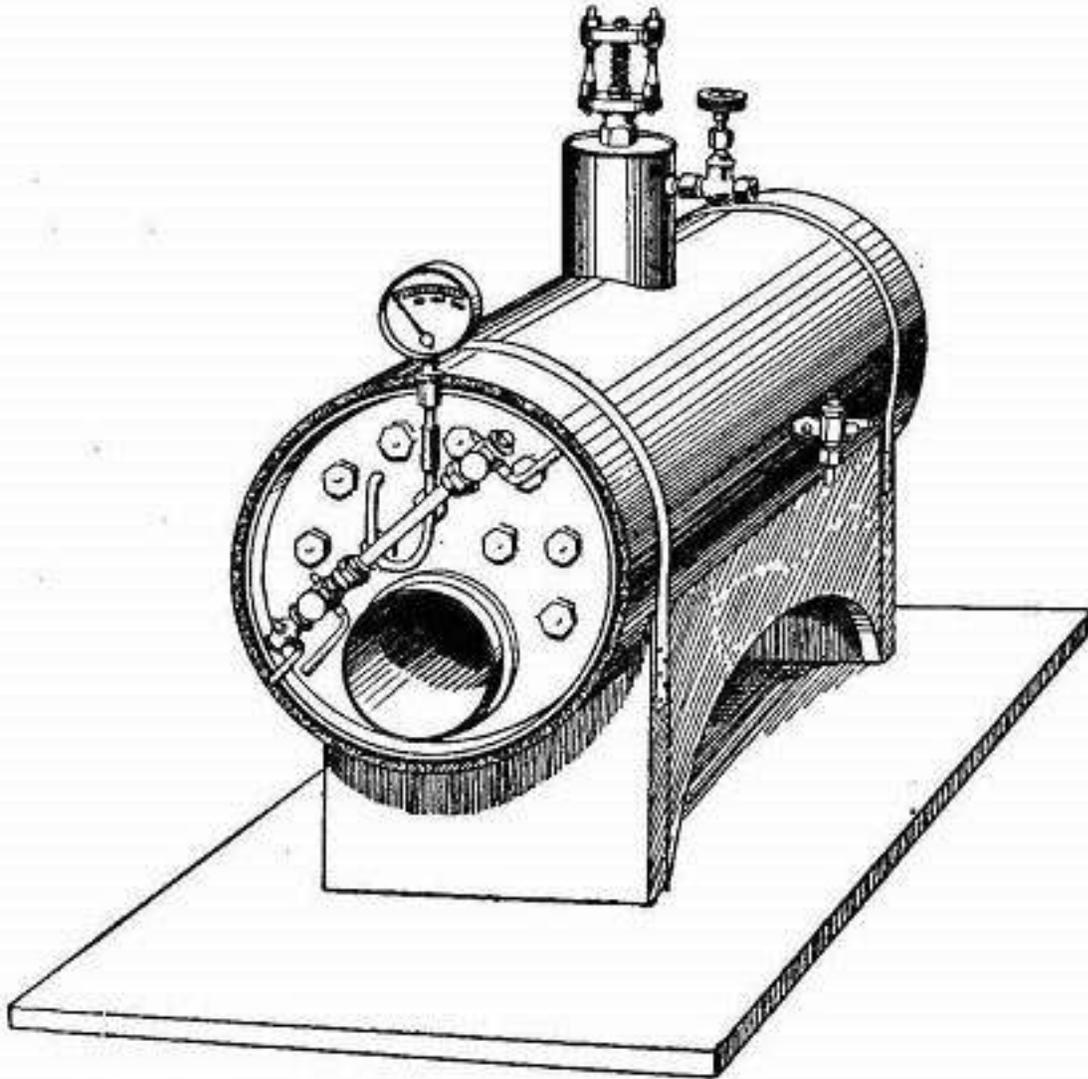


FIG. 8L.—Perspective view of horizontal boiler mounted on wooden base.

Assembling

The order of assembling is: -- Rivet in the bottom; put the steam-pipe in place; rivet in the top; insert the flue, and screw collar *y* to the top; expand the bottom of the flue by hammering so that it cannot be withdrawn; insert the stays and screw them up tight;

silver-solder both ends of the flue, the bottom ends of the stays, and the joint between bottom and barrel. The water-tubes are then inserted and silver-soldered, and one finishes by soft-soldering the boiler top to the barrel and fixing in the seatings for the water and steam gages, safety-valve, mud-hole, filler, and pump-if the last is fitted.

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The furnace is lined with a strip of stout sheet iron, 7 inches wide and 19-1/4 inches long, bent round the barrel, which it overlaps for an inch and a half. Several screws hold lining and barrel together. To promote efficiency, the furnace and boiler is jacketed with asbestos -- or fire-clay round the furnace -- secured by a thin outer cover. The enclosing is a somewhat troublesome business, but results in much better steaming power, especially in cold weather. Air-holes must be cut round the bottom of the lining to give good ventilation.

A boiler of this size will keep a 1 by 1-1/2 inch cylinder well supplied with steam at from 30 to 40 lbs. per square inch.

A Horizontal Boiler

The boiler illustrated by Figure 81 is designed for heating with a large paraffin or petrol blow-lamp. It has considerably greater water capacity, heating surface --the furnace being entirely enclosed -- and water surface than the boiler just described. The last at high-water level is about 60, and at low-water level 70, square inches.

The vertical section (Figure 82) shows 1/16-inch barrel, 13 inches long over all and 12 inches long between the end plates, and 6 inches in diameter. The furnace flue is 2-1/2 inches across outside, and contains eleven 1/2-inch cross tubes, set as indicated by the end view (Figure 83), and 3/4 inch apart, center to center. This arrangement gives a total heating surface of about 140 square inches. If somewhat smaller tubes are used

and doubled (see Figure 84), or even trebled, the heating surface may be increased to 180-200 square inches. With a powerful blow-lamp this boiler raises a lot of steam.

Tubing the Furnace Flue

Before any of the holes are made, the lines on which the centres lie must be scored from end to end of the flue on the outside. The positions of these lines are quickly found as follows: -- Cut out a strip of paper exactly as long as the circumference of the tube, and plot the center lines on it. The paper is then applied to the tube again, and poppet marks made with a center punch opposite to or through the marks on the paper. Drive a wire-nail through a piece of square wood and sharpen the point. Lay the flue on a flat surface, apply the end of the nail to one of the poppet marks, and draw it along the flue, which must be held quite firmly. When all the lines have been scored, the centering of the water tubes is a very easy matter.

The two holes for any one tube should be bored independently, with a drill somewhat smaller than the tube, and be opened to a good fit with a reamer or broach passed through both holes to ensure their sides being in line. Taper the tubes -- 2-7/8 inches long each -- slightly at one end, and make one of the holes a bit smaller than the other. The tapered end is passed first through the larger hole and driven home in the other, but not so violently as to distort the flue. If the tubes are made fast in this way, the subsequent silver-soldering will be all the easier.

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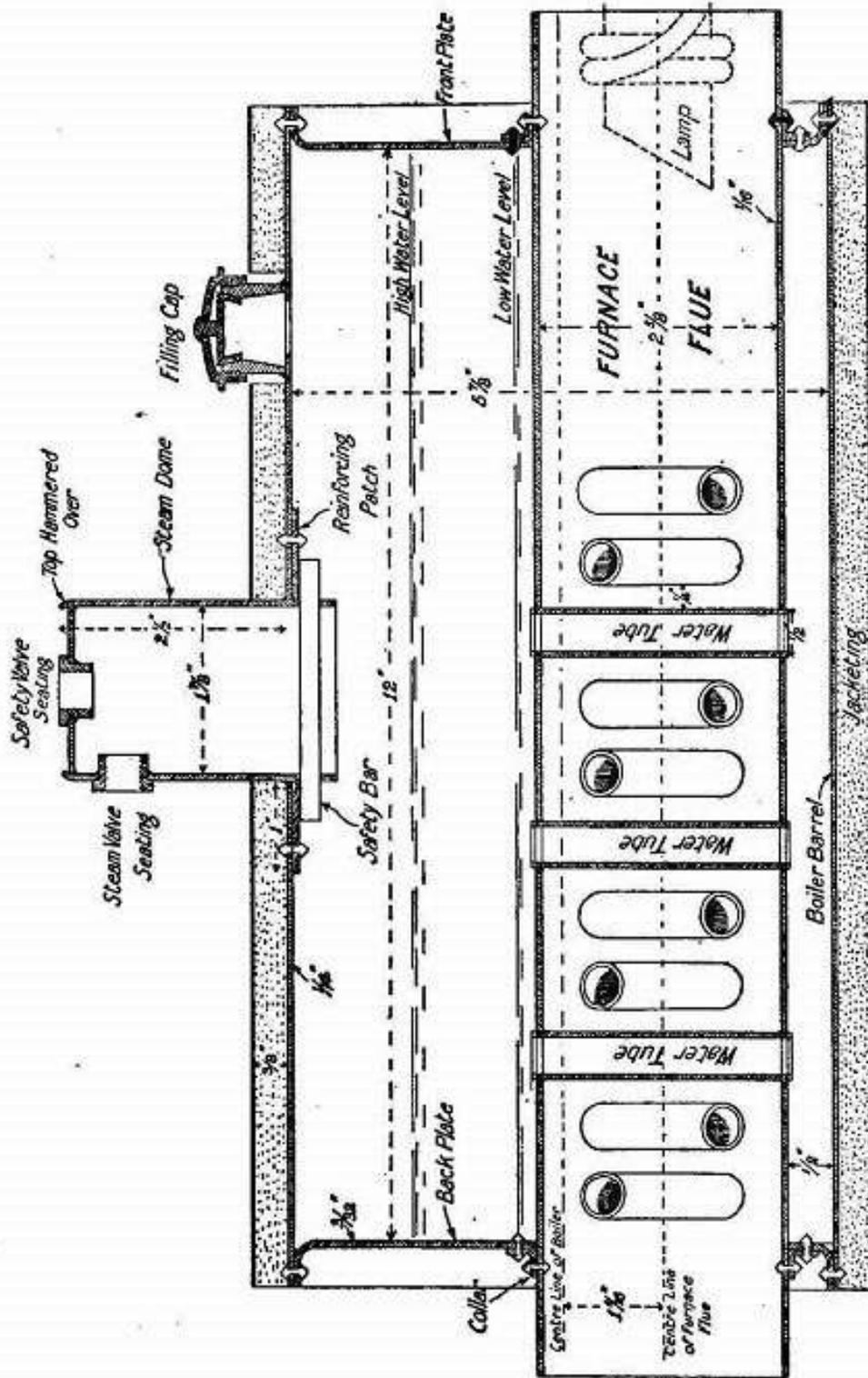


FIG. 82.—Longitudinal section of large water-tube boiler.

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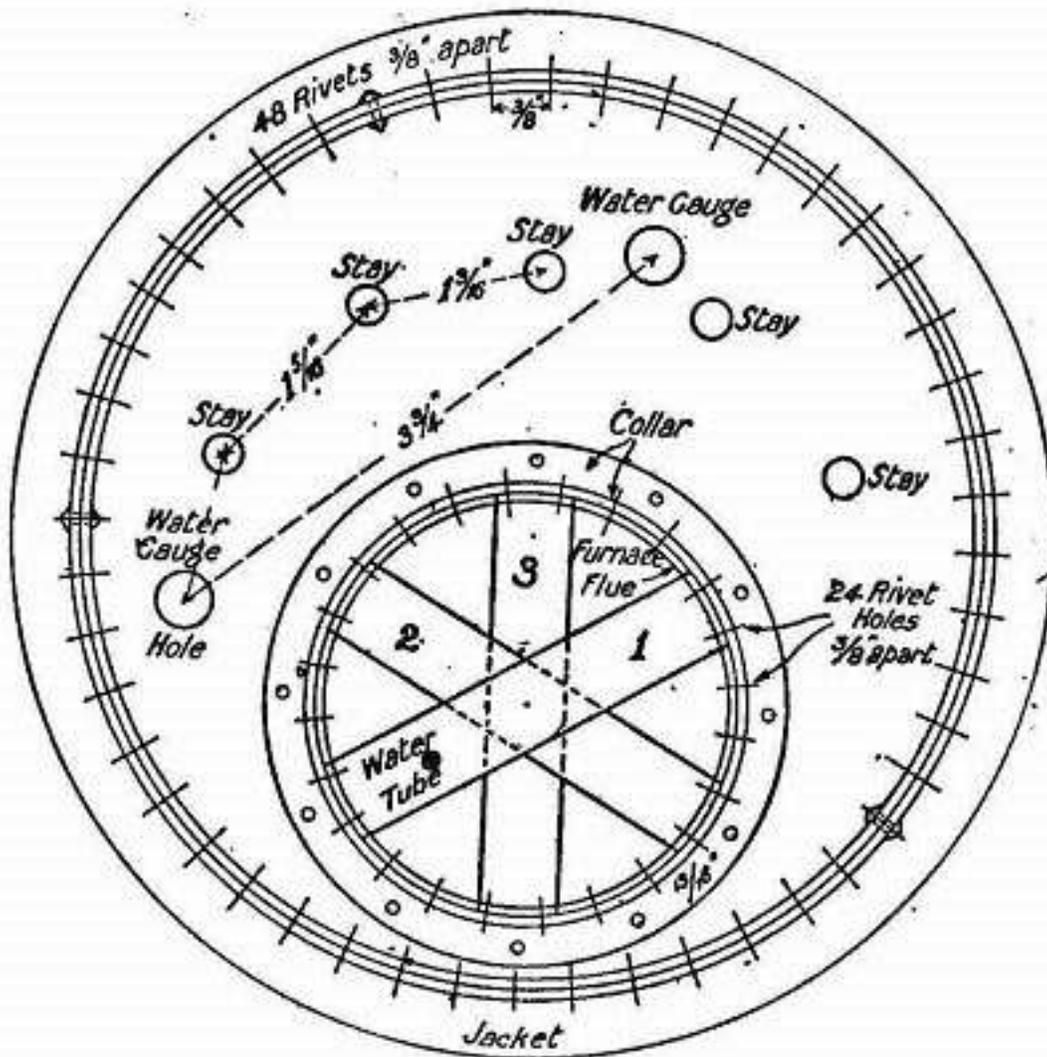


FIG. 83.—End of horizontal boiler, showing position of holes for stays and fittings.

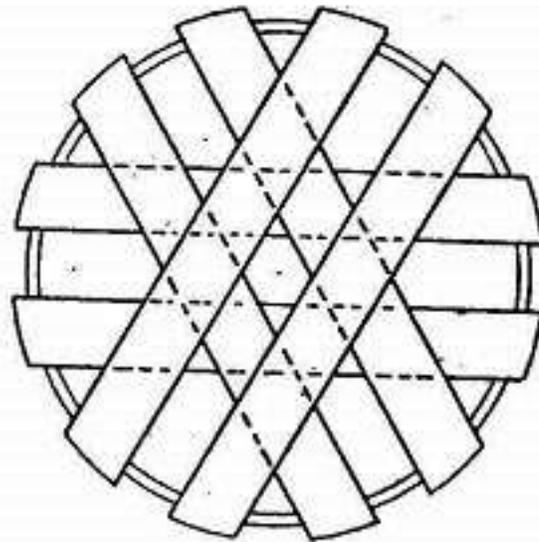


FIG. 84.—Doubled cross tubes in horizontal boiler flue.

The Steam Dome

The large holes -- 2 inches in diameter -- required for the steam dome render it necessary to strengthen the barrel at this point. Cut out a circular plate of metal 4 inches across, make a central hole of the size of the steam dome, and bend the plate to the curve of the inside of the barrel. Tin the contact faces of the barrel and "patch" and draw them together with screws or rivets spaced as shown in Figure 85, and sweat solder into the joint. To make it impossible for the steam dome to blowout, let it extend half

an inch through the barrel, and pass a piece of 1/4-inch brass rod through it in contact with the barrel. The joint is secured with hard solder. Solder the top of the dome in 1/8 inch below the end of the tube, and burr the end over. The joint should be run again afterwards to ensure its being tight.

Chimney

This should be an elbow of iron piping fitting the inside of the flue closely, made up of a 9-inch and a 4-inch part. The last slips into the end of the flue; the first may contain a coil for superheating the steam.

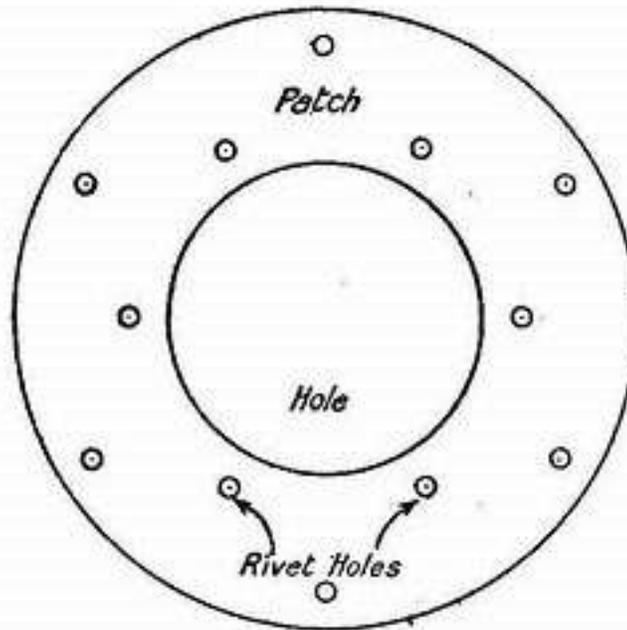


FIG. 85.—Showing how to mark out strengthening patch round steam dome hole.

A Multi-Tube Boiler

Figs. 86 and 87 are respectively end and side elevations of a multi-tube boiler having over 600 square inches of heating surface -- most of it contributed by the tubes -- and intended for firing with solid fuel.

The boiler has a main water-drum, A, 5 inches in diameter and 18 inches long, and two smaller water-drums, B and C, 2-1/2 by 18 inches, connected by two series of tubes, G and H, each set comprising 20 tubes. The H tubes are not exposed to the fire so directly as the G tubes, but as they enter the main drum at a higher point, the circulation is improved by uniting A to B and C at both ends by large

1-inch drawn tubes, F. In addition, B and C are connected by three 3/4-inch cross tubes, E, which prevent the small drums spreading, and further equalize the water supply. A 1-1/2-inch drum, D, is placed on the top of A to collect the steam at a good distance from the water.

Materials

In addition to 1-1/2 feet of 5 by 3/32 inch solid-drawn tubing for the main, and 3 feet of 2-1/2 by 1/16 inch tubing for the lower drums, the boiler proper requires 22-1/2 feet of 1/2-inch tubing, 19 inches of 3/4-inch tubing, 2-1/4 feet of 1-inch tubing, 1 foot of 1-1/2-inch tubing, and ends of suitable size for the four drums.

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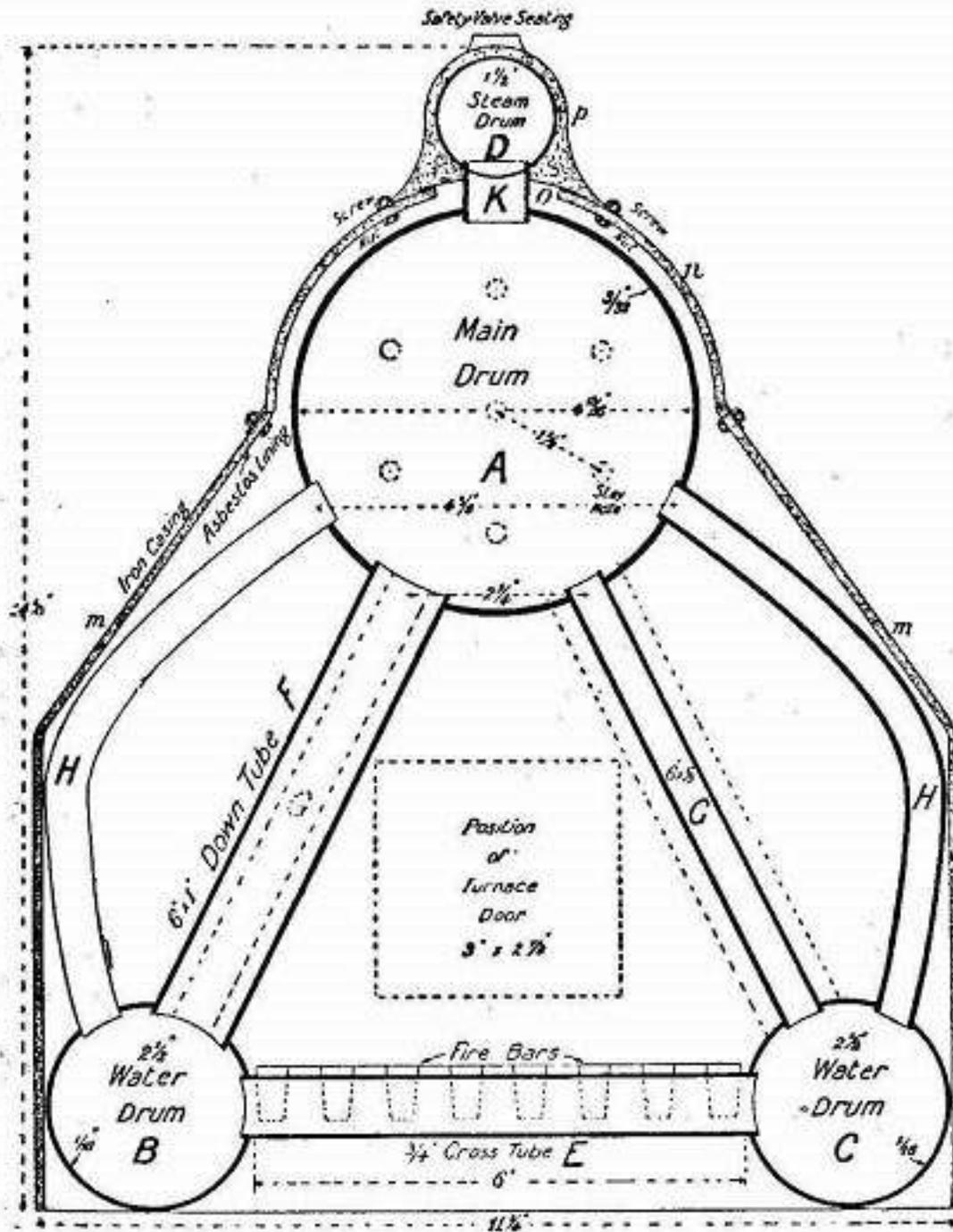


FIG. 86.—Cross section of multitubular boiler.

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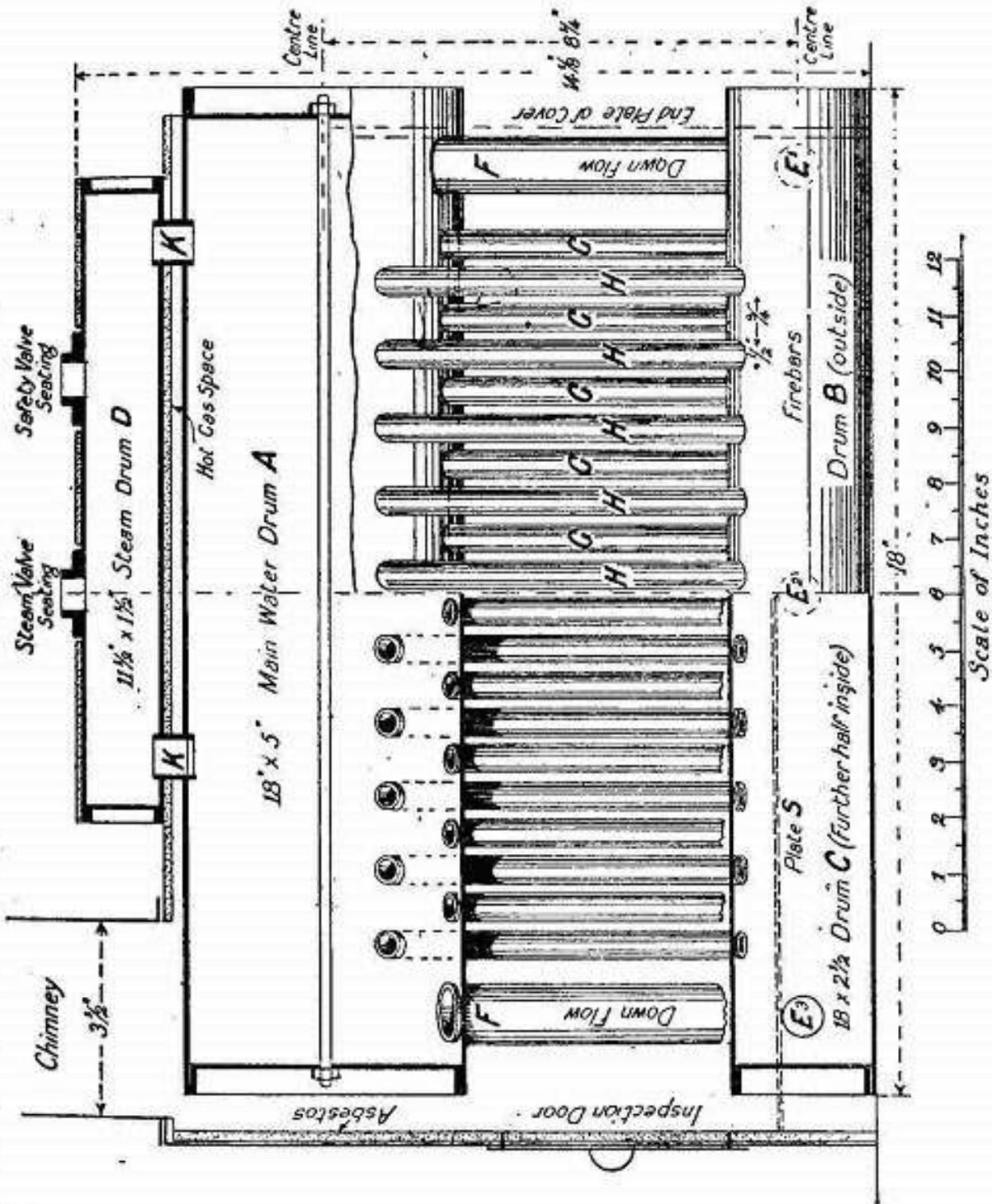


FIG. 87.—Longitudinal section of multitubular boiler.

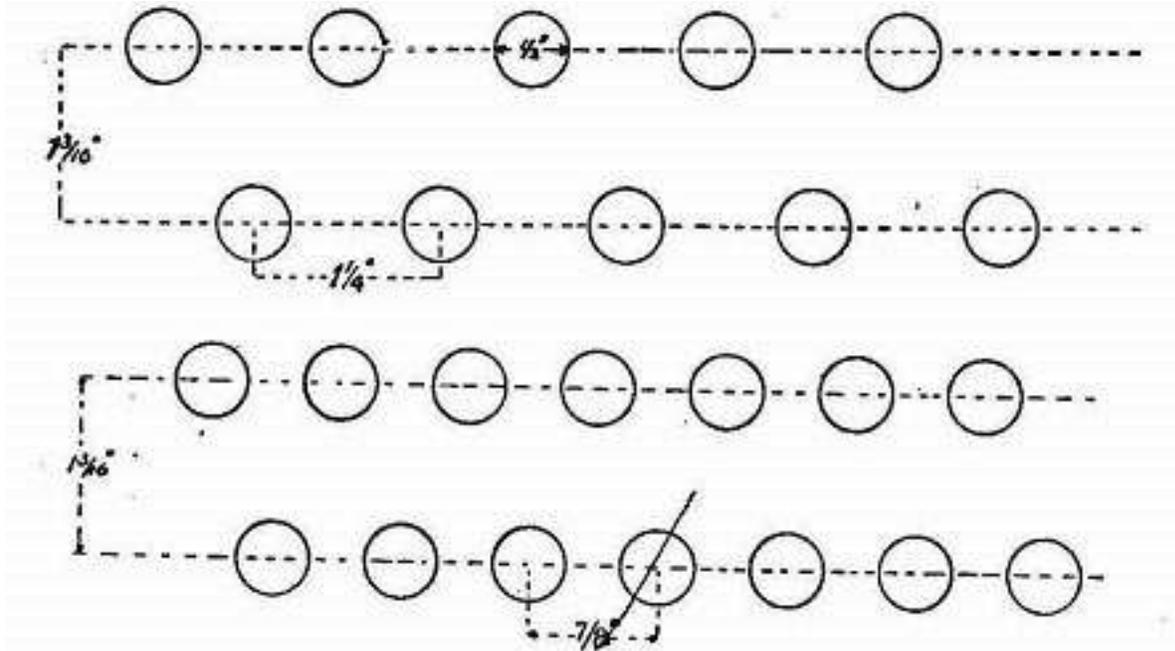


FIG. 88.—Two arrangements for tube holes in multitubular boiler.

CONSTRUCTION

The centres for the water-tubes, G and H, should be laid out, in accordance with Figure 88, on the tops of B and C and the lower part of A, along lines scribed in the manner explained on p. 207. Tubes H must be bent to a template to get them all of the same shape and length, and all the tubes be prepared before any are put in place. If the tubes are set $7/8$ inch apart, center to center, instead of $1-1/4$ inches, the heating surface will be greatly increased and the furnace casing better protected.

Assembling

When all necessary holes have been made and are of the correct size, begin by riveting and silver-soldering in the ends of the drums. Next fix the cross tubes, E, taking care that they and B and C form rectangles. Then slip the F, G, and H tubes half an inch into the

main drum, and support A, by means of strips passed between the G and H tubes, in its correct position relatively to B and C. The E tubes can now be pushed into B and C and silver-soldered. The supports may then be removed, and the G and H tubes be got into position and secured. Drum D then demands attention. The connecting tubes, KK, should be silver-soldered in, as the boiler, if properly made, can be worked at pressures up to 100 lbs. per square inch.

The casing is of $1/20$ -inch sheet iron, and in five parts. The back end must be holed to allow A, B, and C to project 1 inch, and have a furnace-door opening, and an airway at the bottom, 5 inches wide and 1 inch deep, cut in it. The airway may be provided with a flap, to assist in damping down the fire if too much steam is being raised. In the front end make an inspection opening to facilitate cleaning the tubes and removing cinders, etc.

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The side plates, *m m*, are bent as shown in Figure 86, and bolted to a semicircular top plate, *n*, bent to a radius of 6 inches. A slot, 1-1/2 inches wide and 11-1/2 inches long, must be cut in the top, *n*, to allow it to be passed over drum D; and there must also be a 3 or 3-1/2 inch hole for the chimney. A plate, *p*, covers in D. A little plate, *o*, is slipped over the slot in *n*, and asbestos is packed in all round D. The interior of the end, side, and the top plates should be lined with sheet asbestos held on by large tin washers and screw bolts. To protect the asbestos, movable iron sheets may be interposed on the furnace side. These are replaced easily if burnt away. The pieces *m m* are bent out at the bottom, and screwed down to a base-plate extending the whole length of the boiler.

The fire-bars fill the rectangle formed by the tubes B, E1, and E2. A plate extends from the top of E2 to the front plate of the casing, to prevent the furnace draft being "short

circuited."

Boiler Fittings

Safety Valves

The best all-round type is that shown in Figure 89. There is no danger of the setting being accidentally altered, as is very possible with a lever and sliding weight. The valve should be set by the steam gage. Screw it down, and raise steam to the point at which you wish the safety valve to act, and then slacken off the regulating nuts until steam issues freely. The lock nuts under the cross-bar should then be tightened up. In the case of a boiler with a large heating surface, which makes steam quickly, it is important that the safety-valve should be large enough to master the steam. If the valve is too small, the pressure may rise to a dangerous height, even with the steam coming out as fast as the valve can pass it.

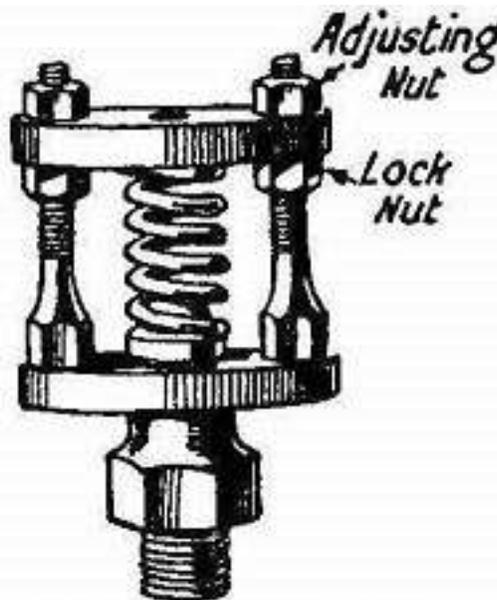


FIG. 89.—Safety valve.

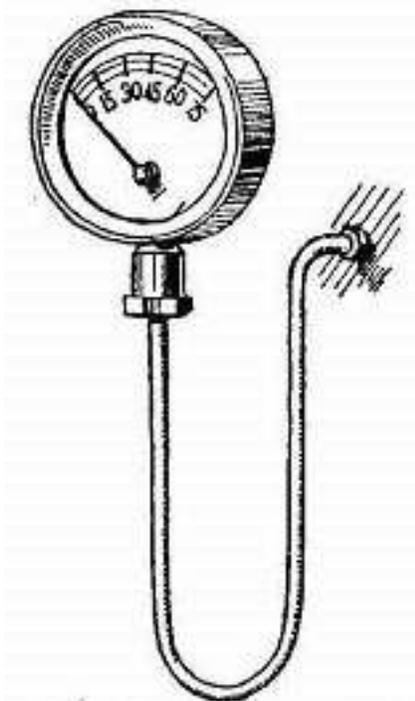


FIG. 90.—Steam gauge and siphon.

Steam Gages

The steam gage should register pressures considerably higher than that to be used, so that there may be no danger of the boiler being forced unwittingly beyond the limit

registered. A siphon piece should be interposed between boiler and gage (Figure 90), to protect the latter from the direct action of the steam. Water condenses in the siphon, and does not become very hot.

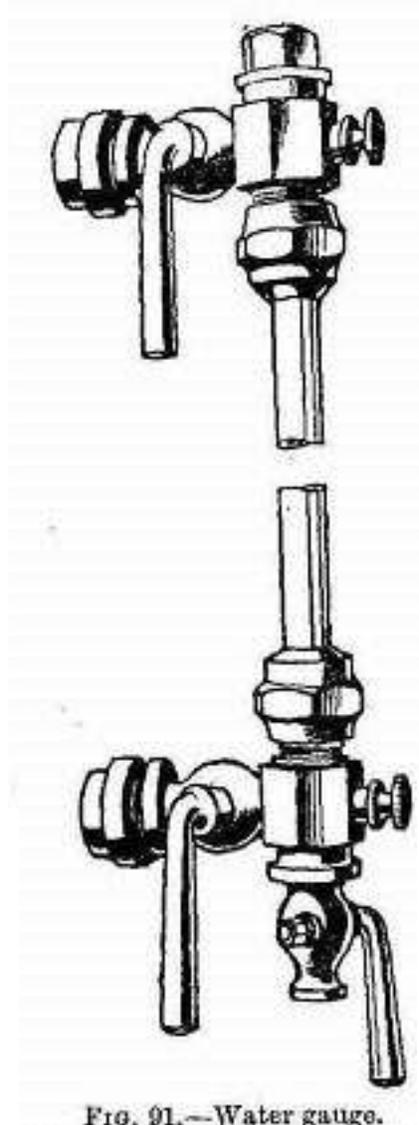


FIG. 91.—Water gauge.

Water Level Gages...

... should have three taps (Figure 91), two between glass and boiler, to cut off the water if the glass should burst, and one for blowing off through. Very small gages are a mistake, as the water jumps about in a small tube. When fitting a gage, put packings between the

bushes and the glass-holders, substitute a piece of metal rod for the glass tube, and pack the rod tightly. If the bushes are now sweated into the boiler end while thus directed, the gage must be in line for the glass. This method is advisable in all cases, and is necessary if the boiler end is not perfectly flat.

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Pumps

Where a pump is used, the supply should enter the boiler below low-water level through a non-return valve fitted with a tap, so that water can be prevented from blowing back through the pump.

Filling Caps

The filling cap should be large enough to take the nozzle of a good-sized funnel with some room to spare. Beat the nozzle out of shape, to give room for the escape of the air displaced by the water.

The best form of filling cap has a self-seating ground plug, which, if properly made, is steam-tight without any packing. If needed, asbestos packing can easily be inserted between plug and cap.

Mud-holes

All but the smallest boilers should have a mud-hole and plug in the bottom at a point not directly exposed to the furnace. In Figure

82 it is situated at the bottom of the barrel. In Figs. 86 and 87 there should be a mud-hole in one end of each of the three drums, A, B, and C. The plug may be bored at the center for a blow-off cock, through which the boiler should be emptied after use, while steam is up, and after the fire has been "drawn." Emptying in this way is much quicker than when there is no pressure, and it assists to keep the boiler free from sediment.

Steam Cocks

The screw-down type (Figure 92) is very preferable to the "plug" type, which is apt to leak and stick.

Testing Boilers

The tightness of the joints of a boiler is best tested in the first instance by means of compressed air. Solder on an *all-metal* cycle valve, "inflate" the boiler to a considerable pressure, and submerge it in a tub of water. The slightest leak will be betrayed by a string of bubbles coming

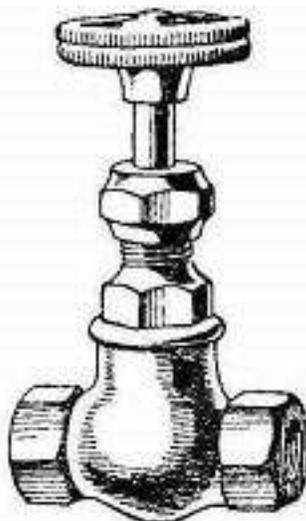


FIG. 92.—Steam cock.

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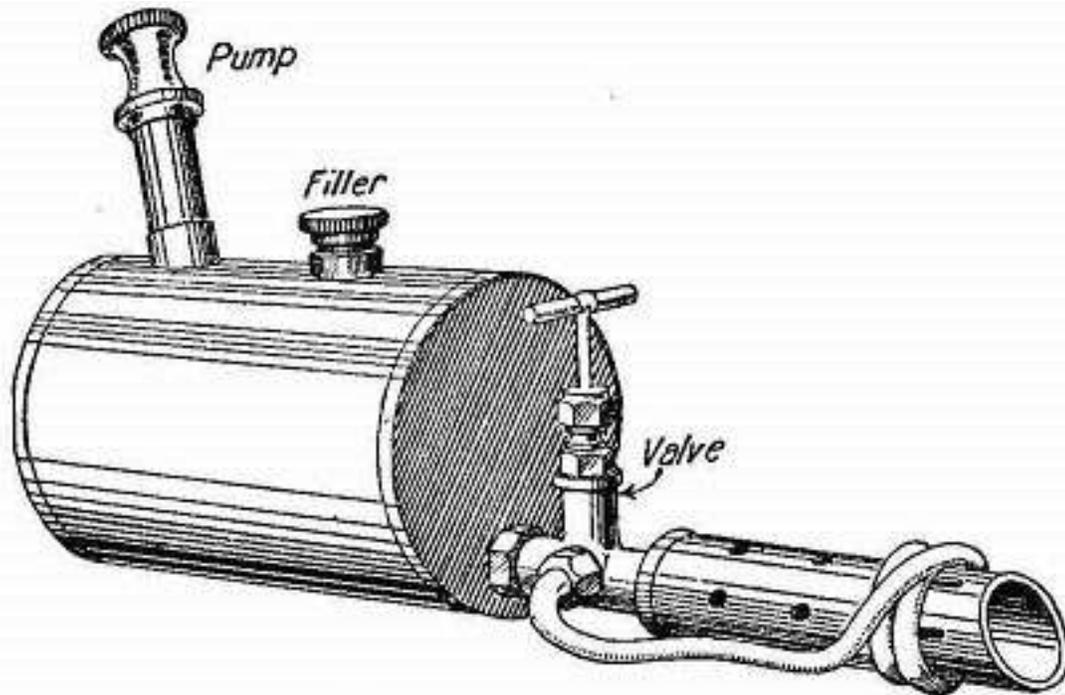


FIG. 94.—Benzoline lamp for model central-flue boiler.

directly from the point of leakage. Mark any leaks by plain scratches, solder them up, and test again.

The boiler should then be quite filled with cold water, and heated gradually until the pressure gage has risen to over the working pressure. There is no risk of an explosion, as the volume of the water is increased but slightly.

The third test is the most important and most risky of all—namely, that conducted under steam to a pressure well above the working pressure.

In order to carry out the test without risk, one needs to be able to watch the steam-gage from a considerable distance, and to have the fire under control. My own method is to set the boiler out in the open, screw down the safety-valve so that it cannot lift, and raise steam with the help of a blow-lamp, to which a string is attached wherewith to pull it backwards along a board. If the boiler is to be

worked at 50 lbs., I watch the steam gage through a telescope until 100 lbs. is recorded, then draw the lamp away. After passing the test, the boiler, when pressure has fallen, say, 20 lbs., may safely be inspected at close quarters for leaks.

This test is the only quite satisfactory one, as it includes the influence of high temperature, which has effects on the metal not shown by "cold" tests, such as the hydraulic.

Do not increase your working pressure without first re-testing the boiler to double the new pressure to be used.

Fuels

For very small stationary boilers the methylated spirit lamp is best suited, as it is smell-less, and safe if the reservoir be kept well apart from the burner and the supply is controllable by a tap or valve. (See Figure 104.)

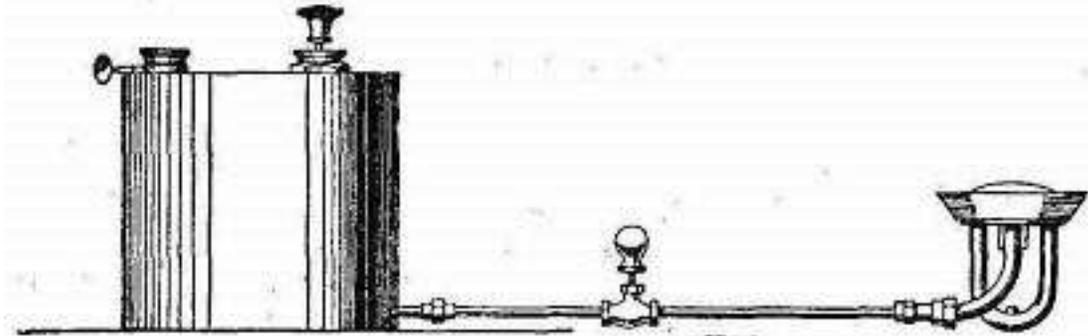


FIG. 95.—Paraffin burner for vertical boiler.

For medium-sized model boilers, and for small launch boilers, benzoline or petrol blow-lamps and paraffin stoves have become very popular, as they do away with stoking, and the amount of heat is easily regulated by governing the fuel supply. Figure 94 is a sketch of a blow-lamp suitable for the horizontal boiler, while Figure 95 shows a convenient form of paraffin stove with silent "Primus" burner, which may be used for a horizontal with considerable furnace space or for vertical boilers. In the case of all these liquid fuel consumers, the amount of heat developed can be increased by augmenting the number of burners. Where a gas supply is available its use is to be recommended for small stationary boilers.

Solid Fuels

The chief disadvantages attaching to these are smoke and fumes; but as a solid fuel gives better results than liquid in a large furnace, it is preferred under certain conditions, one of them being that steam is not raised in a living room. Charcoal, coke, anthracite coal, and ordinary coal partly burned are the fuels to use, the fire being started with a liberal supply of embers from an open fire. Every solid-fuel boiler should have a steam-blower in the chimney for drawing up the fire; and if a really fierce blaze is aimed at, the exhaust from the engine should be utilized for the same purpose.

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