BOILER FITTINGS

Serial 2023 Edition 1

STEAM-GENERATOR FITTINGS

STEAM AND WATER RESERVOIRS

STEAM DOMES

1. A steam dome is a cylindrical vessel riveted to the shell of a horizontal power boiler for the purpose of increasing the steam space, and also for the purpose of drying the steam, the supposition being that the steam will be dried on account of its being farther removed from the water. The hole cut in the boiler shell to allow the steam to pass from the boiler into the dome should be made only large enough to allow a man to pass through, since a large hole materially weakens the shell. The edge of the plate around the hole should be reinforced by a wrought-iron ring riveted to it. Small holes should be drilled through the shell plate at each side of the boiler inside of the dome, where a depression is formed, to allow the water that accumulates there to drain back into the boiler. The dome flange fitting the boiler shell is called the *saddle,* and should be double-riveted to the shell. Steam domes usually have a diameter equal to half the diameter of the boiler, and a height equal to about nine-sixteenths the diameter of the boiler, the proportions given being the average in modern practice.

2. The top of the steam dome is closed by the dome head, which formerly was made of cast iron. Owing, however, to the frequent occurrence of hidden imperfections in cast iron, this material is not safe for the high pressures now commonly carried on boilers, and its use for dome heads has been almost entirely abandoned. In the best modern practice, flanged and crowned steel heads are used, the head being crowned to a radius sufficient to make it stiff enough to withstand the pressure without additional bracing. When flanged flat steel heads are used, they must be well braced by diagonal braces.

In the case of cast-iron sectional boilers, the top section frequently forms the steam dome, being made of greater capacity than the intermediate sections. To it are attached the safety valve, pressure gauge, gauge glass, try cocks, and damper regulator.

STEAM DRUMS

3. Boilers are often fitted with steam drums. The steam drum is simply a cylindrical vessel connected to the shell, its purpose being to provide additional steam space. When several boilers are set so as to form a battery, they are often connected to a drum common to all the boilers. When each boiler has its own furnace, there should be a stop-valve between each boiler and the drum to allow the boiler to be taken out of service when required. When the boilers in battery have a furnace common to all, no stop-valve should ever be placed in the pipe connections between each boiler and the drum. Where boilers are in battery with separate furnaces, each boiler must have its own safety valve, which should always be so fitted that it cannot be cut off from the boiler under any circumstances.

MUD-DRUMS

4. A mud-drum is a cylindrical vessel sometimes attached to a power boiler for the purpose of providing a quiet place for the collection of any mud and sediment that is in mechanical suspension in the feedwater, which, in such case, is fed into the mud-drum. It is located underneath the boiler and at the rear end, being connected to the boiler by a suitable nozzle usually of cast iron. Where several boilers are set in battery, they are sometimes connected to a common mud-drum. This practice is permissible when the whole battery is used at once. When so fitted, none of the boilers can be temporarily taken out of service unless each nozzle is provided with a stop-valve. Owing to the difficulty of protecting the valve from the fire, this is rarely done. This consideration limits the use of a common mud-drum to cases where all the boilers are worked together. When a mud-drum is fitted, the blow-off should be attached to it and the sediment that collects in the drum should be frequently blown out.

BOILER SAFETY DEVICES

SAFETY VALVES

5. The safety valve is a device attached to a boiler to prevent the steam pressure from rising above a certain safe point. It consists simply of a plate, or disk, fitting over a hole in the boiler shell, and held to its place in one of three ways: (1) By a dead-weight; (2) by a weight on a lever; and (3) by a spring. The weight or spring is so adjusted that when the steam reaches the desired pressure the disk is raised from its seat, and the surplus steam escapes through the opening in the shell.

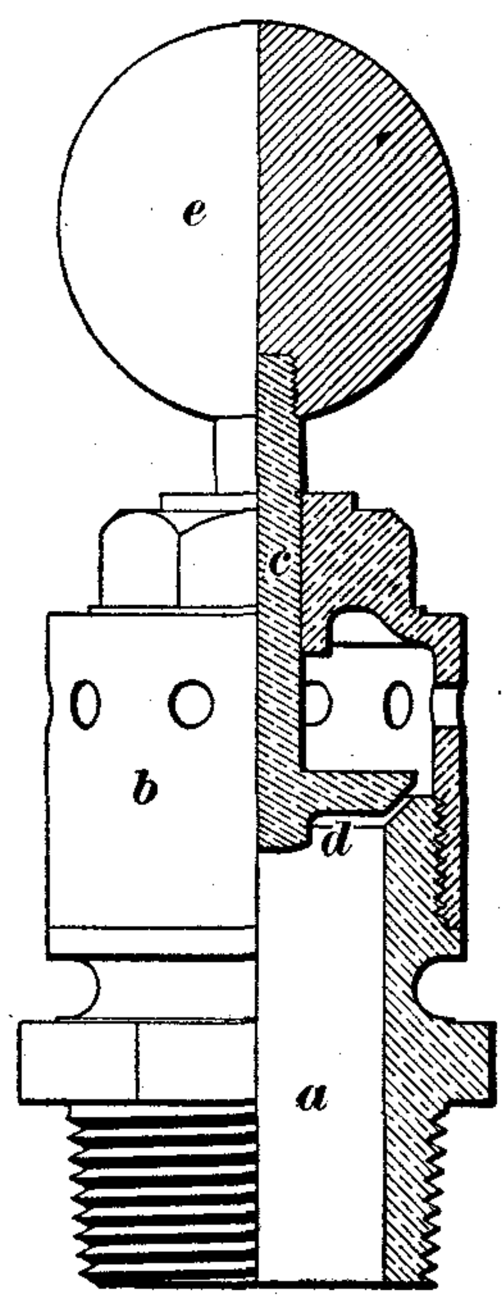


FIG. 1

6. The dead-weight safety valve, in modern practice, is used only for low-pressure boilers. It has the advantage of simplicity and compactness. The construction of a modern dead-weight safety valve is shown in Fig. 1. It consists of a shell *a* screwed in the top of the boiler, the upper part forming the valve seat. The cap *b,* which is perforated to allow the steam to escape, forms the guide for the valve stem *c*. The valve disk *d* closes the opening. The dead-weight resisting the steam pressure consists of the ball *e* and the weight of the valve and stem, and this dead-weight is such that the valve will be raised off its seat, as shown in the illustration, when the steam pressure exceeds 10 pounds per square inch. On special order, valves of the form shown can be obtained weighted for other pressures than 10 pounds.

7. A lever safety valve is shown in Fig. 2. The steam from the boiler enters at *s* and escapes at *r* when the steam pressure is sufficient to raise the valve *v* off its seat. The valve is held to its seat by the weight *w* hung from the lever *l*. The load on the valve is changed by shifting the weight along the lever. Notches are cut into the lever, and figures stamped below the notches indicate the pressure, in pounds per square inch, at which steam will blow off when the weight is hung in the notch above the figures.

8. A spring-loaded safety valve is shown in Fig. 3. The valve *a* is held down by a helical spring *b*, the tension of which can be altered by the screw-cap *c*. When the boiler pressure rises sufficiently to lift the valve, the steam escapes into the chamber *d* and thence to the atmosphere through a pipe attached at *e*. Owing to the abrupt manner in which the valve opens and closes, it is often called a *pop safety valve.*

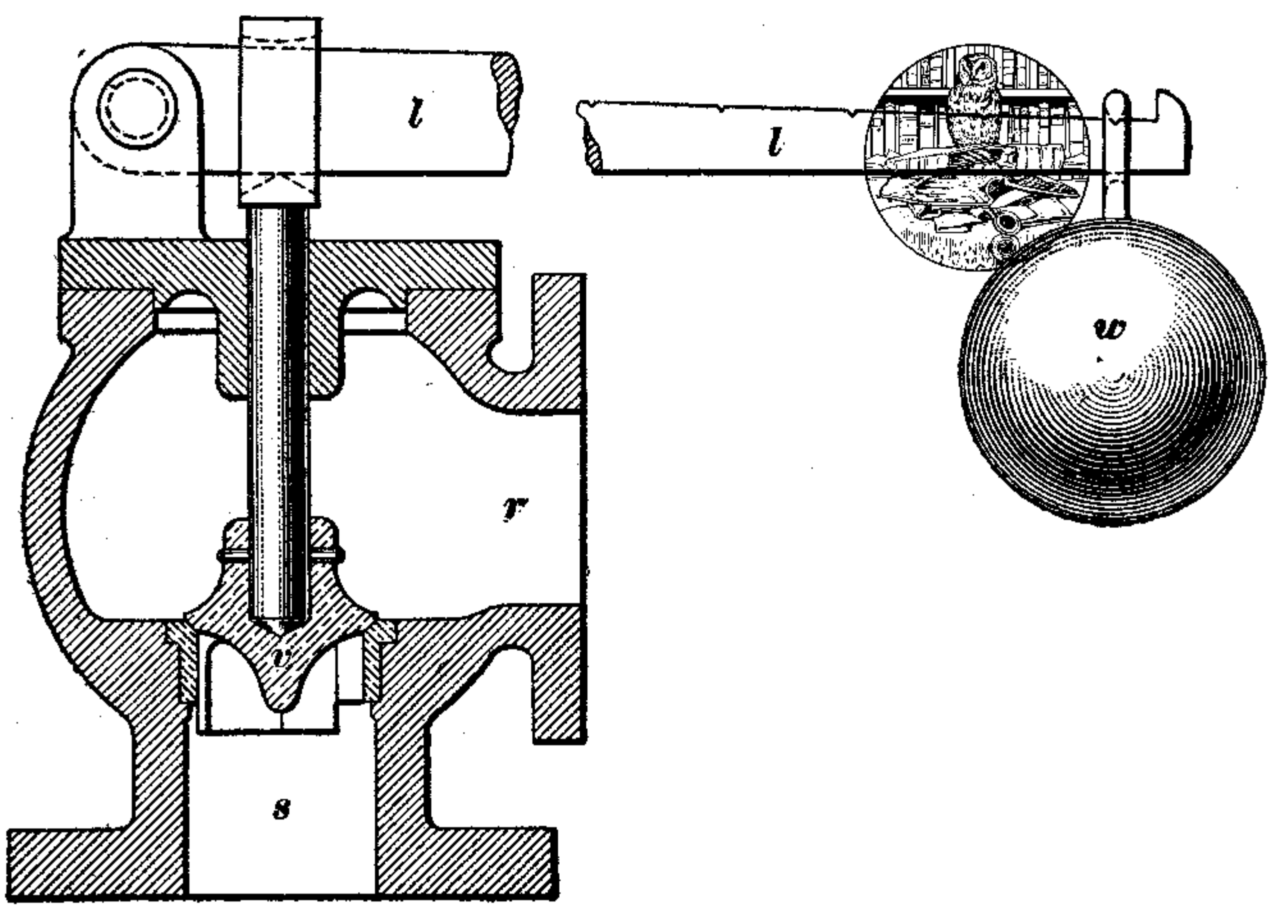


FIG. 2

Spring-loaded safety valves are adjusted to the blowing-off pressure desired by getting up a steam pressure in the boilers to which they are attached, and when the steam gauge indicates the desired blowing-off pressure, the tension of the spring is decreased until the valve opens.

Dead-weight and lever safety valves do not open fully until the pressure in the boiler exceeds, by several pounds, the pressure for which the valve is set. Pop valves, however, operate promptly, and close just as promptly, and for this reason are deservedly preferred. Another reason for preferring the spring valve is that it can be enclosed in a case and locked up, so as to prevent all changing or tampering by unauthorized persons.

9. The area of a safety valve should be large enough to discharge the steam as rapidly as the boiler can generate it. The size of the valve relative to the size of boiler and working pressure is prescribed by law in many localities, and must be made to conform to the law wherever such law is in existence. In localities having no law governing this matter, the size of the safety valve may be calculated by the rule prescribed by the Bureau of Steam Boiler Inspection of the city of Philadelphia, Pennsylvania, which rule is also used by the Hartford Steam Boiler Inspection and Insurance Company. Many other rules differing widely in their results are in use, but the rule here given has stood the test of time, and is unqualifiedly endorsed for boilers working under natural draft.

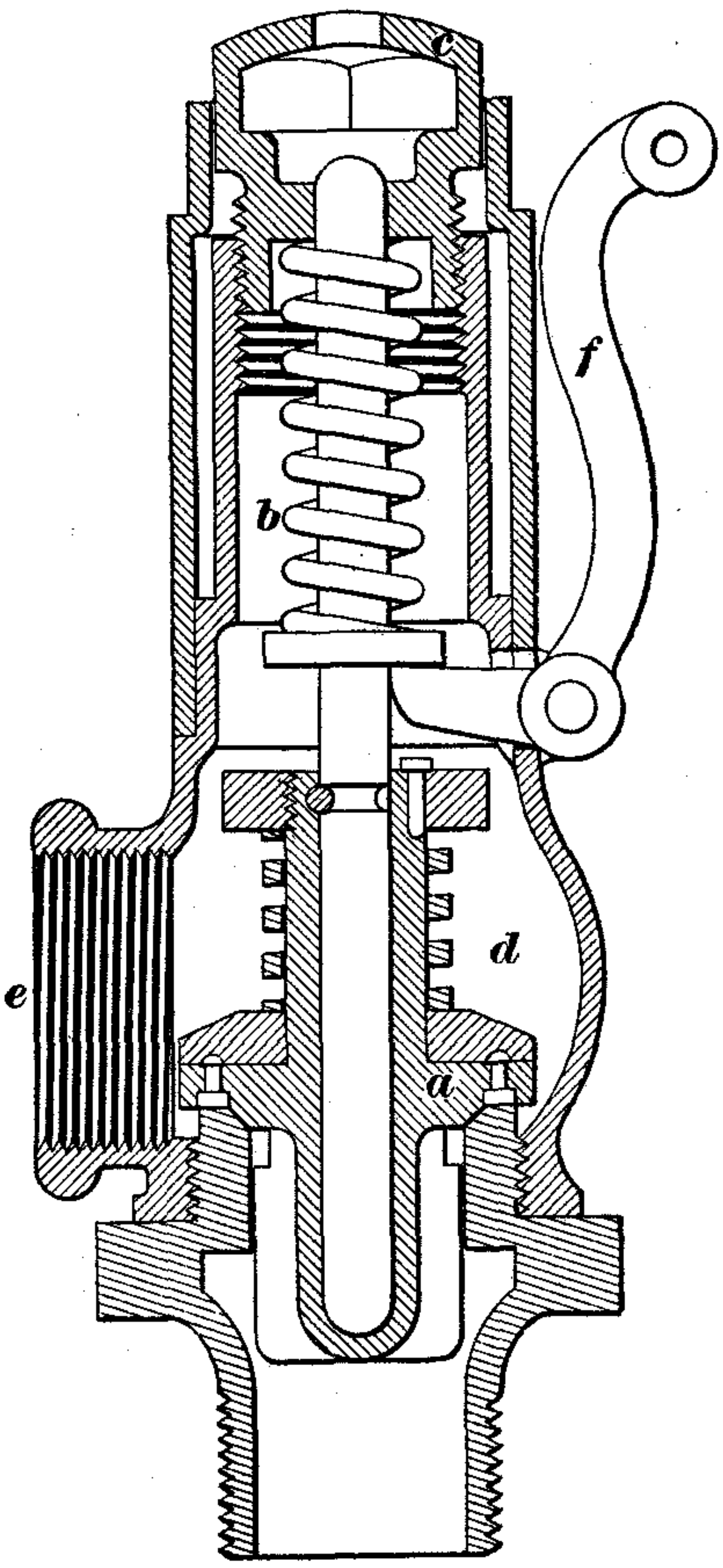


FIG. 3

Rule.—*To find the area of a safety valve, in square inches, multiply the grate surface of the boiler, in square feet, by 22.5. Divide the product by the sum of the gauge pressure it is proposed to carry, in pounds per square inch, and 8.62.*

Stated as a formula, this rule becomes

$$A = \frac{22.5G}{P + 8.62}$$

in which A = area of safety valve, in square inches;
G = grate surface, in square feet;
P = gauge pressure, in pounds per square inch.

EXAMPLE.—What area of safety valve is required for a boiler having a grate surface of 24 square feet and that is to carry a pressure of 70 pounds per square inch?

SOLUTION.—Apply the rule just given, and the area is found to be

$$A=\frac{22.5\times 24}{70+8.62}=6.87 \text{ sq. in. Ans.}$$

10. It is common practice in some localities to connect a pipe to the blow-off side of the safety valve for the purpose of carrying the steam blown off to the outside of the building. Such an escape pipe, while harmless enough when of sufficient area and kept well drained, may become a source of danger if no provision is made for draining it constantly. Instances are not rare where, owing to the absence of a drain pipe, the escape pipe has become filled with water, thus adding greatly to the external force acting on the valve and rendering it inoperative for the blow-off pressure for which it was set. When an escape pipe is used at all, it should not be of smaller diameter than the valve, and should have a drain pipe of ample size at its lowest point. No cock or valve should under any circumstances be placed in this drain pipe.

11. The safety valve should in all cases be attached to the boiler in such a manner that it is an absolute impossibility to shut off connection between the boiler and its safety valve. It should be fitted with a chain, leading to some convenient spot, for raising the valve off its seat. The spring-loaded safety valve usually has a bell-crank lever, as *f*, Fig. 3, to which the chain is attached.

PRESSURE GAUGES

12. The steam gauge indicates the pressure of the steam contained in the boiler. The most common form is the Bourdon pressure gauge, the distinguishing feature of which is a bent elliptical tube tending to straighten out under an internal pressure. Bourdon pressure gauges are made in various ways by different manufacturers; a very common design is shown in Fig. 4. It consists of a tube *a*, of elliptical cross-section, that is filled with water and connected at *b* with a pipe leading to the boiler. The two ends, as at *c*, are closed and are attached to a link *d*, which is in turn connected with a quadrant *e*; this quadrant gears with a pinion *f* on the axis of the pointer *g*. When the water contained in the elliptical tube is subjected to pressure, the tube tends to take a circular form, and, as a whole, straightens out throwing out the free ends a distance proportional to the pressure. The movement of the

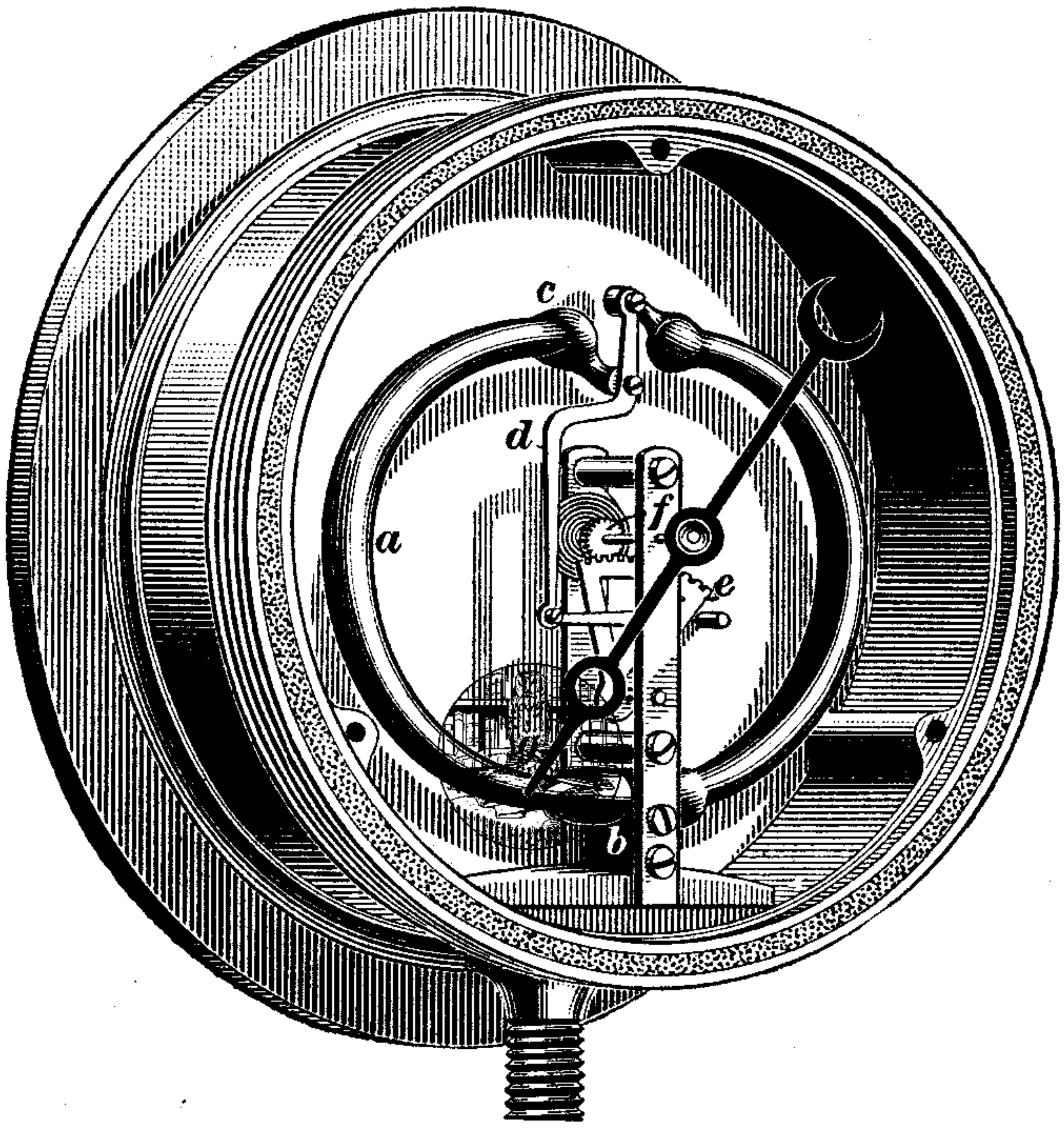
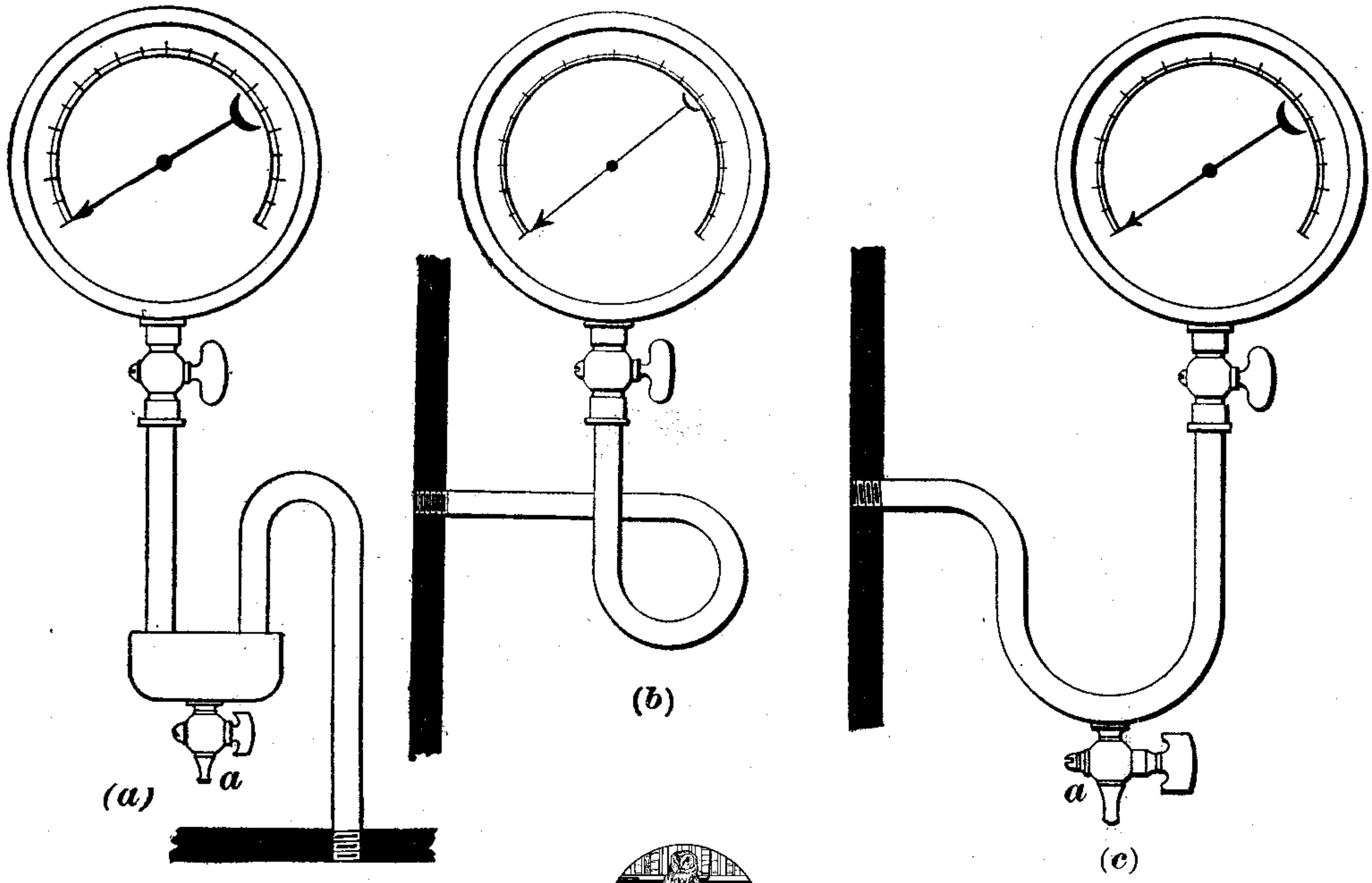


FIG. 4

free ends is transmitted to the pointer by the link, rack, and pinion, and the pressure is thus recorded on a graduated dial in front, which has been removed in order to show the mechanism.

Pressure gauges for indicating steam pressure are invariably graduated to indicate pressure in pounds per square inch, wherever the English system of weights and measures is used, and show how much the pressure has been increased above the atmospheric pressure.

13. The pressure gauge should be connected to the boiler in such a manner that it will neither be injured by heat nor indicate a wrong pressure. To prevent injury from heat, a so-called siphon, which may be made as shown in Fig. 5 (*a*) or (*b*), is usually placed between the gauge and the boiler. This siphon in a short time becomes filled with condensed steam that protects the spring of the gauge from the injury the hot steam would



cause. Care should be taken not to locate the steam-gauge pipe near the main steam outlet of the boiler, since this may cause the gauge to indicate a lower pressure than really exists.

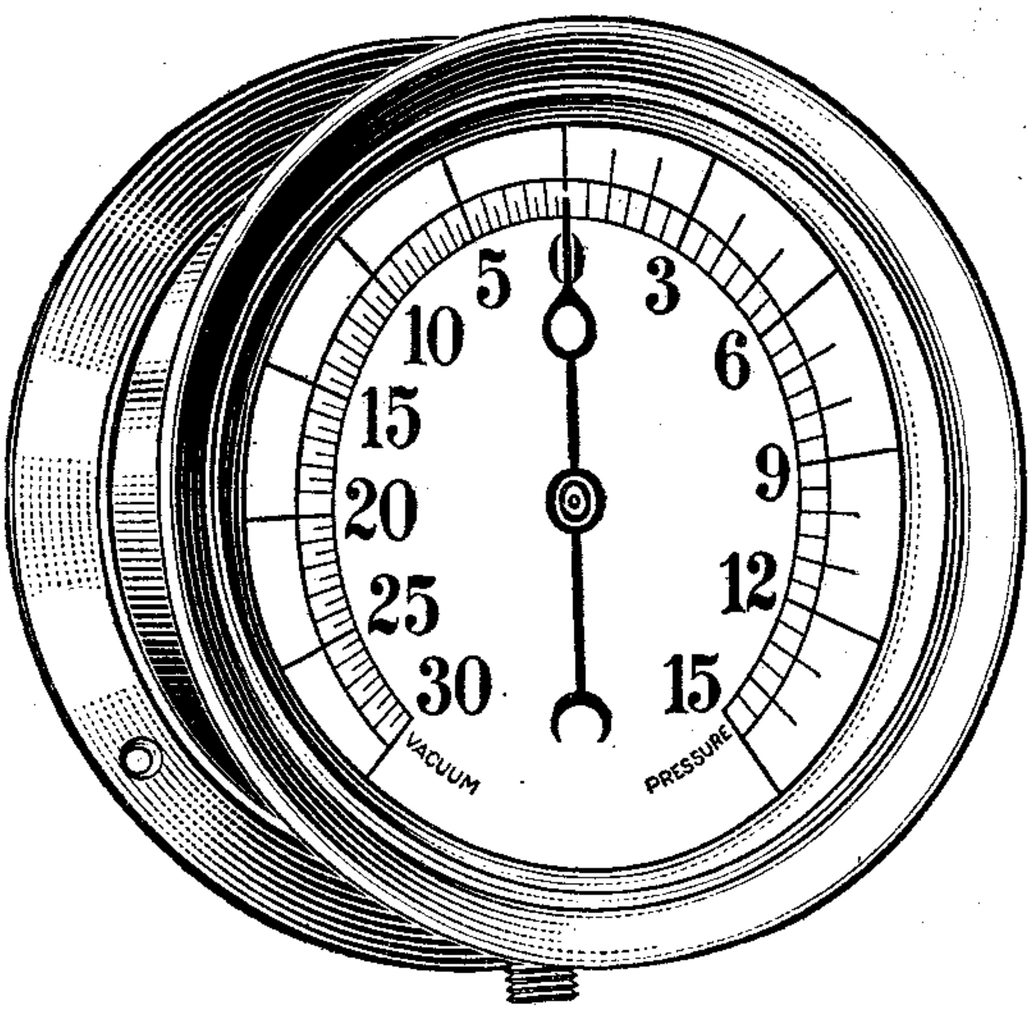


Fig. 6

In locating the steam gauge, care must also be taken not to run the connecting pipe in such a manner that the accumulation of water in it will cause an extra pressure to be shown.

The gauge connection shown in Fig. 5 (*b*) cannot be drained without first being disconnected. To obviate this drawback, the gauge may be connected as shown in (*c*), a petcock *a* being placed at the lowest point.

14. A compound pressure and vacuum gauge is shown in Fig. 6. The scale over which the end of the pointer moves is in two sections. That part which is graduated from 0 to 15 indicates pressures per square inch, in pounds, and that part which is graduated from 0 to 30 indicates vacuum, in inches of mercury. As one pound per square inch corresponds to practically $\frac{1}{2}$ inch of height of mercury column, the equal graduations from 0 to 30 are half the size of those from 0 to 15. Such a gauge is intended for use on a vacuum heating system, or for any service where either pressure or vacuum is to be indicated.

GLASS WATER GAUGES

15. The gauge glass is a glass tube whose lower end communicates with the water space of the boiler and whose upper end is in communication with the steam space. Hence,

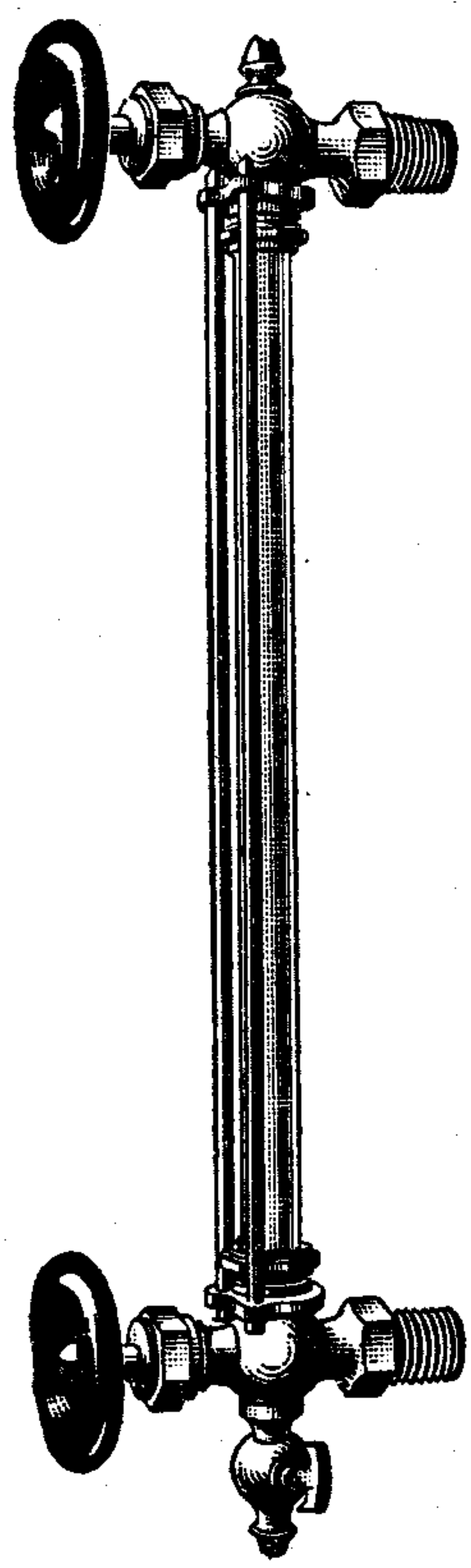


FIG. 7

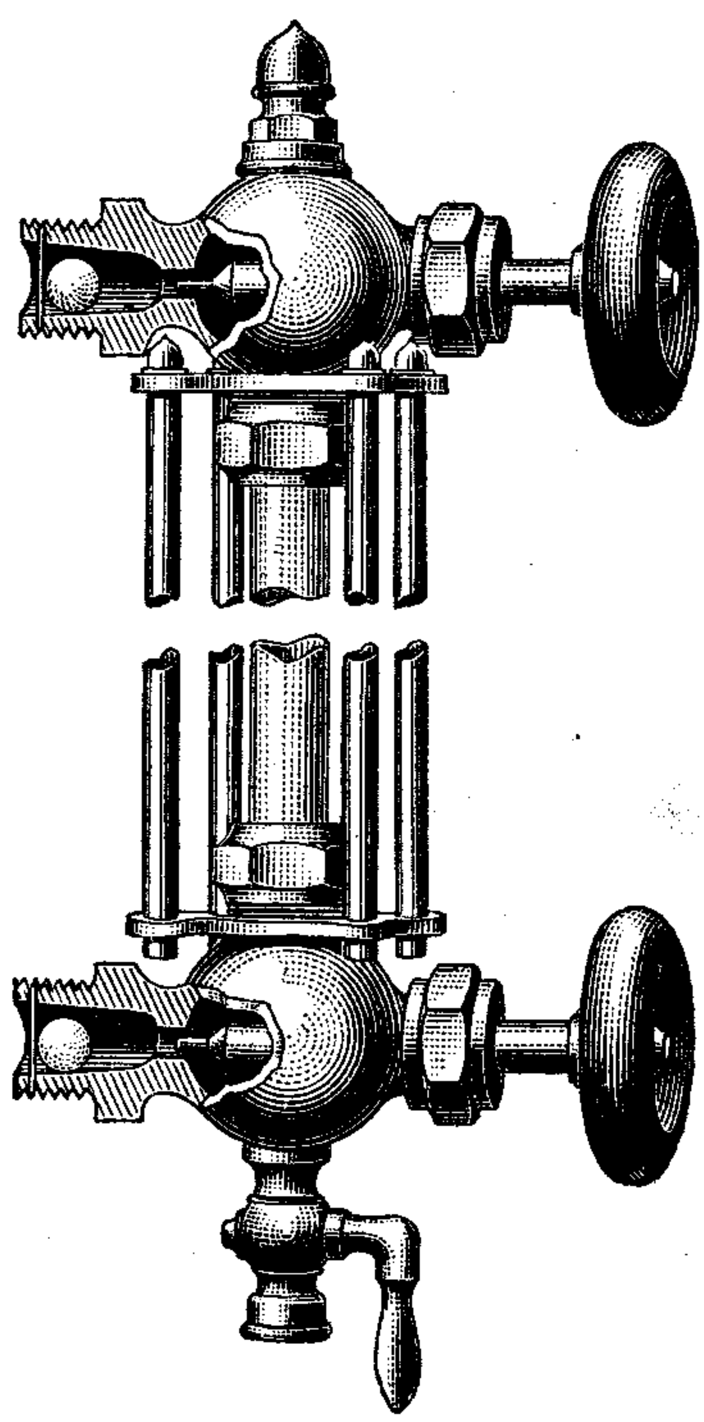


FIG. 8

the level of the water in the gauge should be the same as in the boiler. A common form of gauge-glass connection is shown in Fig. 7. The lower fitting connects with the water space, and the upper fitting with the steam space, of the boiler. A drip cock is placed at the lower end of the glass for the purpose of draining it. Two brass rods tend to protect the gauge glass against accidental breakage. The fittings may be screwed directly into the boiler. The gauge should be so located that the water will show in the middle of the gauge glass when at its proper level in the boiler. Both fittings have compression valves, by means of which communication with the boiler can be shut off in case the gauge glass breaks.

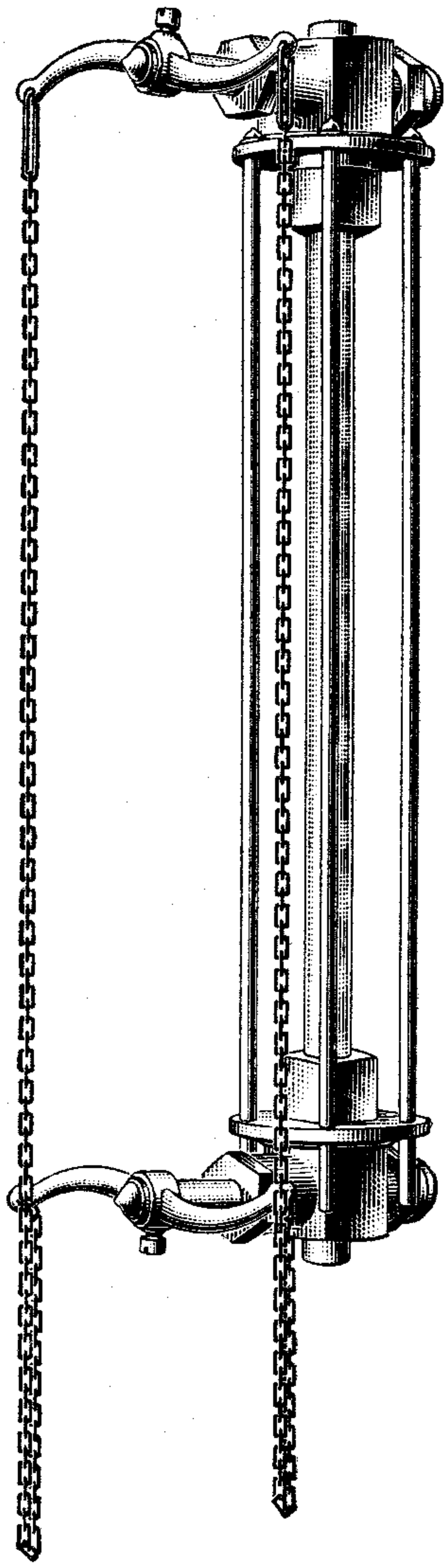


FIG. 9

16. Owing to the danger of scalding the hands and face that is incurred by shutting off the valves by hand in case the gauge glass breaks, and also to prevent the loss of steam and water, it is desirable, for high-pressure work, to have water gauges that will automatically shut off communication with the boiler whenever the glass breaks. There are many designs of such water gauges on the market, one of which, typical of the others, is shown in Fig. 8. A ball is placed within the shank of each fitting, as shown, and is prevented from falling out by a brass pin. Should the gauge glass break, the outrushing steam and water carry the balls forwards and thus close the openings leading to the gauge glass. While the balls may not shut off the steam and water entirely, they will check the outflow sufficiently to permit the valves to be closed without danger.

17. To obviate the danger of scalding the hands, the P. B. H. quick-closing water gauge has been devised. In this, as shown in Fig. 9, a two-armed lever is placed on each valve stem. Chains are led from the ends of the levers to some safe point, and the valves are opened and closed by pulling the chains.

Glass water gauges connected directly to the boiler are open to the objection that the violent ebullition at the surface of the water will cause them to indicate a wrong water level. To overcome this objection, they are frequently placed on a separate fitting known as a *water column,* which consists of a large tube with its ends connecting with the steam and water spaces of the boiler far enough above and below the water level to be unaffected by the violent ebullition of the surface of the water.

GAUGE-COCKS

18. A gauge-cock is a simple cock or valve attached either directly to the boiler or, preferably, to a water column, for the purpose of testing the level of the water in the boiler. Three gauge-cocks are generally employed. The lowest is placed at the lowest level that the water may safely attain, and the uppermost at the highest desirable level. The third cock is placed midway between the other two. On opening a cock above the water level, steam will issue, and on opening one below the water level, water will appear. Hence, the level may be easily located by opening the cocks in succession.

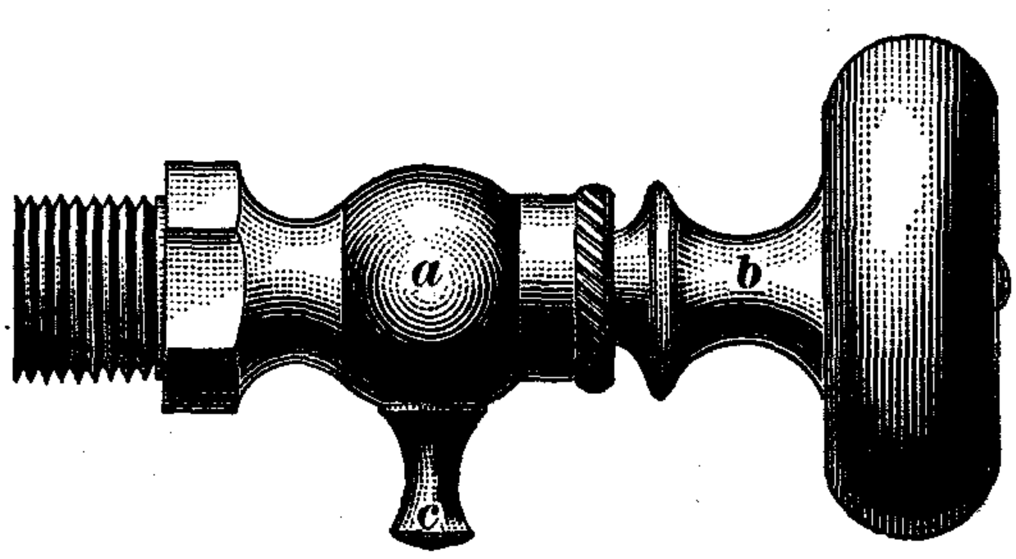


Fig. 10

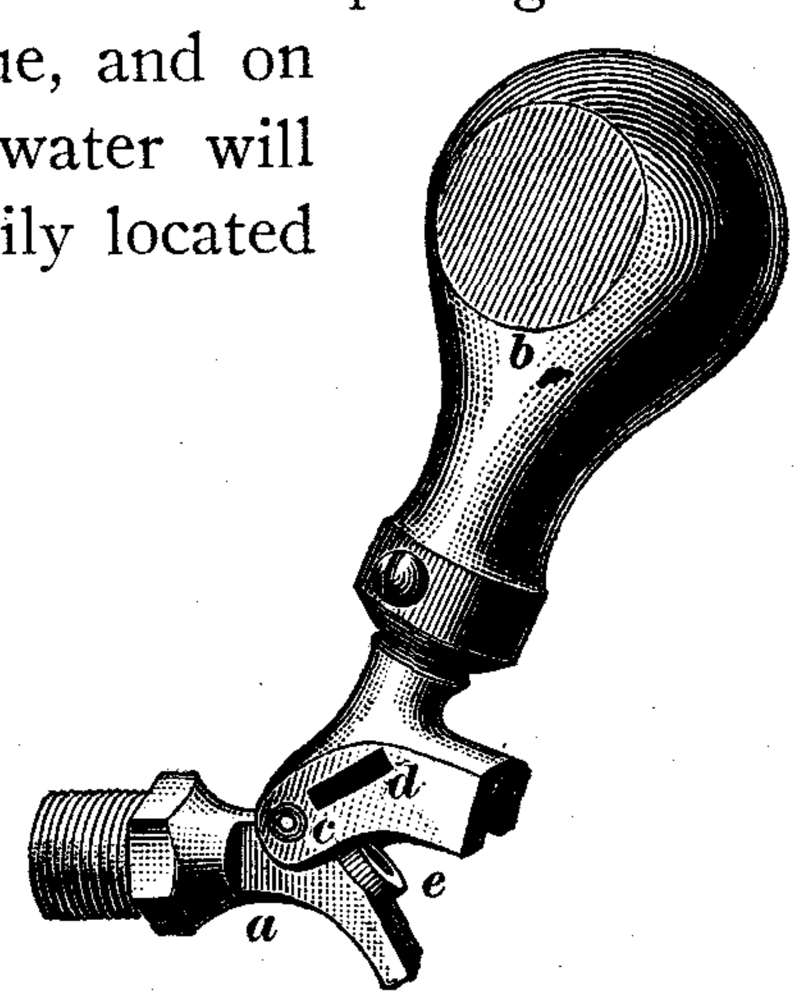


Fig. 11

19. The gauge-cocks most commonly used are of the compression type. Such a cock, with a wooden hand wheel, is shown in Fig. 10. It consists of a brass body *a* having a threaded shank for attaching it to the boiler or water column. The seat within the body is closed by the end of the threaded valve stem *b*. The steam or water issues from the nozzle *c* when the cock is open. The compression gauge-cock can be obtained with a lever handle in the form of a crank, and such a cock can be operated from a distance by means of a rod. In some designs the valve is held to its seat by a strong spring, which automatically closes the valve the moment the hand releases it.

20. A weighted gauge-cock, known to the trade as a Register pattern cock, is shown in Fig. 11. It consists of a body *a* having a threaded shank for attaching it to the boiler or water column. The weight *b* is pivoted at *c* to the body, and when down presses a strip *d* of soft-rubber packing against the face of the opening at *e*. The cock is opened by lifting the weight slightly, and the issuing steam or water is deflected downwards by the curved end wall of the slot. In order to show the construction clearly, the weight is shown raised to the full limit. The strip of soft-rubber packing is simply pushed through two opposite slots. It must be renewed quite frequently, as it rots under the high temperature to which it is subjected.

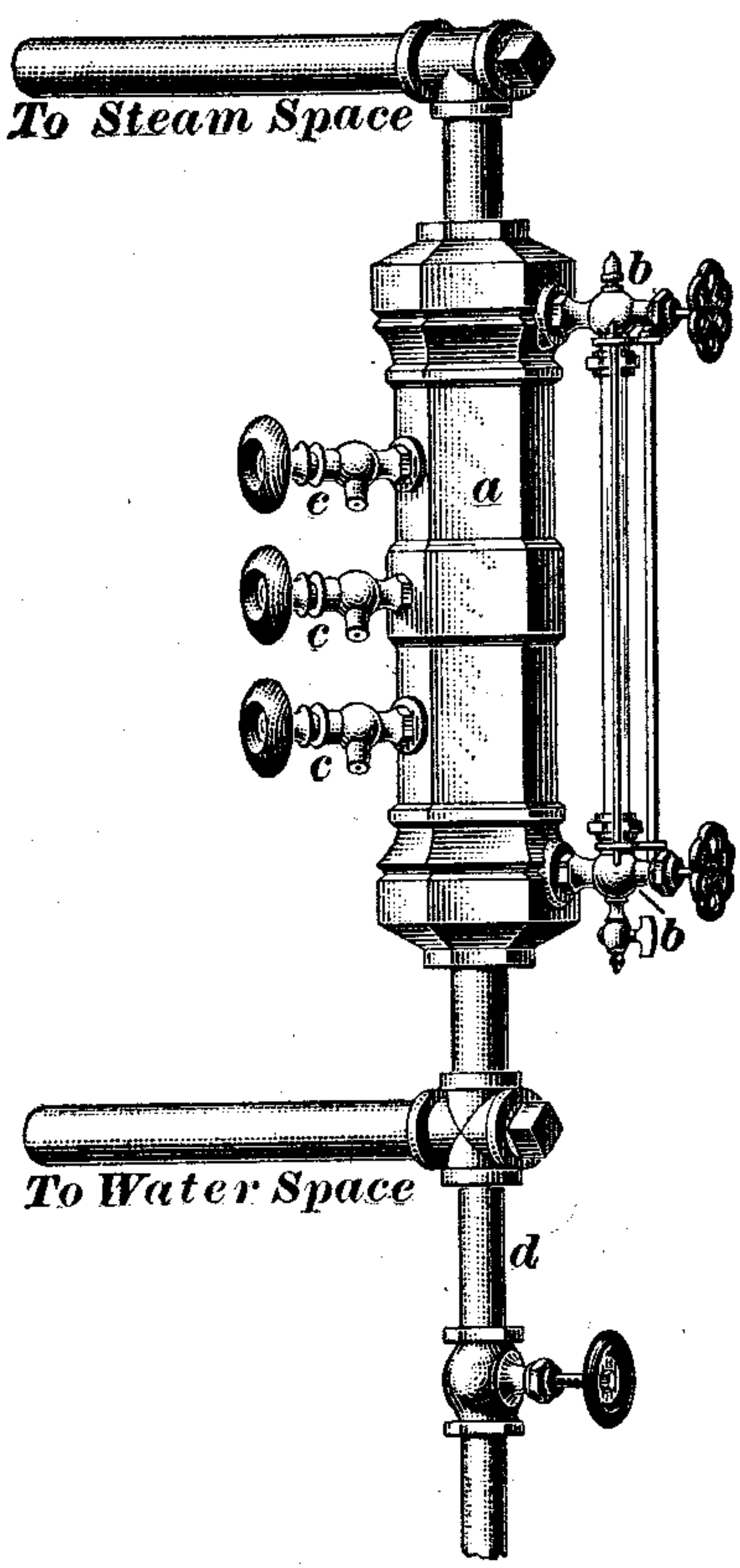


FIG. 12

WATER COLUMNS

21. A common form of water column is shown in Fig. 12. It consists of a cast-iron standpipe *a* tapped on top and bottom for pipe connections to the boiler. Tapped bosses are provided, which receive the threaded shanks of the gauge-glass fittings *b*, and the gauge-cocks *c*. Each maker has his own style of standpipe, the different makes varying chiefly in the ornamentation. The steam gauge is frequently mounted at the top of the water column.

22. The connection to the boiler should be made with a **T** on top and a cross on the bottom, as shown in Fig. 12, the unused openings being closed with brass plugs. If the connections are made in this manner, they can be cleaned with a rod when the plugs are unscrewed. A drain pipe *d* with a valve in it, and leading to the ash-pit, should always be provided for the standpipe, and should be frequently used for blowing out sediment collecting in the standpipe. For low-pressure boilers, no valves need be placed in the pipes leading to the steam and water spaces of the boiler; for high-pressure boilers, however, valves should always be provided. These valves are used in blowing out the standpipe and connections. Closing the valve in the upper pipe and opening the valve in the drain pipe blows out the lower pipe; closing the valve in the lower pipe and opening the valve in the drain pipe blows out the upper pipe and the standpipe.

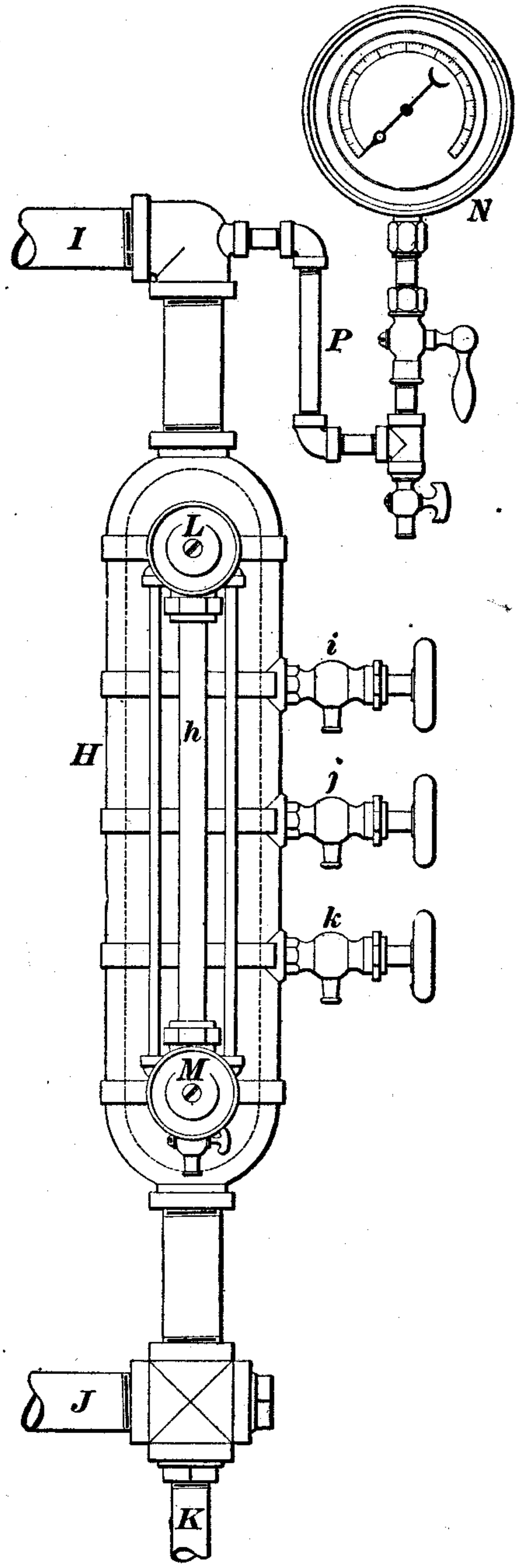


FIG. 13

23. The arrangement in Fig. 13 illustrates how a steam gauge *N* may be attached to the water column by means of a siphon *P* made from ordinary brass pipe and fittings. The standpipe *H* carries on one side the upper fitting *L* and lower fitting *M* for the gauge glass *h*, and at right angles to this gauge the three gauge-cocks *i*, *j*, and *k*. The pipe *I* leads to the steam space of the boiler, and the pipe *J* to the water space. A drain pipe *K* is attached to the cross shown. The arrangement illustrated is recommended by the Hartford Steam Boiler Inspection and Insurance Company.

LOW- AND HIGH-WATER ALARMS

24. In large heating and power plants a device is often attached to the boiler that will give an audible warning, usually by blowing a whistle, of a shortage or a surplus of water. Devices that will indicate a shortage of water are called *low-water alarms;* those that indicate either a shortage or a surplus of water are called *high- and low-water alarms.*

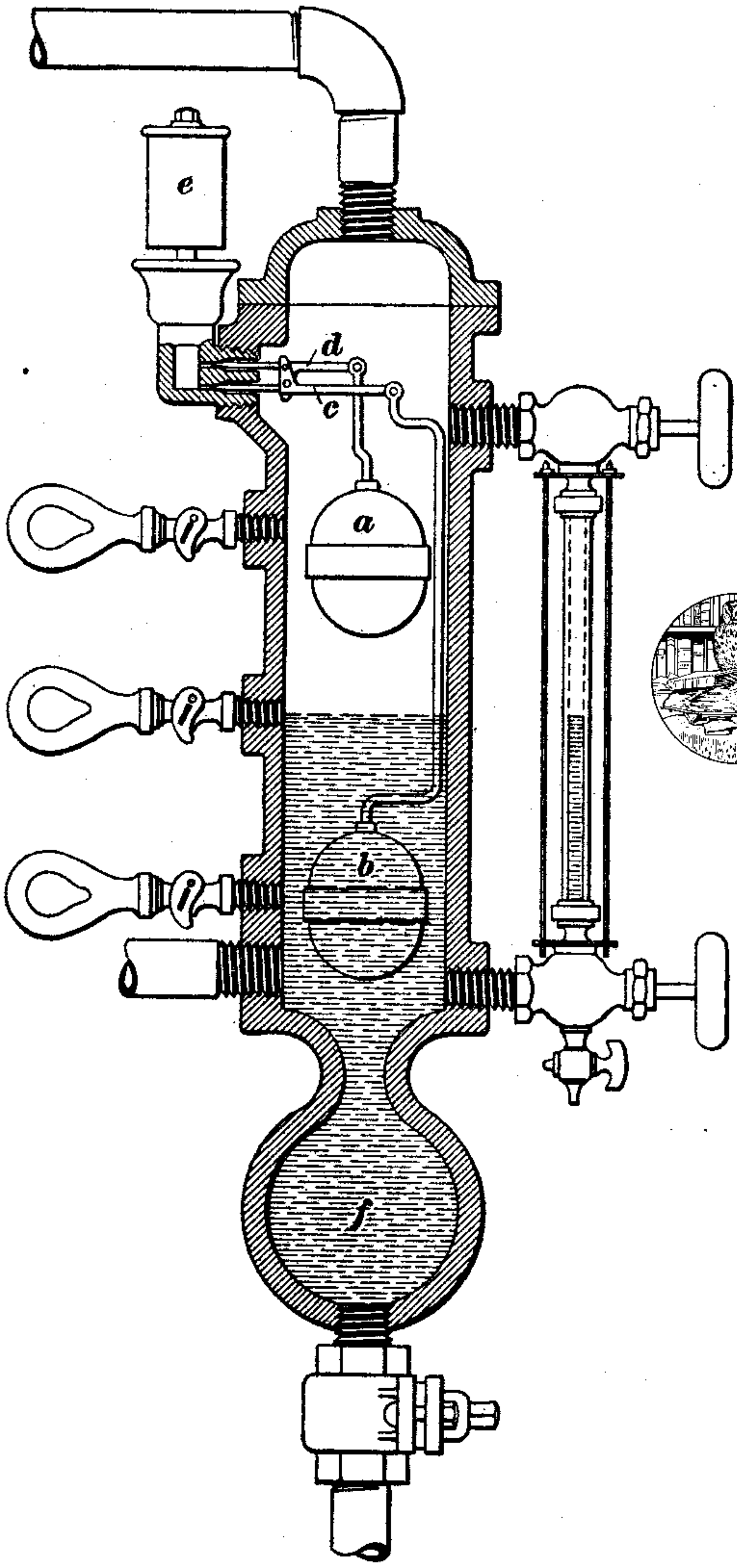


FIG. 14

25. In purely low-water alarms, the whistle may be sounded by the melting of a fusible plug, which, through the falling of the water level in a separate chamber outside the boiler, is brought in contact with the steam. Fusible-plug alarms are cheap and easily applied; they are rather unreliable, however, because of their liability to become incrusted with scale. Alarms depending on the melting of a fusible plug should never be applied to low-pressure boilers, since the temperature of the steam in them is insufficient to melt the plug quickly.

Most low-water alarms employ a float operating a valve leading to a steam whistle, the float being buoyed up by the water. Their construction is so similar to that of high- and low-water alarms that illustrations of them would only be duplications of the latter. Low-water alarms depending on the difference in expansion of different metals for actuating a whistle valve or electric bell have been used occasionally and are on the market; they have not found much favor, however, chiefly on acount of being too delicate.

26. The Reliance high- and low-water alarm is shown in Fig. 14. The device consists of two hollow floats *a* and *b* suspended from the bell-cranks *c* and *d*. To the short arm of each bell-crank is attached the valve stem of a small valve, there being one valve for each float. These valves serve to put the steam space of the water column in communication with the alarm whistle *e*. In this particular design, a sediment chamber *f* is formed at the bottom of the column and collects all foreign matter that settles from the water. The water-column drain is connected to the settling chamber. When the water is at its proper level, the float *b* is surrounded by water and, being hollow, is pressed upwards; this keeps the upper whistle valve closed. If the water becomes low in the column, so as to begin to uncover the float, then the upward pressure due to the buoyant effect of the water gradually diminishes and finally will become so small that the float will descend, thus opening the upper whistle valve and sounding the alarm. The high-water alarm float *a* keeps the lower whistle valve closed by the weight of the float. When the water rises, the float is carried upwards, the lower whistle valve is opened, and the alarm sounded.

FUSIBLE PLUGS

27. A fusible plug is a device that, by the melting of its filling when exposed to an undue temperature, gives warning of low water in the boiler. In many places fusible plugs are required by law to be attached to all high-pressure boilers, whether used for power or heating purposes. The reliability of the plug depends on the melting point of the filling at the time it should operate. Impurities in the filling may cause a change in its composition and possibly render it useless.

28. The ordinary fusible plug in common use is shown in section in Fig. 15. It consists of a brass or iron shell threaded on the outside with a standard pipe thread. The plug has a conical filling, the larger end of the filling receiving the steam pressure. The conical form of the filling prevents its being blown out by the pressure of the steam.

The filling is either an alloy of lead, tin, and bismuth, or pure Banca tin. As long as the plug is well covered with water, it is kept from melting by the water, but should the water sink low enough to uncover the plug, it quickly melts and allows the steam and water to rush into the furnace, thus giving warning of low water by the noise produced.

29. A form of plug especially adapted to internally fired boilers of the locomotive type is shown in Fig. 16. The plug *a* is screwed into the crown sheet *b*, and the fusible cap *c* is laid on top of it and kept in place by the nut *d*. A very thin copper cup *e* is placed over the top of the cap *c* to protect it from any chemical action of the water. The top of the cap extends from $1\frac{1}{2}$ to 2 inches above the crown sheet, so that when it melts, on account of the water being too low, there will still be enough water left to protect the sheet from being overheated, or *burned*, as it is often called.

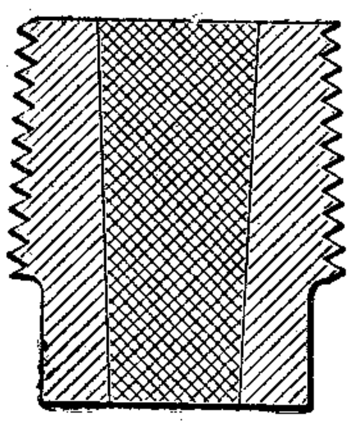


FIG. 15

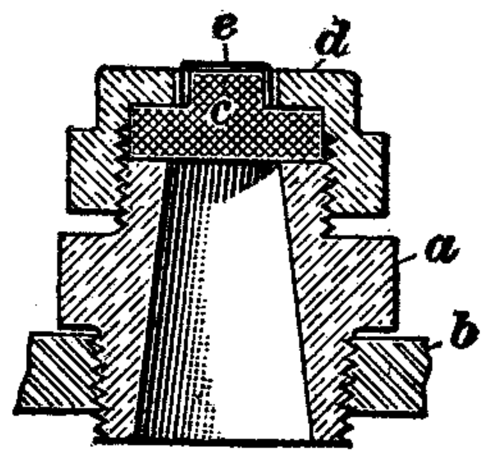


FIG. 16

30. In horizontal return-tubular boilers, the plug is usually placed in the back head 3 inches above the upper row of tubes. In flue boilers of the two-flue type, one plug is screwed in each flue at its highest point, or in the back head at a level about 2 or 3 inches above the top of the flues. The latter practice is considered the better, since it will give warning of shortness of water before the flues become uncovered. In firebox boilers, the plug is screwed into the highest point of the crown sheet. In vertical boilers, it is usually screwed into one of the tubes about 2 inches below the lowest gauge-cock. In water-tube boilers, it is located usually in the shell of the steam drum. In general, it should be so located that it will prevent, by the warning it gives, the overheating of the parts within the fire-line.

STEAM WHISTLE

31. While the steam whistle is not essentially a boiler safety device, yet the fact of its being used in connection with low- and high-water alarms, besides being used for signaling purposes, warrants a description of its principle of action in connection with the subject of safety devices. Two of the most common constructions, as used for signaling, are shown in Figs. 17 and 18. The bell, shown in Fig. 17, is a hollow cylinder, closed at the top and open at the bottom, and held in position by a stud that passes through the center and is secured at the upper end by a screw and a jam nut. The hollow base has a narrow circular orifice that communicates with the steam pipe and valve. As the steam rushes upwards out of the orifice toward the mouth of the bell, it slightly compresses the air contained in the bell. The air being elastic will not retain a fixed or stationary position, but will slightly spring back toward the inrushing steam, where it is again forced back in a compressed state, causing a vibration of the air and steam. These vibrations continue so long as steam is permitted to flow, and are communicated to the surrounding atmosphere, thus producing sound. The tone may be changed to a higher pitch by lowering the bell, or to a lower pitch by raising it. This may be done by loosening the jam nut and turning the bell up or down, after which the nut should again be tightened. Whistles are also constructed to produce two or more tones of different pitch simultaneously by dividing the bell into two or more cell-like parts, as shown in Fig. 18. Each chamber produces a different tone, and when these tones chord perfectly the effect is quite pleasing.

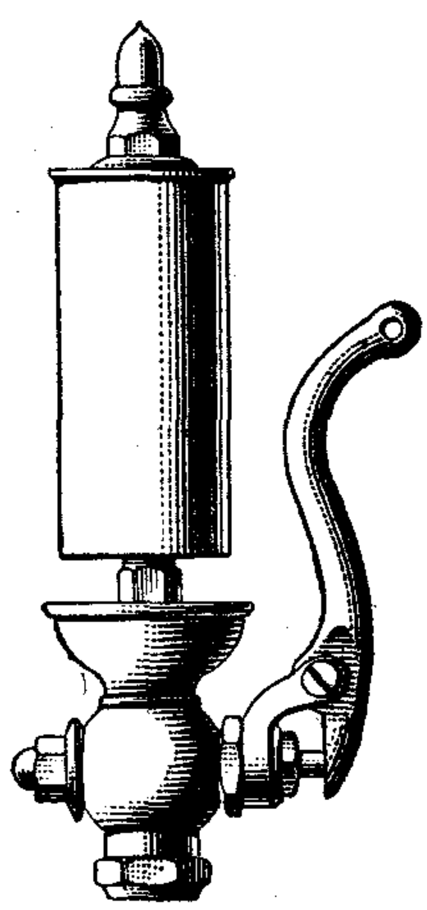


FIG. 17

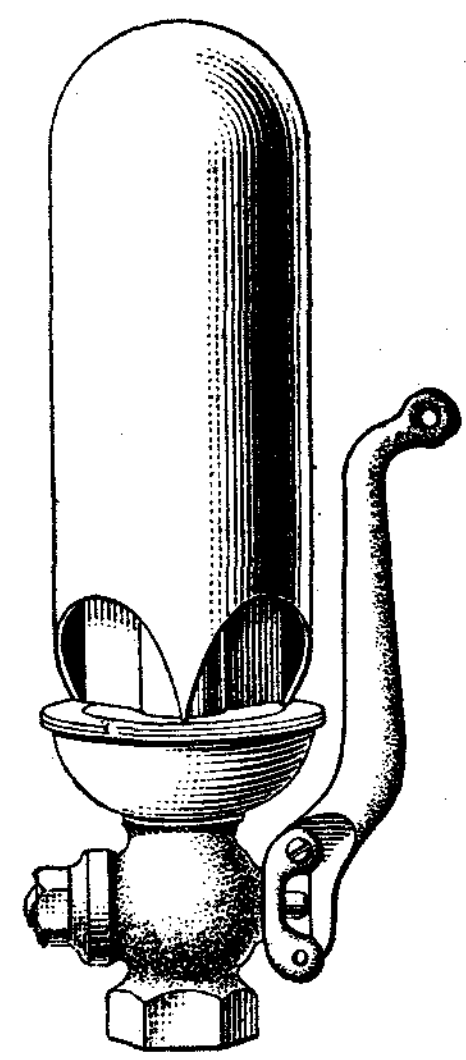


FIG. 18