RECENT DEVELOPMENTS IN BOILER FEED WATER REGULATION

by

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Past History

The gradual increase in size and forcing rates of boilers in the period between the wars brought with it feed regulation troubles. Not much trouble was experienced until the almost simultaneous introduction of twin internal feed pipes and circulation augmentors, which caused a hunting of the water level and of the entire feed system at certain powers. The reasons for this were fully discussed in a paper read before the Institution of Mechanical Engineers by H. Hillier.

The principal argument put up in this paper was that the feeding of the boiler was interrupted by swelling and subsidence of the water level, created by cold water from the feed pipes causing bubbles of steam to collapse, this also affecting circulation. Although present at all powers, this phenomenon was only able to form the cyclic state necessary for violent hunting at one power and it could be cured completely by arranging for the feed water to be heated to saturation temperature before it reached the tube nest ; this he claimed was done by the use of pots or other form of spray arrangements in the steam drum, the drops of water being heated by direct contact with the steam.

STEAM FLOW REGULATORS

Shortly after the War, when the ex-German destroyers came over to this country, it was found that they had a system of steam flow control of the boiler water supply and had practically no troubles with water level variation. They had a regulator of very different type to that used in the United Kingdom, being an Askania, worked by an oil relay, the power being provided by a motor-driven pump, which also provided power for the automatic combustion equipment. This design (Fig. 1) used a diaphragm, which compared the level in the steam drum with a constant head, and also an element, working in parallel with the diaphragm, which measured the pressure drop across a venturi in the main steam line and adjusted the rate of feed accordingly. The Askania relays were very small, as all they had to do was to move the Askania Nozzle, which required little force.

The steam flow regulator, since it keeps water flowing in direct proportion to the offtake, is not subject to cyclic variations of the water level unless these are very large, and surging with it does not in fact take place.

It was decided to try the steam-flow principle in service in one of H.M. ships and a control was made by Messrs. Weir to fit in parallel with the normal Steadiflow control. At the same time, the possibilities of a radically different type of feed regulator, the thermostat, were investigated.

The Weir Steam-Flow Feed Regulator

The general principle of operation is shown in Fig. 2. The steam-flow unit is connected across the superheater, whose pressure drop it measures. From this it is possible to make the unit open the feed check valve in proportion to the steam offtake of the boiler. The connection from the feed regulator float

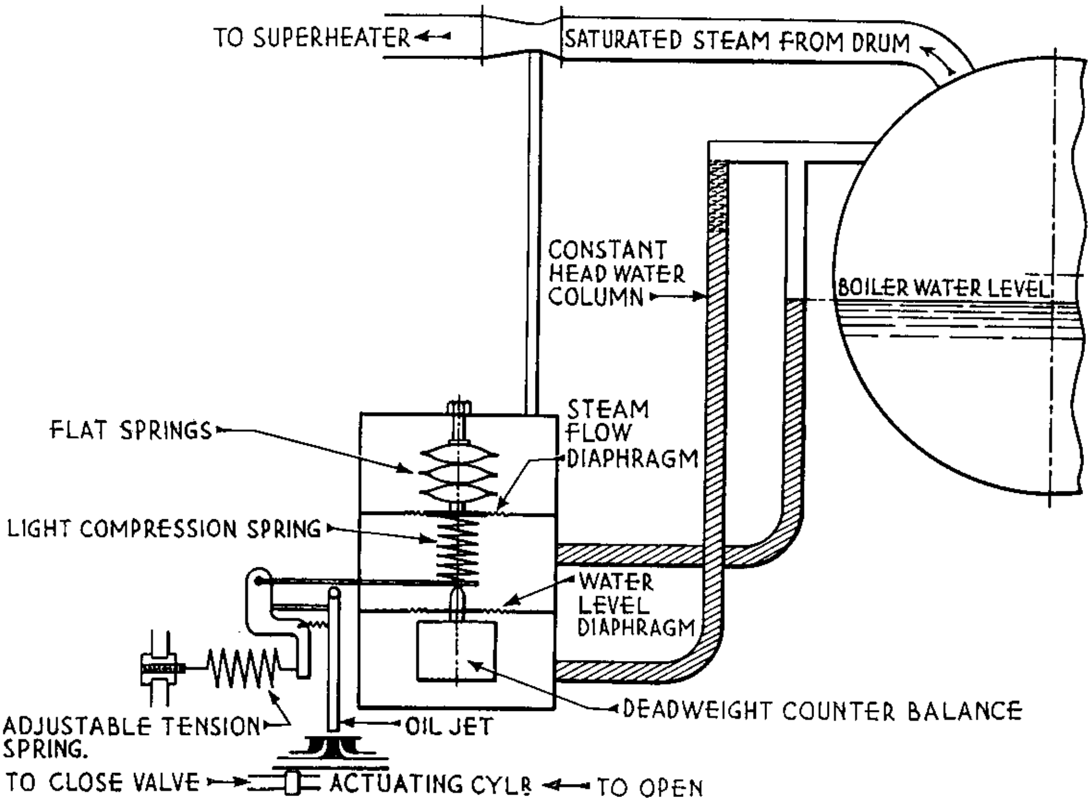


FIG 1.—ASKANIA REGULATOR

box to the feed check valve is tapped and a lead taken to the steam-flow unit ; leak-off is to the boiler steam drum.

The method of operation of the steam-flow unit is as follows :—

Referring to Fig. 3, the connections to the superheater are at A and B. The connection to the feed check valve is at C and the leak-off at D.

The needle valve is mounted on diaphragm plate E, which is maintained in its uppermost position by the action of the springs F, G and H. The diaphragm plate is attached to a flexible metal bellows, which seals the two sides of it, which are connected to the superheater. As the output of the boiler increases, the pressure drop across the superheater increases and moves the diaphragm plate downwards against the action of the springs, carrying the needle valve with it. The needle valve closes and allows less leak-off from under the feed check piston and more water is admitted to the boiler.

The use of three springs, F, G and H, instead of one, requires explanation. The pressure drop through the superheater varies as the square of the quantity of steam flowing through it. Thus, to get opening of the feed check which varies approximately linearly with the output, it would be necessary to have a parabolic spring in the steam-flow element or, alternatively, a profiled feed check. This is impossible, but the three springs F, G and H in series come reasonably near to it ; spring F takes all the load, until its carriage has moved enough for spring G to come into play as well and share the load until movement of its carriage makes contact when spring H also comes into play.

It is found, in practice, that the steam-flow element does all the controlling of the feed, unless the level of water in the steam drum either becomes very

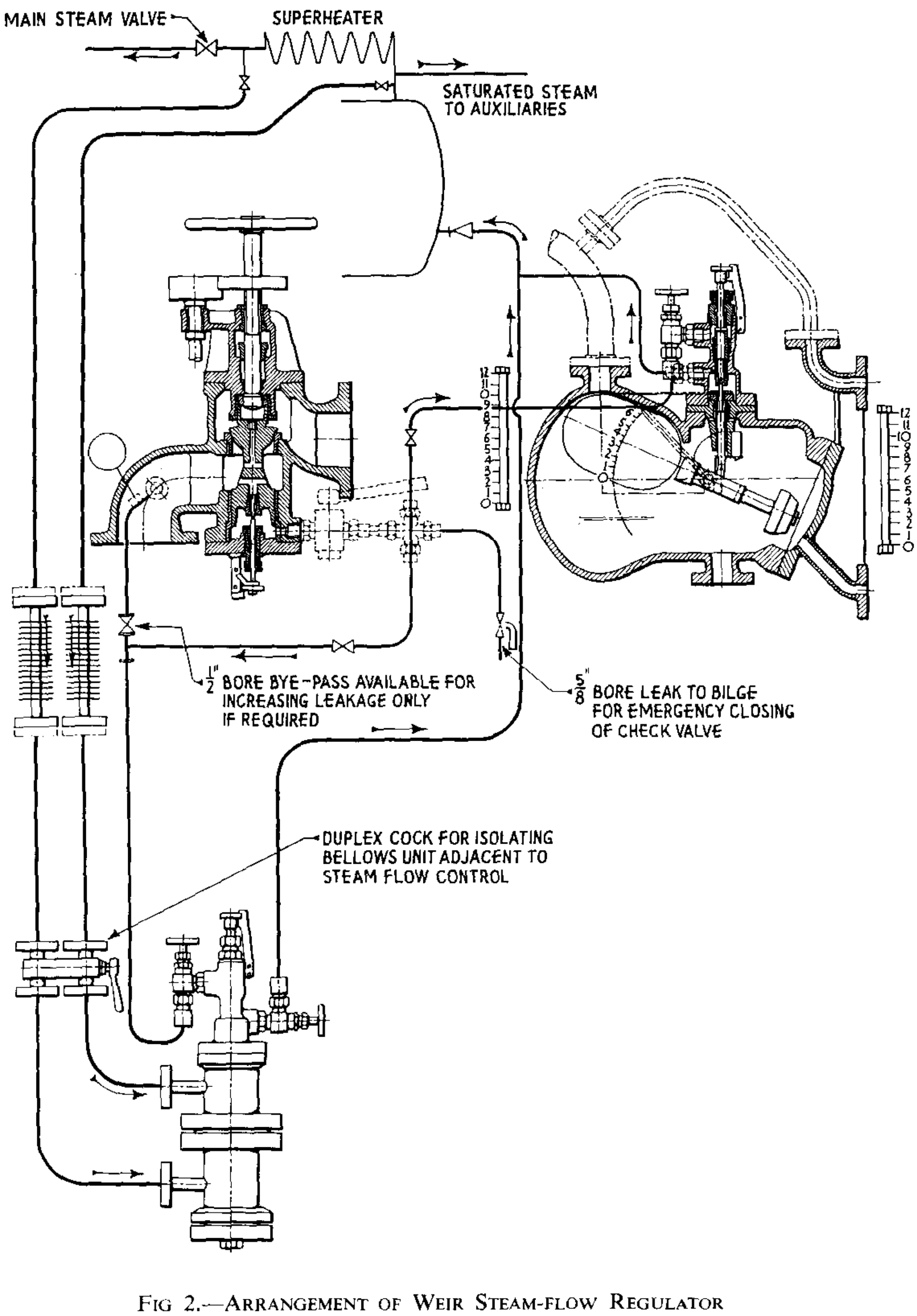
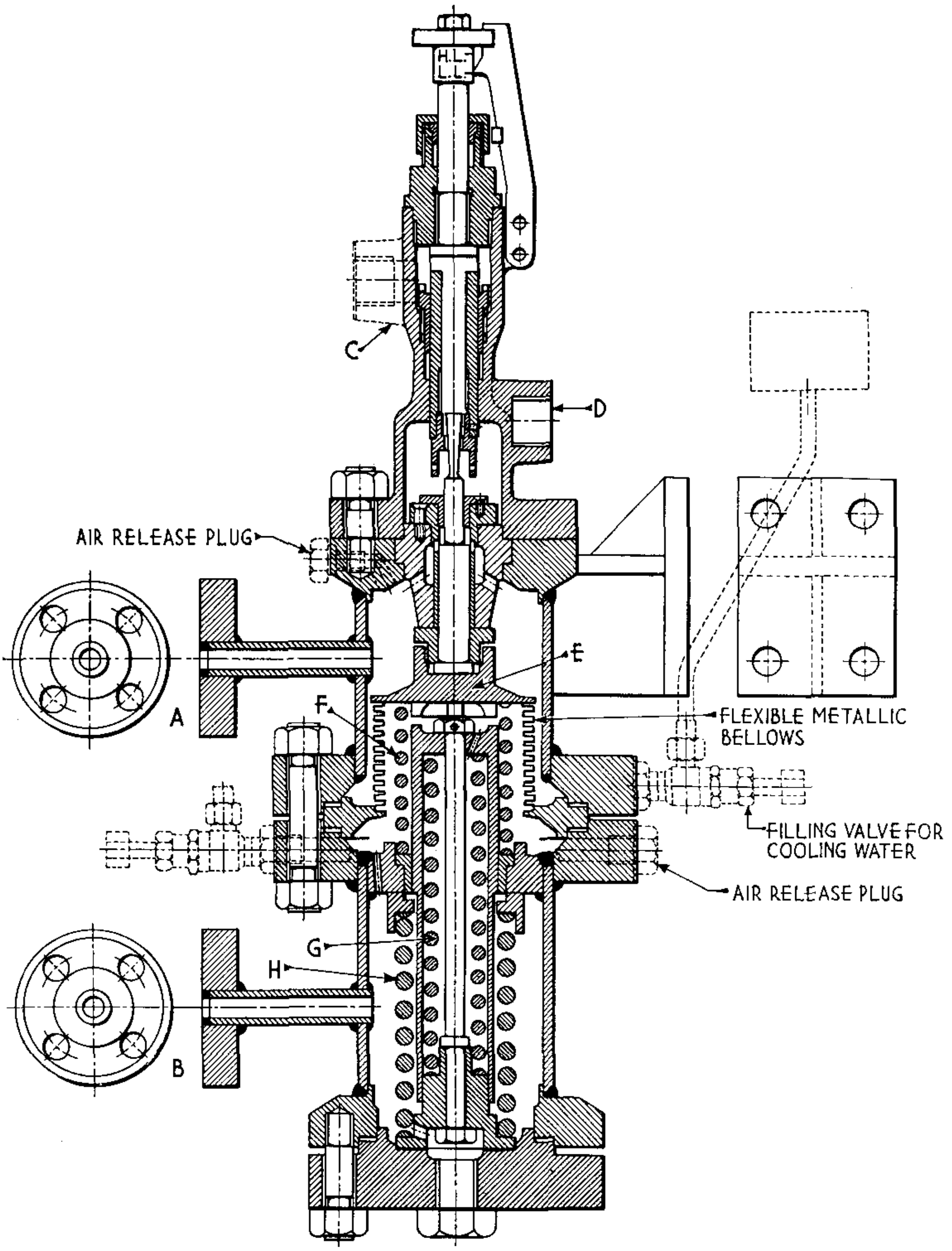


FIG 2.—ARRANGEMENT OF WEIR STEAM-FLOW REGULATOR



DETAIL OF STEAM FLOW CONTROL
MAXIMUM PRESSURE ACROSS BELLOWS – 50 LB. PER □"

FIG 3.—STEAM-FLOW UNIT WEIR REGULATOR

high or very low, when the float overrides it and takes charge. This is intentional and is caused by making the float box needle valve with a small taper, so that considerable movement of the float makes very little difference to the annular leak-off space between the needle valve and the seat. The two ends of the float needle are sharply profiled, so that, at the ends of its travel, its effect is considerable, sufficient to override the steam-flow element.

The Weir type of steam-flow control was first tried in H.M.S. *Jutland* and, after a small amount of experimenting with various needle valve profiles, proved entirely satisfactory. There was no hunting of any sort of the water level or of the feed system and the feed pump ran much more smoothly, as is to be expected when its output is kept proportional to the offtake and the effect of sudden increases and decreases of output is much less pronounced.

The only snag with the steam-flow regulator is that, having two controls, the leak-off past the needle valves is considerable and may, at low outputs, be sufficient to keep the boiler supplied with feed water without any passing the feed check. This is unlikely to occur except in destroyers in harbour.

The trials in *Jutland* indicated that the former practice of leading the water connection to the float box inside the augmentor, which was done to prevent a large drop in level between low and full power in the old float-only type of control, was no longer necessary and gave, in fact, a rising characteristic to the water level. In later conversions, it has therefore been decided to move the water leg to the space outside the augmentor and to raise the float bodily through $3\frac{1}{2}$ inches on the steam drum end to compensate.

The Weir steam-flow control has been adopted as a Class A and A for the *Battle* Class destroyers and is being fitted as standard in the *Daring* Class.

Further Developments of the Weir Regulator

With the current increase in boiler pressure to 650 lb/sq in, the offset manhole in the steam drum becomes difficult to design without sacrificing considerable weight. It has therefore been decided to fit a central manhole to some of the *Darings* and to later classes. This entails moving the feed regulator float box, as it normally is fitted to the steam drum just about in the centre of the end plate. For *Daring* Class, this has been done by mounting the float box on a cantilever sticking out from the boiler and leaving room for a man to slide in through the manhole. This arrangement is inelegant in the extreme and is also bulky and weighty ; the whole arrangement in fact shouts for the float box to be got rid of.

With the main onus of feeding the boiler removed from the float and transferred to the steam-flow element, it is quite possible that the German arrangement of a diaphragm can be adopted. Here, all that is necessary on the boiler front is a constant head pot, which can be placed at the back, if required, or is small enough to be removed bodily when access to the steam drum is required. The diaphragm can be mounted near the floor plates, or at any other convenient place below the level of the constant head pots. By comparing the level in the steam drum with that of the constant head pot, sufficient movement of the needle valve can be obtained to provide the overriding control required from the level regulator. Due to the small force available, this diaphragm control will not be very sensitive, but this does not matter very much with the main control vested in the steam flow element. This arrangement is to be tried at sea, the diaphragm being fitted in parallel with the existing float box, which will be left in position, to see how it works. If successful, it may be adopted generally.

Apart from the inconvenience of the float box, there is another pressing reason

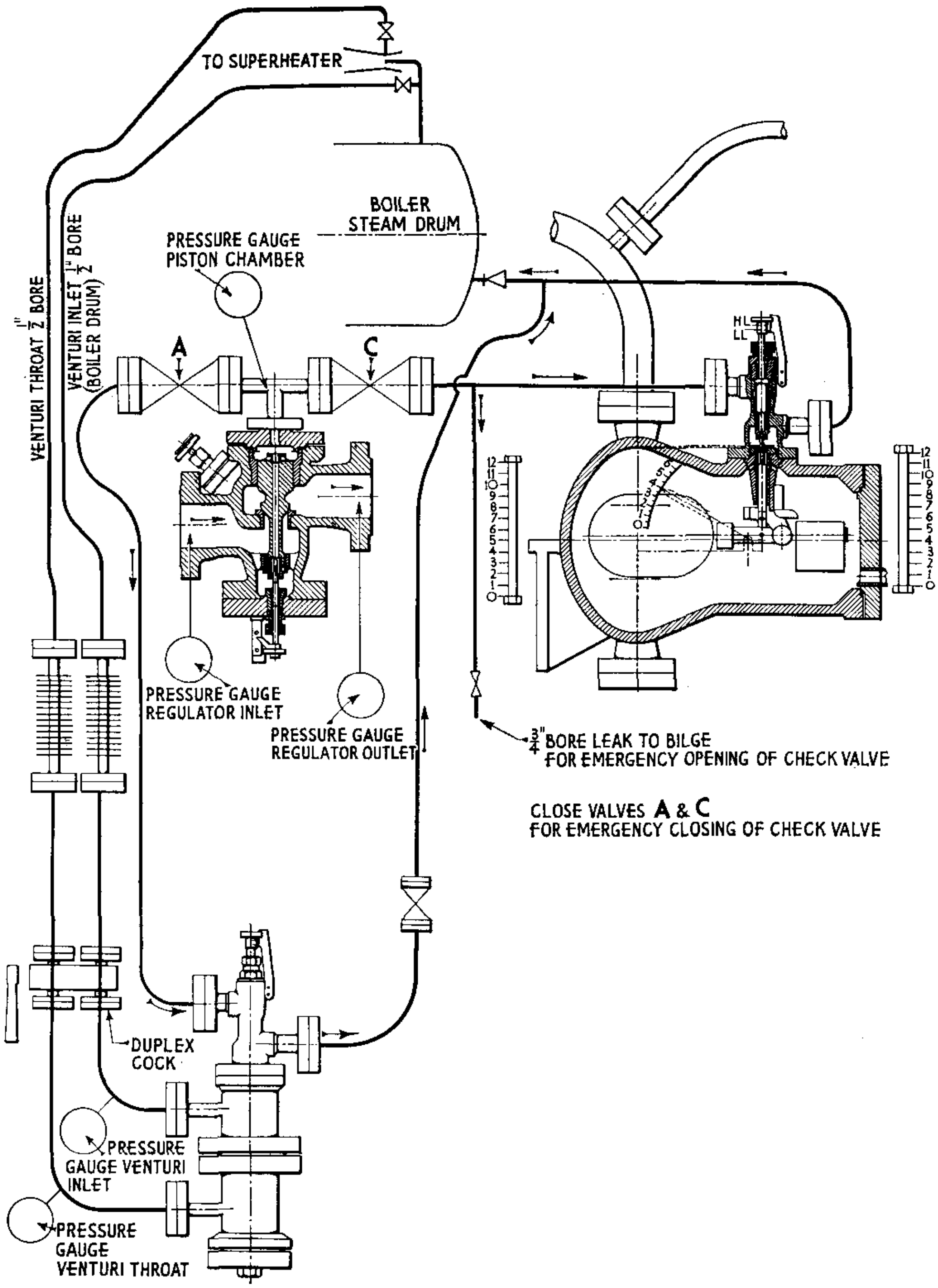


FIG 4.—ROBOT STEAM-FLOW REGULATOR

for abolishing it. Pressures are continually rising, a process which is most unlikely to stop, and thus the float box is becoming heavier and heavier and so is the float. Also, with rises in pressure, the difference in density between the steam and the water is decreasing, so that the force available on the float, is significantly decreased ; thus a stage may fairly soon be reached where, quite apart from any other considerations, it may be impossible to use a float of reasonable size. The diaphragm, which is merely interested in the weight of two columns of water, does not suffer from this drawback to the same extent.

Steam-flow regulation, with its superior control and its power of controlling hunting has also come in just in time from the point of view of the internal gear ; the feed pots were bulky and awkward, and, with the recent progress in boiler design, which has reduced drastically the diameter of the steam drum, fitting them in would be a major difficulty. Also, the necessity for fitting steam dryers in the drum takes up all available space and it would just not be possible to fit complicated internal feed gear inside the drum.

Robot/Steam Flow Regulator

A design has also been prepared for adaptation of the Robot Regulator to steam-flow control. It is similar fundamentally to the Steadiflow steam-flow regulator, the shape and size of the needle valves being adjusted to take into account the different principle of operation of the Robot. The actual feed control valve is removed from the top of the float box and placed in the feed line, for convenience of manufacture and adjustment, but the performance is, as can be seen from Fig. 4, exactly the same as in the normal Robot.

The main advantage of the Robot design, as compared with the Steadiflow is that in the former, at very low outputs, the leak-offs are a minimum so that there is little danger of the boiler being able to steam on the leak-off, as has occurred in one case with the Steadiflow.

Feed Regulators of the Thermostatic Type

At the end of the War, it was realized that shore boiler installations mostly used a type of regulator different in principle from the float box type. A thermostat was used to control the water level, in conjunction with a steam-flow unit.

Following successful trials of this type of regulator ashore at A.F.E.S., Haslar, one has been fitted in a *Battle* Class destroyer for trials, where its performance to date has been entirely satisfactory.

The Copes Flowmatic Feed Regulator

The Copes Flowmatic which has been used ashore for some years is similar in principle to the Weir, in that the main control is vested in a steam-flow unit, the water level control being rather less sensitive. With this fundamental similarity, however, the likeness ends.

The feed control valve is placed in the feed line between the pump and the boiler and uses a normal type feed check valve. The control valve is balanced and has profiled ports in it, though no real attempt is made to obtain parabolic control over the majority of the range. The feed valve is moved by an external lever, to which are connected both the steam-flow and the thermostat controls (Fig. 5).

The steam-flow element (Fig. 6) for which the trade name " Flowmatic " is used, has a diaphragm arrangement very similar indeed to the Weir unit, but

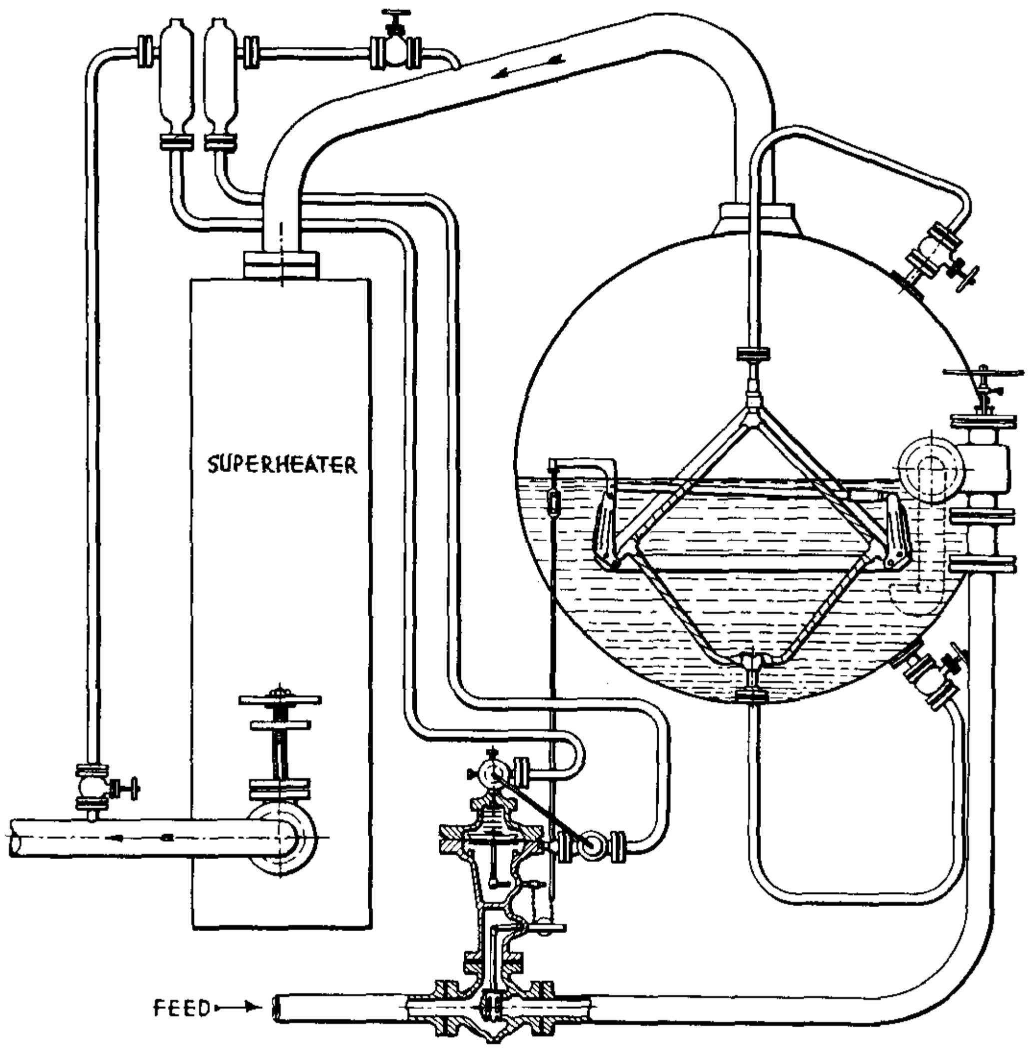


FIG 5.—COPES FLOWMATIC FEED REGULATOR, GENERAL ARRANGEMENT

it has only a simple spring ; the two sides of the diaphragm are connected across the superheater.

The water level in the steam drum is communicated to the feed control valve by means of a thermostat (Fig. 7). The thermostat is arranged on the boiler front and is made of a stainless steel tube of rhombic shape, as is shown in the diagram. The thermostat is supported only at its top end and is connected at its two elbows to a link arrangement which is supported by a frame. As the level of water rises and falls, the thermostat moves its elbows in and out, so altering the attitude of the linkage and moving the arm which moves the feed control valve. Movement of the thermostat occurs because, being exposed to the ambient temperature, this is, even in H.M. ships, considerably cooler than the saturation temperature of the boiler. As the water level in the boiler rises, the level in the thermostat rises with it and more of the tube is cooled. The tube is made of 18/8 austenitic stainless steel, which has a very high

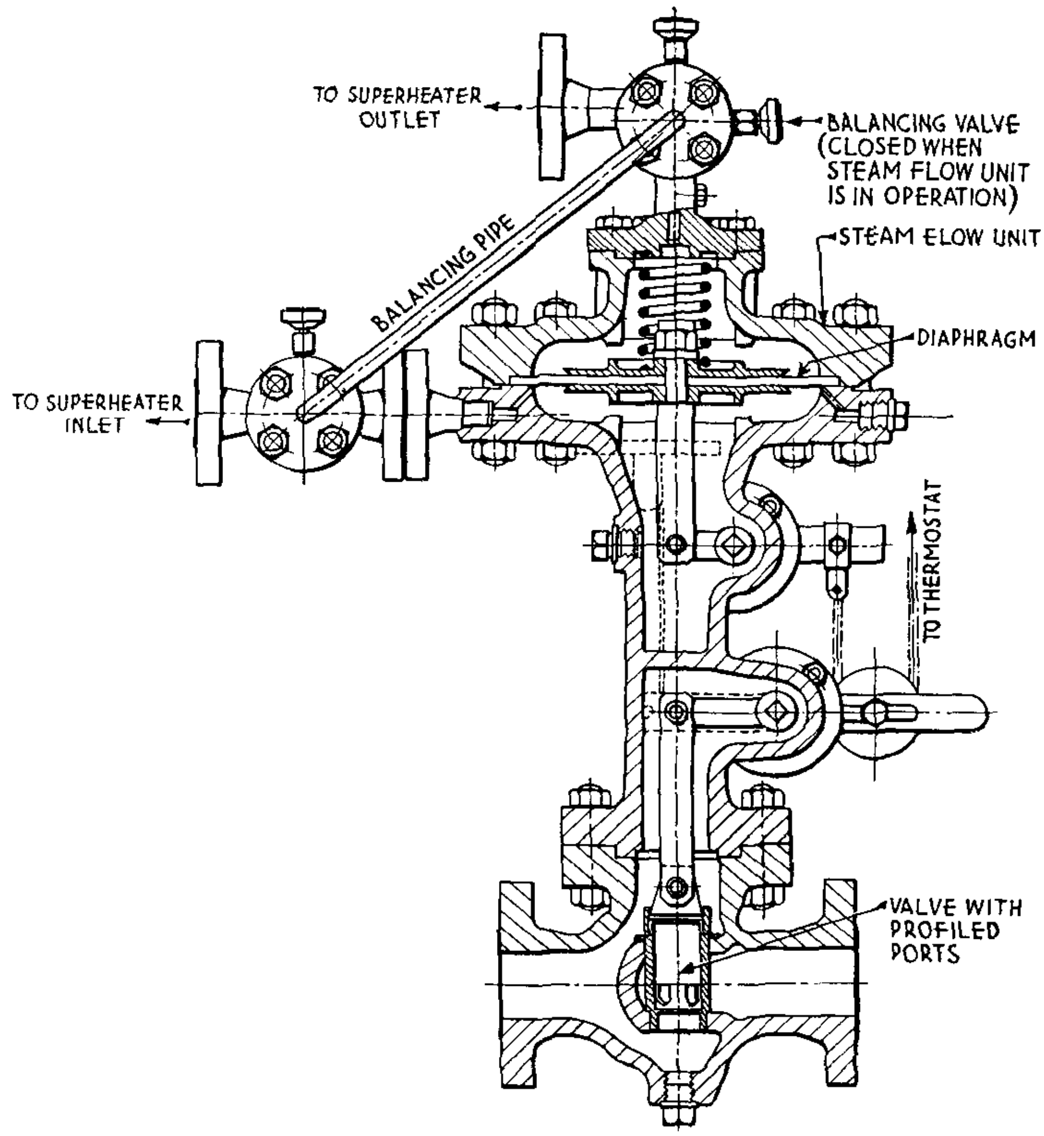


FIG 6.—COPES FLOWMATIC STEAM UNIT

coefficient of expansion, so a small change in water level is sufficient to cause movement of the feed regulator valve.

The main advantage of the thermostatic type of regulator is that it is extremely simple and all the moving parts are exposed, so that servicing is easy. It is also very sensitive and is in no way concerned with the relative density of water and steam. The thermostat can be used conveniently with a central manhole boiler, as the assembly is sufficiently small and light to be handled easily and can be removed and replaced without disturbing the settings.

The Copes regulator was tried experimentally at A.F.E.S., Haslar, where it was subjected to violent treatment on one of the boilers and proved better than the ordinary regulator then fitted. Following this and subject to several modifications to make it as robust as possible, it was fitted in a *Battle* Class Destroyer, H.M.S. *Barrosa*, for trial at sea. Preliminary trials showed that it was a cure for hunting, though this had never been very bad in this particular ship which was fitted with feed pots, and that its sensitivity under the most

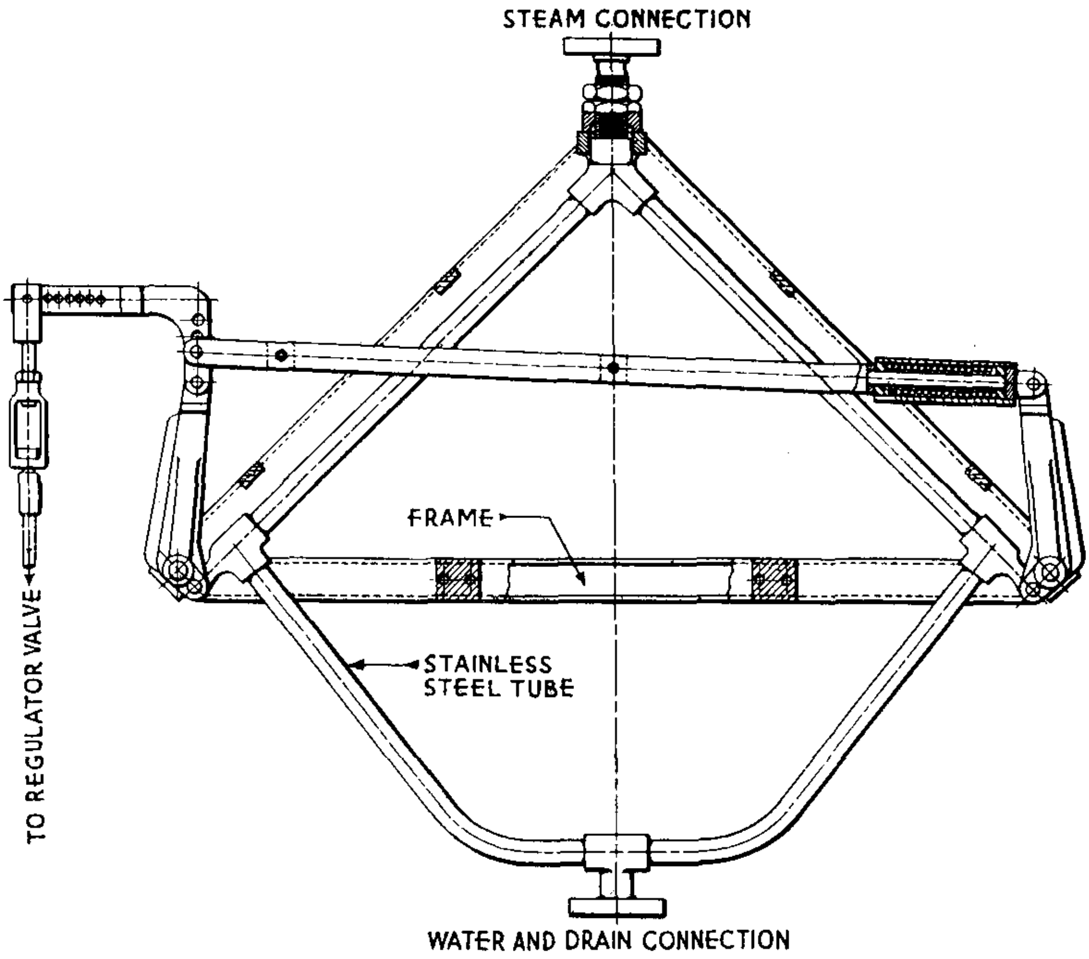


FIG. 7.—COPES FLOWMATIC THERMOSTAT

violent manoeuvring conditions was excellent. It is too early to say that this regulator is entirely satisfactory, as the prolonged sea trial may reveal weaknesses which had not been foreseen, but, if successful and there is no reason to suppose otherwise, it may become a formidable rival to the established float type.

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