June 4, 1946. H. A. SCHLIEDER 2,401,512

FEED WATER REGULATING APPARATUS FOR BOILERS

Filed Oct. 2, 1944 2 Sheets-Sheet 1

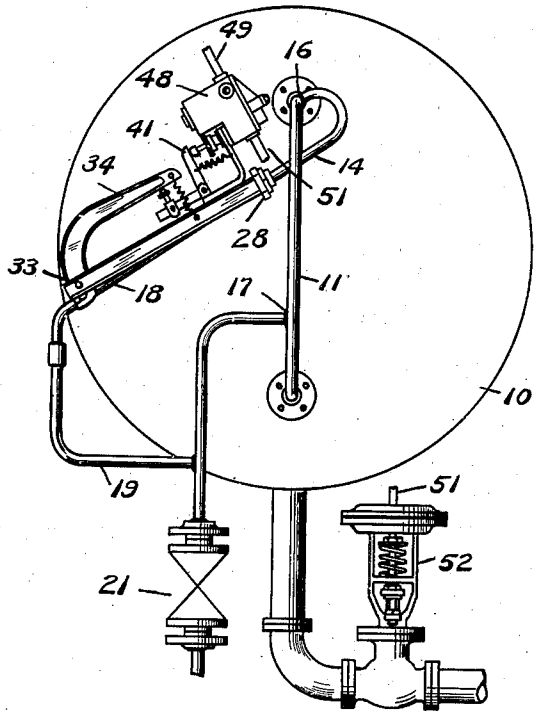

Fig. 1

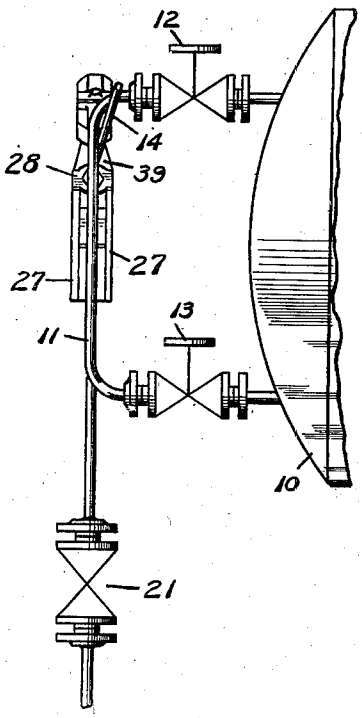

Fig. 2

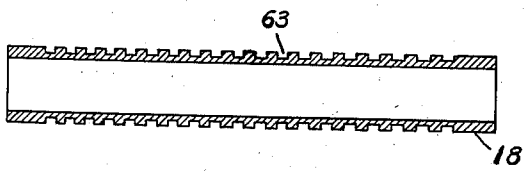

Fig. 3

INVENTOR.
HAROLD A. SCHLIEDER
BY W. H. Sullivan
ATTORNEY

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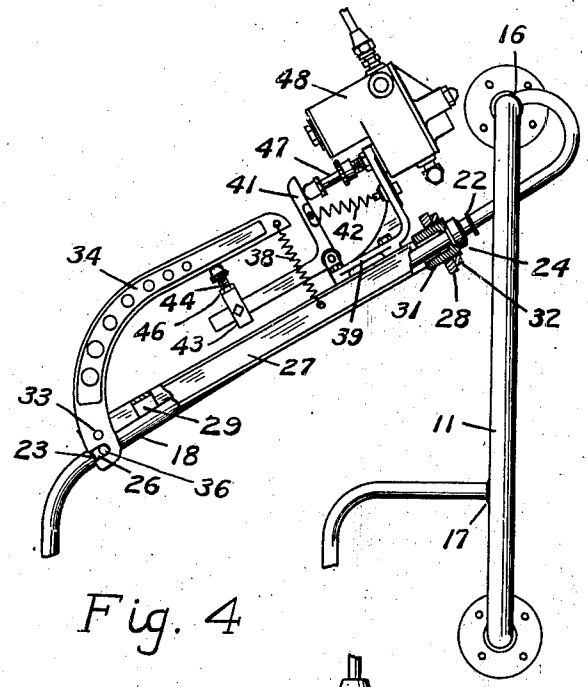

Fig. 4

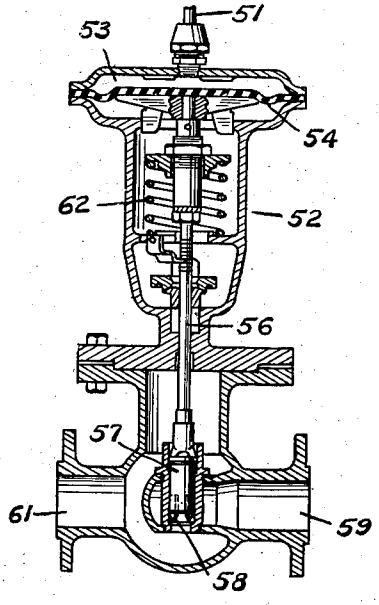

Fig. 5

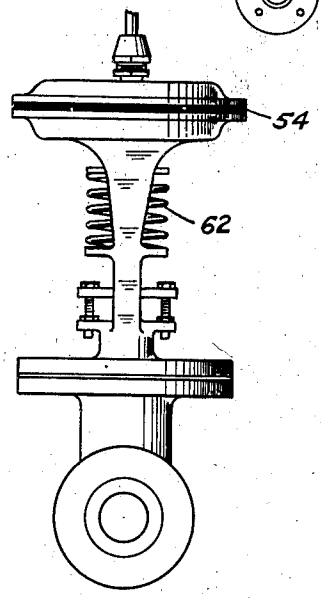

Fig. 6

INVENTOR.
HAROLD A. SCHLIEDER
BY W. G. Sullivan
ATTORNEY

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FEED WATER REGULATING APPARATUS FOR BOILERS

Harold Augustus Schlieder, Erie, Pa., assignor to Northern Equipment Company, Erie, Pa., a corporation of Pennsylvania

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8 Claims. (Cl. 122—451.1)

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This invention relates to boiler feed water regulating apparatus, and more particularly to improved regulating apparatus of the type comprising a thermostatic element responsive to boiler water level variations, a servo-motor operated control valve for the feed water, and means controlling the motor in accordance with thermal change in the thermostatic element.

It is a primary object of the invention to provide feed water regulating apparatus for boilers which is of simple, compact, construction and adapted to efficiently feed the boiler.

Another object of the invention is to provide boiler feed water regulating apparatus having a level responsive element highly sensitive and quickly responsive to level variations.

Another object of the invention is to provide regulating apparatus of the above type comprising parts which may be installed as a unit with the level responsive element bearing a fixed relation to the normal water level in the boiler.

According to the invention a unit comprising a cross connection conduit adapted to be connected to the steam and water spaces of the boiler in a conventional manner supports a conduit communicating with the cross connection at the top and below the normal boiler water level by a U shaped section. An intermediate portion of the conduit comprises a thermostatic tube with the tube center disposed at the approximate normal boiler water level. The conduit supports a frame preferably formed of channel members and forming the cold section of the unit. The thermostatic expansion tube, heated or cooled by changes in boiler water level, acts on a bell crank lever pivoted to one end of the frame. The thermostat lever movement, multiplied or reduced by an auxiliary lever acts on a pilot valve mounted on the frame. The pilot valve varies the pressure of relay supply, or auxiliary source of energy, so that a servo mechanism will cause a feed water valve of any size to move in proportion to boiler water level variations.

The cross connection in addition to supporting the level responsive tube and associated parts acts as a separator permitting a supply of dry steam to be continuously furnished to the expansion tube. By connecting the level responsive tube directly to the cross connection instead of directly to the steam and water spaces of the boiler improved performance is secured. With conventional connections, all steam condensing in the piping above the expansion tube runs through the tube and keeps the water in the lower part hot, resulting in less temperature difference between the steam

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and water therein and less total movement from the device. With my improved arrangement most of the condensate will drain through the cross connection. In instances where the steam is released violently within the boiler drum, or on marine installations where the water moves around within the drum, particles of water are frequently thrown into the steam connection of the feed water regulator. In the present arrangement these water particles will drop through the cross connection and not be carried into the expansion tube.

Another advantage secured from the construction described is that the water connection to the expansion tube can be taken at a point in the cross connection corresponding to the height of the lower end of the expansion tube. Heretofore, the water connection of level responsive devices for feed water regulators has been taken directly from the boiler at an opening well below the minimum safe water level. With such a hook-up, as the level in the boiler falls unusually low it also falls in the thermostatic element or expansion tube and connecting piping. Steam follows the level down through the expansion tube and sometimes well down into the piping below the tube. The steam heats this piping and when the level rises again the water passing through the hot section absorbs heat from the pipe as it rises. Upon reaching the active section of the expansion tube it may be so hot that it will not cause the tube to control as required.

The use of a cross connection eliminates this condition since during an extreme drop in boiler water level, the water will drop in the cross connection below the point at which the water connection to the expansion tube is made but since this water connection includes a loop forming a trap, the water cannot drop below the end of the expansion tube. When the water level rises the cool water retained in the loop will enter the expansion tube and cause the regulator to respond more accurately and rapidly than otherwise.

A further advantage of the cross connection is the provision of a level responsive device wherein the elevation of the water level in the tube and in the boiler drum maintains a more nearly constant relationship. Due to the difference in density of the fluid in the boiler drum and expansion tube, the level is lower in the tube than in the boiler. In prior constructions with which I am familiar, the amount by which the thermostat water level is relatively lower was dependent on the installation and influenced by the location of the water connection at the drum head and by the distance

the water connection was disposed below the thermostat. In the present arrangement wherein the thermostat is supported from the cross connection with the water connection to the thermostat at a fixed distance below the normal water level and a horizontal portion of the water connection at a fixed distance below the lower end of the thermostat, a constant level relationship is maintained.

Other objects of the invention and the invention itself will become increasingly apparent from a consideration of the following description and drawings wherein:

Fig. 1 is an end elevational view, largely diagrammatic, of a boiler drum and my improved regulating apparatus.

Fig. 2 is a side elevational view of the regulating apparatus of Fig. 1 and a portion of the boiler drum.

Fig. 3 is a longitudinal sectional view of a type of thermostatic tube I preferably employ.

Fig. 4 is an enlarged view of a portion of the apparatus illustrated in Fig. 1 with parts broken away for clearness of illustration.

Fig. 5 is a vertical medial sectional view of a fluid pressure motor and associated feed water valve I may employ, and

Fig. 6 is a side elevational view of the motor and valve illustrated in Fig. 5.

Referring now to the drawings, and particularly Figs. 1 and 2, I have indicated a conventional boiler drum at 10 and a cross connection extending between the steam and water spaces of the drum generally at 11. Valves 12 and 13 are provided in the cross connection for controlling communication between the cross connection conduit and the boiler. Supported from the cross connection 11 is a conduit generally indicated at 14 communicating with the top portion of the cross connection as indicated at 16 and with a point thereof below the normal boiler water level as indicated at 17. Conduit 14 includes an inclined tube 18 adapted to change length under thermal change. The center of the thermostat or expansion tube 18 is disposed at the approximate normal boiler water level with the lower or water connection end thereof disposed at a height substantially corresponding to the point 17 at which conduit 14 communicates with cross connection 11. It will be noted that the section of conduit 14 below the thermostat 18 is of generally U form including a horizontal lower portion 19, the right hand leg of this section being extended downwardly to communicate with a drainage valve 21.

With this arrangement when there is an extreme drop in boiler water level the water will drop down below the point 17 in the cross connection 11 but due to the U form or loop section forming a trap the water cannot drop below the end of the expansion tube 18. Upon a rise in boiler water level the cool water retained in the loop will enter the expansion tube 18 and cause the regulator to respond more accurately and rapidly than if the water connection of conduit 14 was made directly with the boiler drum. In a direct connection hookup as the boiler water level falls unusually low it also would fall in conduit 14 with the steam following the level and heating the conduit. Water passing through this section upon a rise in level absorbs heat to the extent that it may not cause the thermostat to contract as required.

The expansion tube 18 is preferably weld connected to the conduit portions extending to the boiler as indicated at 22 and 23, the upper end of the expansion tube having an enlarged collar or heel piece 24 secured thereto and the lower end a head piece collar 26, both collars preferably being secured by welding. Also, the conduit 14 is preferably weld connected to the cross connection 11. Prior constructions with which I am familiar have employed elbow like head and heel pieces at each end of the expansion tube to effect piping to the boiler. Elimination of these masses of metal which stored or released heat with water level variations with resultant less radiation from the upper connection and less heat storage at the lower connection effects more accurate response to water level variations.

The conduit 14 or more specifically expansion tube 18 supports a frame comprising a pair of steel channel members 27 spaced laterally from and at each side of the expansion tube and interconnected at the top by a block 28. A U shaped spacing element extending between the lower portion of the channel members is illustrated at 29.

The block 28 is threaded to receive an adjusting collar 31 which abuts the expansion tube heel piece collar 24. Rotation of collar 31 will move the frame longitudinally relative to the expansion tube and a lock nut 32 maintains the frame in an adjusted position. A pin 33 supported by the channel members 27 forms a pivotal mounting for a generally L shaped bell crank lever 34. Lever 34 preferably has a forked end which straddles the head piece collar 23 with the forks being notched to receive aligned pins 36 extending from each side of the collar. A pair of tension springs 38 are secured to the free end of lever 34 and to the channel members 27.

The frame forms the cold section of the unit and upon an increase in the length of the expansion tube due to a drop of water level and a corresponding increase in the steam therein the lever 34 will be permitted to rock in a clock-wise direction about pin 33 under the influence of springs 38. Upon a rise in water level the tube 18 will contract rocking lever 34 in a counterclock-wise direction about pin 33 against the tension of springs 38. A bracket 39 secured to the frame pivotally supports a bell crank lever 41 which is continuously urged in a clock-wise direction by a spring 42 secured to the upstanding arm of the lever and the bracket. An element 43 slidable along the lower arm of lever 41 and adapted to be locked at an adjusted position by a set screw or the like has an adjusting pin 44 threaded thereinto which bears against the upper arm of lever 34. A lock nut 46 holds pin 44 in a desired adjusted position. It will now be understood that clock-wise movement of lever 34 effects counter-clock-wise movement of lever 41 or that the levers rotate around their pivotal points in reverse direction.

The upstanding arm of lever 41 bears against and actuates the stem 47 of a pilot valve 48. The pilot valve is of a well known type wherein the pressure of fluid from a relay supply at substantially constant pressure will be varied in accordance with stem displacement. The line to the relay supply is indicated at 49 and the variable or controlled pressure line at 51. Line 51 extends to a fluid pressure motor or servo mechanism generally indicated at 52.

Figs. 4 and 5 illustrate a type of fluid pressure motor and feed water valve which I may employ. Valves of this general type are well known wherein a servo mechanism will cause a valve of any size to move in correspondence with pressure

variations as controlled by the pilot valve or in accordance with boiler water level variation acting on my improved regulating apparatus. The line 51 communicates with a chamber 53 and upon an increase of pressure therein a diaphragm 54 and stem 56 are forced downwardly causing the valve piston 57 to further close the ports 58 and restrict flow from the inlet 59 to the outlet 61. The underside of the diaphragm is exposed to atmosphere and downward movement of the stem is resisted by an adjustably mounted compression spring 62 which aids opening movement of the valve upon a decrease in pressure in chamber 53.

It will now be understood that the expansion and contraction of tube 18 occurs between the heel piece collar 24 and head piece collar 26 with springs 38 acting on lever 34 and pin 33 maintaining the frame firmly against collar 24. Since collar 24 is fixed any change in length of tube 18 causes collar 26 to move. Threaded collar 31 which bears against collar 24 may be screwed in or out effecting movement of the frame relative to the expansion tube 18 to effect a coarse adjustment with a finer adjustment being obtained by manipulation of pin 44. Element 43 may be moved along the lower arm of bell crank lever 41 to relatively increase or reduce the response.

Referring now to Fig. 3, I have shown a type of expansion tube which I preferably employ wherein a series of circumferential grooves 63, preferably square in cross section, are formed in the external surface of the tube. A tube of this type has decided advantages relative to a non-grooved tube in that the reduction in the amount of metal compared to the amount of water stored in the tube improves the rate of heating and cooling. About twice the radiating surface is provided thereby increasing the temperature differential between the steam and water ends of the tube resulting in relatively more movement. The reduction in cross sectional area of the path by which heat is continually flowing along the tube from the steam end to the water end reduces the heat flow and increases the temperature differential between the tube ends resulting in relatively more movement.

Within practical limits I preferably employ a small size expansion tube since a small diameter pipe has a larger ratio of surface to volume. For example, in the present apparatus I preferably use a ½" expansion tube rather than a ¾" tube. The smaller cross-sectional area of the ½" tube reduces the amount of heat conducted from the hot to the cold end of the tube through the tube walls and the relatively larger surface ratio tends to cool the water in the tube at a faster rate. These two factors tend to increase the amount of tube movement available by increasing the temperature differential between the steam and water. Also, a thinner gage tube than standard may be used to further reduce the wall area and path for conduction of heat and the ratio of the amount of metal to volume of water in the tube. This will further reduce the time lag, since with a rising level the walls of the tube being thinner will have less heat to give up to the water and the final temperature will be attained more rapidly.

The combination of features set forth above provides more temperature difference and hence greater movement for a given change in water level than in prior regulating apparatus of this

general type with which I am familiar and enables a relatively larger pilot valve to be more accurately operated over a longer stroke thereby eliminating the need for relay supply amplifiers, or multipliers, common to prior servo-motor equipment.

The apparatus described including the cross-connection, the conduit and expansion tube supported thereby, the pilot valve, frame, and levers supported by the tube may be assembled and installed as a unit merely by connecting the cross-connection with the boiler drum and the line from the fluid pressure motor to the pilot valve. Also, connection will be made with the drainage valve. The level responsive element or expansion tube will then bear a desired fixed relationship to the normal boiler water level eliminating installation errors as might occur if it was necessary to adjust the expansion tube relative to the normal boiler water level at the time of installation of the apparatus on the boiler.

As previously pointed out, with conventional connections not employing a cross connection all steam condensing in the piping above the expansion tube and particles of water thrown thereinto runs through the tube keeping the water in the lower part of the expansion tube hot whereas in the present arrangement most of the condensate will drain through the cross connection with the cross connection acting as a separator permitting a supply of dry steam to be continuously supplied to the expansion tube.

I preferably take the steam supply to the expansion tube from the highest point of the cross connection 11 since I have found that if it were taken at a lower point which might be sealed off by a sudden rise in boiler water level the expansion tube will be caused to contract closing the regulating valve in a normal manner until the level reached the junction point, then the expansion tube would heat up again and open the feed valve when it should be closed. This action is probably the result of circulation within the inclined section of the tube when it is completely submerged.

The tube 18 is preferably formed of material having a high coefficient of expansion but this is not essential and I have found that a regulator of the type herein described with the expansion tube formed of ordinary steel pipe and having substantially the same coefficient of expansion as the frame or channel members 27 will operate satisfactorily. The relative or operating movement secured is not dependent on the difference in expansion coefficient but on the fact that the frame temperature remains substantially constant while the tube temperature varies with the water level therein.

Although I have shown and described a preferred embodiment of the invention it is understood that numerous and extensive departures may be made therefrom without departing from the spirit of the invention and the scope of the appended claims.

The invention is hereby claimed as follows:

1. Feed water regulating apparatus comprising parts adapted to be installed as a unit on boilers having a fluid pressure motor operated feed water valve, said unit comprising a cross connection adapted to be connected to the steam and water spaces of the boiler, a conduit supported by the cross connection and communicating therewith at the top portion and at a point above the bottom portion and below the normal level, an intermediate portion of the conduit being formed by

an inclined expansion tube extending substantially equal distances above and below the normal boiler water level, the expansion tube bearing a fixed relation to the said level upon installation, a frame relatively insensitive to thermal change extending along the tube and supported at one end by the tube, a rock lever pivoted to the other end of the frame and movable in a given direction by tube contraction, spring means urging the lever in a reverse direction, a pilot valve supported by the frame adapted to be connected to a relay supply of fluid and to the fluid pressure motor, the pilot valve having a stem adapted to vary fluid pressure to the motor in accordance with stem displacement, and a second rock lever pivotally supported on the frame operable by the first rock lever and actuating the stem.

2. The regulating apparatus as described in claim 1 and wherein means are provided for adjusting the frame longitudinally relative to the tube, and for adjusting the effect of the second rock lever on the stem for a given movement of the first rock lever.

3. The regulating apparatus as described in claim 1 and wherein the conduit portion below the tube includes a loop having its lower portion at a fixed distance below the cross connection juncture with the boiler water space.

4. The regulating apparatus as described in claim 1 and wherein the tube is weld connected to the conduit portions communicating with the boiler.

5. The regulating apparatus as described in claim 1 and wherein the expansion tube is formed with a series of external circumferential grooves reducing the cross-sectional area of the heat path along the tube.

6. Feed water regulating apparatus for boilers comprising a boiler drum, a cross connection communicating with the water and steam space of the drum at an end thereof, a tube communicating with the cross connection adjacent its point of entry to the steam space and intermediate the normal water level and the point of entry of the cross connection to the drum water space, the tube including an inclined thermally expansible portion, a frame extending along the tube incline portion and fixed thereto at one end of the frame, a generally L shaped lever pivotally mounted adjacent the other end of the frame and rockable by movement of the thermally expansible tube portion, a second lever mounted on the frame and adapted to transmit movement initiated by the first lever, a feed water valve, a fluid pressure motor controlling the feed water valve, a pilot valve for the motor mounted on the frame, and the levers conjointly controlling operation of the pilot valve.

7. The apparatus as described in claim 6 and wherein both levers have spring means associated therewith to maintain the levers in operative relationship.

8. The apparatus as described in claim 6 and wherein both levers have adjustment means associated therewith.

HAROLD AUGUSTUS SCHLIEDER.