Oct. 7, 1930. J. M. BARRETT 1,777,633

FEED WATER REGULATING SYSTEM

Filed May 4, 1925 3 Sheets-Sheet 1

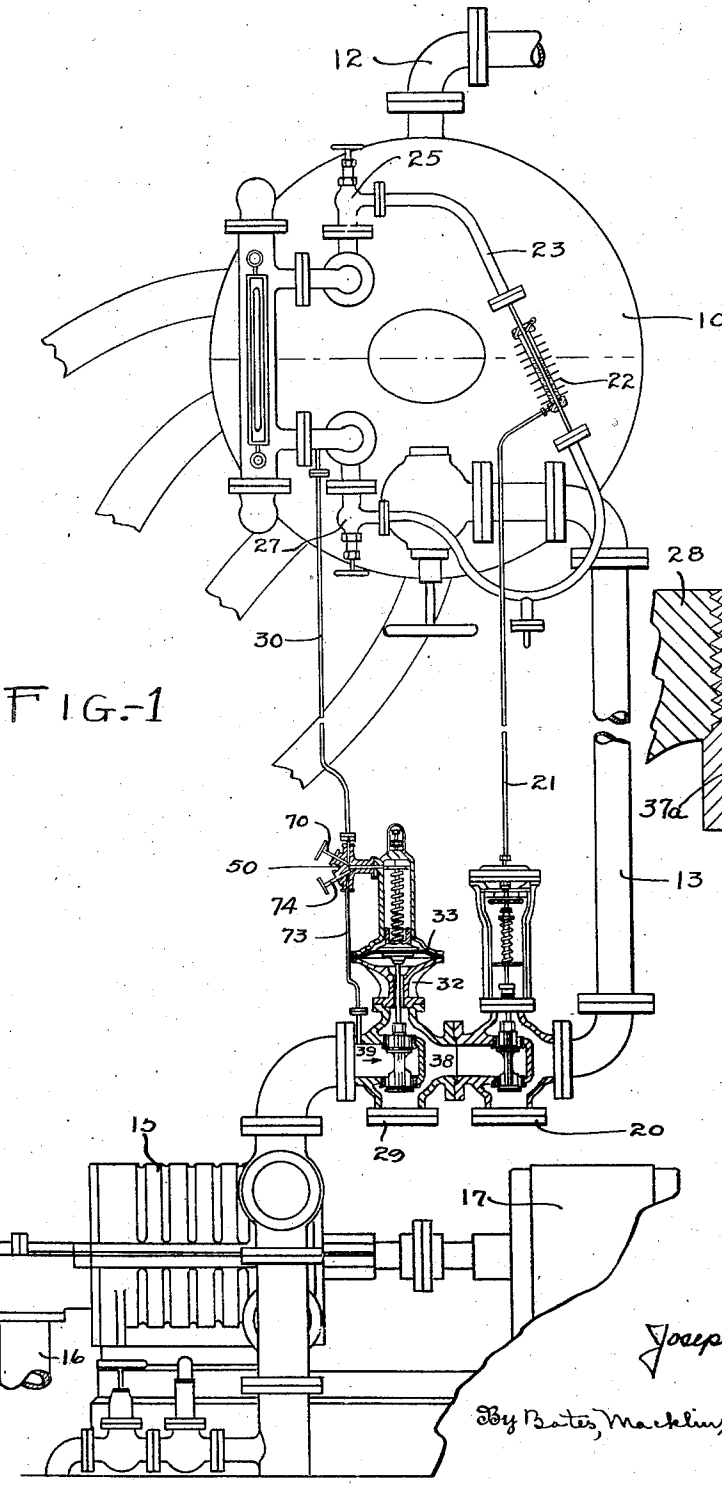

FIG.-1

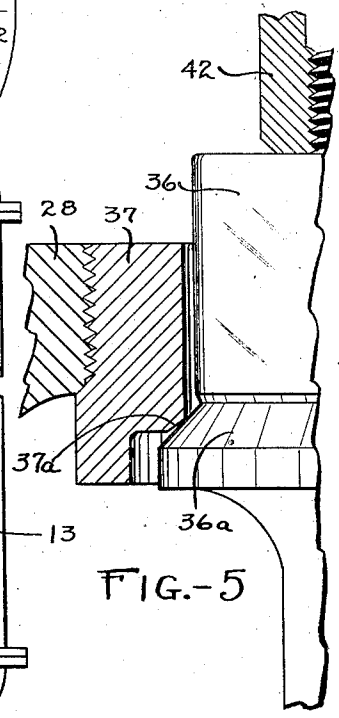

FIG.-5

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FEED WATER REGULATING SYSTEM

Filed May 4, 1925 3 Sheets-Sheet 2

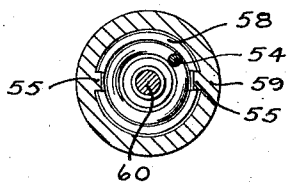

FIG.- 4

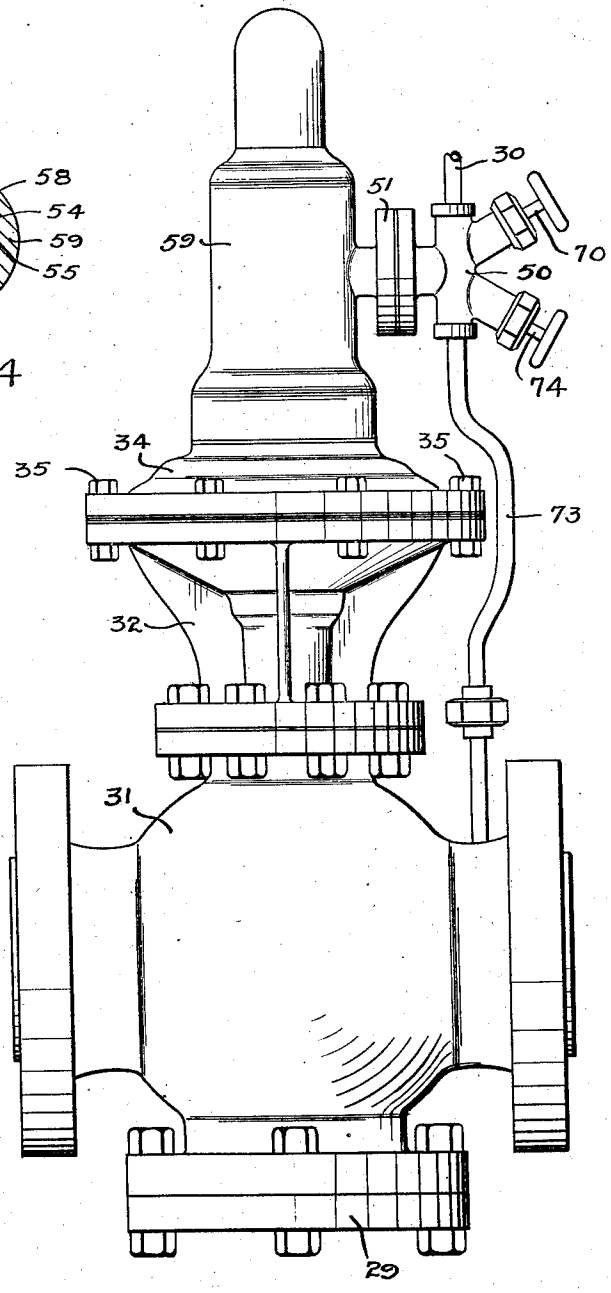

FIG.- 2

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Oct. 7, 1930. J. M. BARRETT 1,777,633

FEED WATER REGULATING SYSTEM

Filed May 4, 1925 3 Sheets-Sheet 3

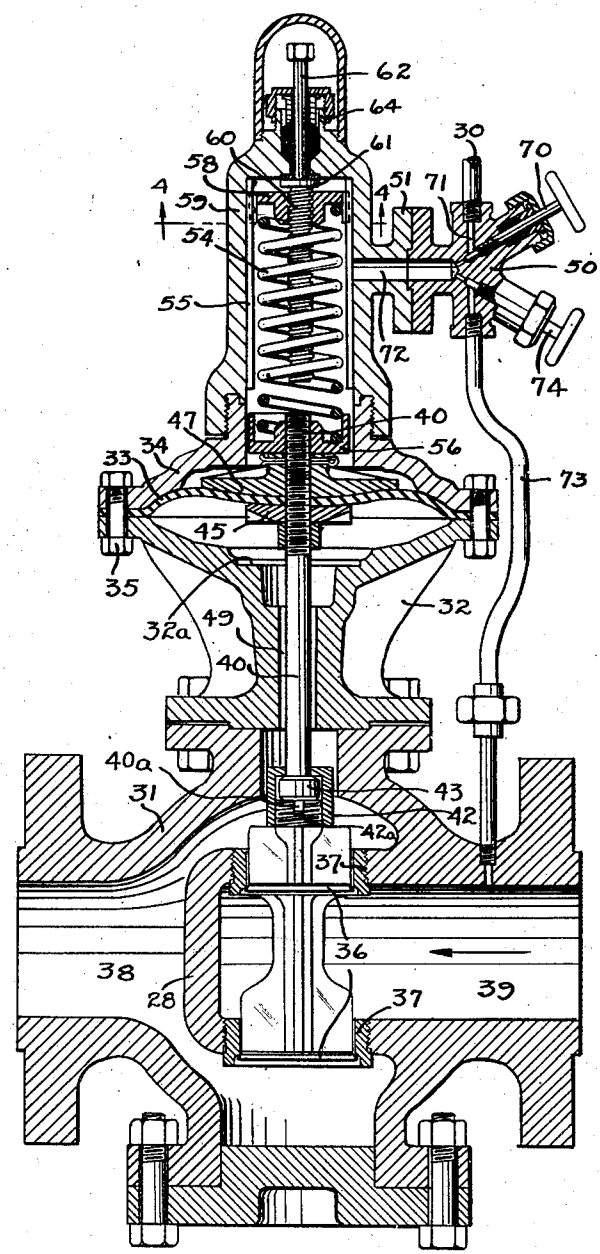

FIG.-3

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1,777,633

UNITED STATES PATENT OFFICE

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FEED-WATER-REGULATING SYSTEM

Application filed May 4, 1925. Serial No. 27,735.

This invention is concerned with improvements in feed water regulators of the continuously operated type. Such regulators are usually responsive to changes in the water level of the boiler being fed, but changes in the rate of water flow in the feed water line to the boiler are not entirely dependent upon variations in the boiler water level for changes in the feed water pressure over the boiler pressure effects, to a considerable extent, the rate of the feed water flow to the boiler when such devices are used. While the pressure in a feed water line may be maintained at a constant excess relative to the boiler pressure, nevertheless pressure changes in the boiler may continually take place when the steam demand on the boiler varies, for example, when the boiler rating is stepped up or down and such constant feed water excess pressure while being proper for normal rating may be inadequate for heavy over-rating. Hence it is apparent that the rate of feed water flow to the boiler can not be absolutely controlled by the usual feed water regulator and particularly when the pressure in the feed water line is greatly in excess of the pressure in the boiler thus causing an unbalanced steam delivery from the boiler. If the boiler being fed happens to be one of a battery servicing a common steam header, this boiler steam delivery will be changed, thus causing variation in the steam pressure in the header, or the line being serviced; all due to the fact that the proper rate of evaporation of the water in the boiler is lacking as a consequence of the overfeeding of the boiler by the feed water line. Adjusting the firing or furnace conditions of the boiler will not reach this deficiency as the time element involved is short but very frequent in the course of a day's operation, and the entire balanced boiler environment is upset, in that, the superheater may accumulate condensate; there is a tendency to decrease the temperature of the stack and thus to cause a drop in percentage of CO_2 gases; a lowering of the feed water temperature, etc. All of the foregoing deficiencies in boiler operation in the modern power plant may be directly traceable to irregularity of feed water flow to the boiler, and this irregularity is caused primarily by varying excess feed water line pressures over boiler pressures.

The general object of my invention therefore, is the provision of a boiler appliance which is directly responsive to pressure conditions in the boiler for regulating or maintaining pressure in the feed water line at a constant excess relative to the boiler pressure.

A more specific object of my invention is the provision of a pressure reducing apparatus for the feed water line of a boiler to serve as a protective means for a feed water regulator valve of a pressure generator system controlling the feed water flow to the boiler and which serves to maintain a constant difference between the pressure in the feed water line and in the boiler.

Other objects of my invention will hereinafter become apparent from the following description referring to the accompanying drawings illustrating a preferred form thereof. The essential characteristics are summarized in the claims.

In the drawings, Fig. 1 is a side elevation of a boiler and feed water system therefor including an electrically driven pump; Fig. 2 is an enlarged view of a feed water pressure regulating apparatus; Fig. 3 is a cross-sectional elevation of the same; Fig. 4 is a cross-sectional view taken along the line 4—4 of Fig. 3 and Fig. 5 is an enlarged fragmentary cross-sectional view showing the close fitting relationship of the valve contacting surfaces.

My invention contemplates the use of a pressure generator device connected to a diaphragm operated valve, the latter serving to regulate the flow of water in feed water lines and a pressure reducing valve controlled by the boiler and serving as a protection to the feed flow valve as well as an excess pressure controller. The feed water regulator embodied in the present invention is disclosed in a general way in a patent to N. G. Copley on a feed water regulator, No. 1,193,125 and issued August 1, 1916. Such a mechanism is usually mounted on the boiler to have the pressure generator thereof extend through the plane of the normal water level of the boiler.

The heat exchange of the pressure generator of such an appliance is not sufficiently rapid or efficient enough to afford refined regulation of the feed water flow of a high pressure modern power plant boiler since no refined regulation of the flow of the feed water can be obtained without maintaining a uniform difference between the varying pressure in the boiler and the feed water line pressure. I propose to regulate such pressure in the feed water line to maintain it at a constant differential relative to the varying boiler pressure before passing through the feed water regulator valve. In Fig. 1, I show the drum 10 of a water tube boiler connected to a header or line 12, and to a source of water supply through a feed water line 13. The feed water line 13 is fed by a pump 15 connected to a suction line 16, the pump being driven by a turbine or motor 17. Connected in the feed water line is a feed water flow regulating valve 20 of the diaphragm type such as is disclosed in the Copley patent referred to and this diaphragm valve is operated by pressure in a line 21 connected to a pressure generator 22. The pressure generator 22 is disposed to stand or extend through the plane of the normal water level of the boiler drum 10 and to surround a conduit 23 connected to the boiler drum above and below the water level thereof. Such a connection may be made to a water column valve 25 above the water level and below the water level to a second water column valve 27. Immediately adjacent the regulating valve 20 I provide a pressure control valve 29 preferably of the diaphragm type which is connected to a lower region of the drum 10 of the boiler by a conduit 30. This valve functions in a manner to be hereinafter described, to maintain a constant difference between the pressures in the boiler drum and the pressure in the feed water line to the point of passage through the feed water regulator valve 20, and as shown in Figs. 2 and 3, is disposed in the feed water line between the valve 20 and the pump 15.

The pressure regulating valve 29 comprises a main valve body 31 having a diaphragm supporting extension 32 attached to a branch thereof, and the upper perimeter of the extension member 32 comprises a bearing or clamping surface for a diaphragm 33.

The nut 45 is formed to rest in a counterbore 32ª of the extension member and thereby limit the downward deflection of the diaphragm and the cap 34 serves to restrict the upward movement of the diaphragm. This diaphragm is acted upon by the boiler pressure plus an excess pressure in the form of an adjusted spring pressure on one side and by an opposing feed water pressure on the other side which is enclosed by a closure or cap member 34 secured to the extension member in any suitable manner preferably with bolts 35. Hence the operating mechanism of this valve is such that it may be adjusted to obtain any predetermined or desired excess pressure of the feed water line over the boiler pressure, regardless of the prevailing pressure in the boiler as long as the pump pressure exceeds the maximum boiler pressure. The valve proper may comprise a removable double seat close fitting member 36 to contact or seat upon outlets 37 removably supported by the valve body partition wall 28. The lower seat portion of the number 36 may be of greater effective area than the upper so that the number 36 is urged downwardly by the feed water pressure, so that the valve will assume an open position in the event of breakage of any of the controlling parts. The valve member 36 may be connected to a diaphragm actuated stem 40 by a hollow nut 42 which engages an enlarged head 43 formed on the lower end of the stem. The upper end of the stem is threaded as indicated at 44 to receive a flanged nut 45 contacting with the under face of the diaphragm 33 and a flanged nut 47 engaging the upper face thereof. A passageway 49 is formed in the extension member 32 of sufficient diameter to permit the feed water to pass through the extension member and exert pressure on the underface of the diaphragm 33. A conduit 30 extending from the boiler drum to the valve mechanism is connected to the valve through a by-pass valve 50 mounted upon a branch 51 of a spring housing member 59 which encloses an excess-pressure spring 54. The member 59 is mounted upon the cap 34 in a leak-proof manner and is of sufficient strength to withstand the greatest pressure which may be exerted at any time within the boiler drum 10. The excess pressure spring 54 is supported between a collar member 56, in engagement with the upper end of the valve stem 40, and an adjustible collar 58 which is suitably slotted to engage ribs or ways 55 formed on the interior wall of the member 53 and the collar member 58 is in threaded engagement with an excess pressure adjusting screw 60 which has a shoulder 61 bearing against the upper wall of the spring housing member 53. A packing gland 64 is provided in the upper wall of the spring housing member to closely fit about the screw member shown.

I would suggest certain refinements in the pressure valve structure described tending to insure constant and accurate performance and particularly in the body structure of the valve which supports and houses the diaphragm. For instance the shape of the inner face of the plate cap 34 may be such that when the pressure in the boiler is unusually low, the major portion of the upper face of the diaphragm will be supported by the plate and the collar 47 and the contours of these two members may be such that the diaphragm

will have a recurved shape to eliminate diaphragm friction loss, thus making the pressure regulator extremely sensitive. The diaphragm supporting end of the extension member may also be formed to support the under face of the diaphragm under adverse pressure conditions.

Also the connection between the stem 40 and the valve member 36 may be such that the cap nut 42 will firmly join the stem and valve member. The enlarged end of the valve stem may be provided with a key portion 40^a to engage in slot 42^a formed in the upper threaded end of the valve member 36 to prevent relative turning between the stem and valve member. It will be seen that by changing the members 32 and 34 to support diaphragms of different diameters, a standard product may be manufactured for an extensive range of pressure controls while necessitating only the dimensional change of but three of the elements of the mechanism.

I also find that the seating relation between the seats 37 and the valve member 36 may be of the specific shape shown in Fig. 5 wherein the coniformed seats 36^a are shown as having a substantially ring contact on the annular coniform shoulders 37^a of the sleeve members. This restricted contact permits the valve members to be urged into a close seating or closing relation under a predominating high pressure in the pump line.

The by-pass valve is provided with a valve stem 70 which controls a passage 71 extending to the branch passage 72 of the spring housing and this valve stem 70 may be of the needle type to interrupt fluid pressure between the boiler drum and the spring side or upper side of the diaphragm. A second valve stem 74 is provided in the by-pass valve 50 which is adapted to close communication between a by-pass conduit 73 and the spring housing passageway 72. Thus in normal operating condition, communication between the boiler drum and the spring chamber above the diaphragm is restricted to a small cross section by use of the needle valve. I find this to be a factor on the side of safety, particularly in the event of a fracture of the diaphragm, for this restricted passage would then prevent any harmful flow of feed water to the boiler drum through the diaphragm by way of the by-pass and at the same time would create a back pressure above the diaphragm which with the aid of the pressure of the spring 54 would keep the differential valve open until the stem 74 could be moved to open position and the stem 70 moved to closed position. Thus the prevailing pump pressure in the branch passageway 39 of the valve body 31 may be exerted within the spring housing 53 and consequently on the upper face of the diaphragm. Hence the valve may be rendered inoperative, when desired.

It will be seen from the foregoing description of this valve mechanism, that since the position of the valve is ahead of the feed water regulator, the desired excess pressure may be obtained by adjusting the screw 62 to compress the spring 54 whereby there will be exerted on the upper face of the valve and within the spring housing 59, a pressure which is equal to the spring pressure plus the prevailing pressure in the boiler drum 10 and there will be exerted on the underface of the diaphragm and through the extension member 32, the pump pressure exerted on the feed water in the branch passageway 38, and the valve body 31. When this latter pressure is greatly in excess of the combined pressures of the prevailing boiler pressure plus the spring pressure, the diaphragm 33 will be deflected upwardly thus carrying the valve members 36 to seating or near seating position relative to the valve sleeves 37. It will thus be seen, that even though the feed water level in the boiler is below normal and the pressure generator 22 has generated sufficient pressure to completely open the feed water flow control valve 20, and if there has been an extreme drop in the boiler pressure very little water will pass through the boiler until the pressure in the boiler increases, whereupon this increase in pressure will cause a downward deflecting of the diaphragm 33 and thus open the pressure regulating valve to permit flow of feed water through the regulating valve 20 at a pressure which is at the desired excess over the pressure prevailing in the boiler. On the other hand if the water level is sufficiently low to cause the valve 20 to be wide open and the pressure governor valve is partly open, the water will be fed to the boiler at the desired excess pressure over the prevailing steam pressure in the boiler.

Taking a practical example of boiler operation to illustrate one of the chief advantages to be found in the use of my invention, I will first assume that a power plant having a battery of ten boilers is operating with a two hundred pound pressure demand in the header line. When the boiler feed pumps are under a common governor control to supply the feed water to the boilers, the feed pressure is say twenty-five pounds in excess of the steam pressure. Frictional losses in the feed water line, etc., will give approximately a twenty pound excess pressure in the feed water line at the feed water regulator valve. This excess pressure, of course is excess over the two hundred pound boiler header line pressure and not a twenty-pound excess pressure over the actual drum pressure. If there is a two-hundred pound pressure in the header line, then there is an excess pressure in each of the boilers of about two hundred and five pounds when the boilers are operating at their usual boiler rating. We would then have only an actual excess feed water

pressure of fifteen pounds over the prevailing drum pressure of the boiler.

Under the foregoing conditions, regulation may be maintained, but if we assume that a condition arises calling for a one hundred per cent increase in the rating of say half of the boilers, there is an additional excess pressure or five pound increase in the excess pressure of the drum pressure relative to the header line pressure leaving the feed water line with an excess pressure of only ten pounds. Now, if for certain operating reasons, the remaining five boilers should drop below the normal rating operation with a resulting decrease in excess drum pressure over line pressure, then the excess water pressure in the feed line to these low rating operating boilers, would be about eighteen pounds. In the latter boilers, there would be a resulting increase of feed water flow with the resulting further lowering of their steaming ability and for a short period they would merely function as water heaters. The water level in the high rating operating boilers would drop due to the increasing vaporation therein and also due to the lowering of the excess water pressure over the drum pressure.

It will be obvious that if pressure governors are positioned in each individual feed water line in the respective boilers, that only such pressures will prevail in the feed water line as will have a constant excess relative to the prevailing pressure in the boiler being fed irrespective of the regulating condition of the feed water regulator being operated by a pressure generator responsive only to prevailing water level conditions in said boiler. It also will be obvious that a further use of such a governor valve will be found where high excess water pressures are to be carried at pumps, due to small feed water lines (incidental to high pressure practice) and friction losses in such lines and in the lines on the other side of the pump, namely economizer friction losses, etc. Furthermore it will be apparent that if the high excess pressures are carried at the feed water regulator valve and not reduced before reaching the valve, excess of wear results in the feed water regulator valve members and furthermore the slightest change in feed water regulator valve operation effects a change in water flow, all out of proportion to the actual requirements of the moment due to high velocity of the feed water flow under high excess pressure.

I claim:

1. In a boiler feed pipe, the combination of a valve responsive to changes in water level in the boiler, a fluid actuated valve disposed adjacent thereto and responsive to changes in pressure drop through the first named valve, excess pressure means associated with the latter valve, means for throttling the flow of actuating fluid to the latter valve and means for balancing the actuating fluid pressure so that the excess pressure means forces the latter valve open.

2. In a feed water regulating system for a boiler, having a feed water pump for exerting pressure in the feed water line in excess of the maximum rated boiler pressure, the combination of a pressure reducing means in the feed water line, comprising a diaphragm actuated valve, a feed water flow regulating device connected in the feed water line between the boiler and the diaphragm valve, said diaphragm actuated valve being connected in the line whereby the reduced pressure may be exerted upon one side of the diaphragm, a conduit connected to the boiler below the normal water level thereof, a second conduit connected to the feed water line between the pump and said valve, means connecting said conduits to the valve whereby either boiler pressure or pump pressure may be exerted upon the opposite side of said diaphragm, a needle valve interposed in the first named conduit and adapted to protect the boiler from an excess flow of cold water in event of fracture of said diaphragm, and means for exerting upon the diaphragm in opposition to the reduced line pressure and by way of addition to the prevailing boiler pressure, a predetermined excess pressure.

3. In a feed water regulating system for a boiler, having a feed water pump adapted to maintain feed water pressure in excess of the maximum boiler pressure, the combination of a diaphragm operated pressure reducing valve in the feed water line, a feed water flow regulating device connected in the feed water line between the boiler and said valve, a conduit connected to the boiler drum and to a chamber adjacent the diaphragm of said valve whereby boiler pressure may be exerted upon one side of the diaphragm, a conduit connected to the feed water line between the pump and said valve and leading to said chamber whereby the pump pressure may be substituted for the boiler pressure upon said diaphragm, means including a by-pass valve to effect such substitution, excess pressure means adapted to act in the same direction with regard to said diaphragm, and means affording communication between the other side of said diaphragm and the feed water line between said valve and said regulating device whereby the pump pressure plus the excess pressure may act against the boiler feed water pressure so that said valve may be held open when such substitution is effected by the by-pass valve.

4. In a feed water regulating system for a boiler, having a feed water pump adapted to maintain feed water pressure in excess of boiler pressure, the combination of a diaphragm operated valve in the feed water line, a feed water flow regulating device connected

in the feed water line between the boiler and said valve, a conduit connected to the boiler drum and to a chamber adjacent the diaphragm of said valve whereby boiler pressure may be exerted upon one side of the diaphragm, a conduit connected to the feed water line between the pump and said valve and leading to said chamber whereby the pump pressure may be exerted upon the same side of said diaphragm, means for establishing on the opposite side of said diaphragm fluid pressure equal to that between said valve and said device, and a valve in said last named conduit for controlling the flow of fluid therethrough by means of which varying pressures in excess of boiler pressure may be established upon said diaphragm.

5. In a feed water regulating system, having a feed water pump adapted to maintain feed water pressure in excess of boiler pressure, the combination of a diaphragm operated valve in the feed water line, a feed water flow regulating device connected in the feed water line between the boiler and said valve, a conduit connected to the boiler drum and to a chamber adjacent the diaphragm of said valve whereby boiler pressure may be exerted upon one side of the diaphragm, a second conduit connected to the feed water line between the pump and said valve and leading to said chamber whereby the pump pressure may be exerted upon said diaphragm, excess pressure means adapted to act upon and in the same direction with regard to said diaphragm, means connecting the opposite side of said diaphragm with the feed water line between said valve and said device, and means for controlling the flow of fluid through at least said last named conduit.

6. In a boiler feed pipe, the combination of an orifice, a fluid actuated valve disposed adjacent thereto and responsive to changes in pressure drop through said orifice and urged toward closed position by the fluid pressure between said orifice and said valve, excess pressure means associated with said valve, means for conducting actuating fluid to said valve from a point on the boiler side of said orifice, means for conducting actuating fluid to said valve from the feed water pipe ahead of said valve, and valve means associated with both said last named conducting means for controlling the flow of fluid therein.

7. The combination of a boiler, a feed water pipe, an orifice in said pipe, a feed water pump, a diaphragm actuated valve positioned between the orifice and the pump, means for establishing fluid pressure on one side of said diaphragm equal to the pressure between said valve and said orifice, means for conducting fluid to the opposite side of said diaphragm from a point on the boiler side of said orifice, means for conducting fluid to the same side of said diaphragm from a point between said valve and said pump, valve means associated with both said last named means for controlling the flow of fluid therethrough and varying the pressure exerted upon the diaphragm.

8. The combination according to claim 7 including adjustable excess pressure means supplementing the force controlled by said valve means.

9. The combination of a boiler, a feed water pipe, an orifice in said pipe, a feed water pump, a diaphragm actuated pressure controlling valve disposed between said pump and said orifice, means connecting one side of said diaphragm with the feed water line between said valve and said orifice, means connecting the opposite side of said diaphragm to the boiler side of said orifice, means connecting the same side of said diaphragm with the feed line between the pump and said valve, and independently operable valve means associated with each of said last named means for controlling the flow of fluid therethrough and for varying the pressure exerted on said diaphragm.

10. The combination of a boiler, a feed water pipe, an orifice in said pipe, a feed water pump, a diaphragm actuated valve in said pipe between said pump and said orifice, adjustable means tending to force said valve open, means for establishing fluid pressure equal to the pressure between said valve and said orifice on said diaphragm tending to close said valve, a conduit leading to the opposite side of said diaphragm for establishing boiler pressure thereon, a second conduit leading to the same side of said diaphragm for establishing pump pressure thereon, and independently operable valve means in each of said conduits for increasing or decreasing the openings through which fluid may flow in each of said conduits whereby the fluid pressure exerted tending to open the diaphragm actuated valve is a function of the relation between the openings of said last named valve means.

11. The combination of a boiler, a feed water pipe, an orifice in said pipe, a feed water pump, a pressure actuable valve in said pipe between said pump and said orifice having a part movable by and subjected to fluid pressures for varying the opening of said valve, means tending to force said valve open, means for establishing fluid pressure equal to the pressure between said valve and said orifice on said part tending to close said valve, fluid conducting means leading to the opposite side of said part from a point on the boiler side of said orifice, a second fluid conducting means leading to the same side of said part from a point between said pump and said valve, and valve means in the latter of said fluid conducting means for controlling the flow therethrough whereby fluid pressure tending to equal pump pressure may be established on said part.

12. In combination, a boiler, a feed water pipe, a fluid pressure actuated valve disposed in said feed water pipe and having a part subjected to fluid pressures for moving the valve, means for establishing the pressure existing at the outlet side of said valve on one side of said part, a conduit for conducting fluid between the other side of said part and a point on the boiler side of said valve, a conduit for conducting fluid to the last named side of said part from a point on the inlet side of said valve, and means for controlling the movement of fluid through said last named conduit.

13. In a boiler feed water pipe, the combination of an orifice, a fluid pressure actuated valve disposed in said feed water pipe in advance of said orifice and having a part subjected to fluid pressures for moving the valve, means for establishing the pressure existing at the outlet side of said valve on one side of said part, a conduit for conducting fluid between the other side of said part and a point on the boiler side of said orifice, a conduit for conducting fluid to the last named side of said part from a point on the inlet side of said valve, and means for controlling the movement of fluid through said last named conduit.

14. In combination, a boiler, a feed water pipe, a fluid pressure actuated valve disposed in said feed water pipe and having a part subjected to fluid pressures for moving the valve, means for establishing the pressure existing at the outlet side of said valve on one side of said part, a conduit for conducting fluid between the other side of said part and a point on the boiler side of said valve, a conduit for conducting fluid to the last named side of said part from a point on the inlet side of said valve and means for controlling the movement of fluid through both of said conduits.

15. In a boiler feed water pipe, the combination of an orifice, a fluid pressure actuated valve disposed in said feed water pipe in advance of said orifice and having a part subjected to fluid pressures for moving the valve, means for establishing the pressure existing at the outlet side of said valve on one side of said part, a conduit for conducting fluid between the other side of said part and a point on the boiler side of said orifice, a conduit for conducting fluid to the last named side of said part from a point on the inlet side of said valve and means for controlling the movement of fluid through both of said conduits.

16. In a boiler feed pipe, the combination of an orifice, a fluid actuated valve movable in response to changes in pressure drop across said orifice and urged toward closed position by the fluid pressure between said orifice and said valve, excess pressure means associated with said valve, means for conducting actuating fluid to said valve from a point on the boiler side of said orifice, and means for forcing said valve to open position.

17. In a boiler feed pipe, the combination of an orifice, a fluid actuated valve disposed adjacent thereto and movable in response to changes in pressure drop across said orifice and urged toward closed position by the fluid pressure between said orifice and said valve, excess pressure means associated with said valve tending to open it, means for conducting actuating fluid to said valve from a point on the boiler side of said orifice, and means apart from said excess pressure means for positively forcing said valve to open position.

18. The combination of a boiler, a feed water pipe, an orifice in said pipe, a feed water pump, a pressure actuable valve in said pipe between said pump and said orifice having a part movable by and subjected to fluid pressures for varying the opening of said valves, means tending to force said valve open, means for establishing fluid pressure equal to the pressure between said valve and said orifice on said part tending to close said valve, fluid conducting means leading to the opposite side of said part from a point on the boiler side of said orifice, and means for exerting a force on the last named side of said part to force and hold said valve in open position.

19. The combination of a boiler, a feed water pipe, an orifice in said pipe, a feed water pump, a pressure actuable valve in said pipe between said pump and said orifice having a part movable by and subjected to fluid pressures for varying the opening of said valve, means exerting a relatively constant force tending to open said valve, means for establishing fluid pressure equal to the pressure between said valve and said orifice on said part tending to close said valve, fluid conducting means leading to the opposite side of said part from a point on the boiler side of said orifice for establishing fluid pressure on said part tending to open said valve, and means for forcing and holding said valve in an extreme position of its travel.

In testimony whereof, I hereunto affix my signature.

JOSEPH M. BARRETT.