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BOILER FEED PUMP CONTROL

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2 Sheets-Sheet 1

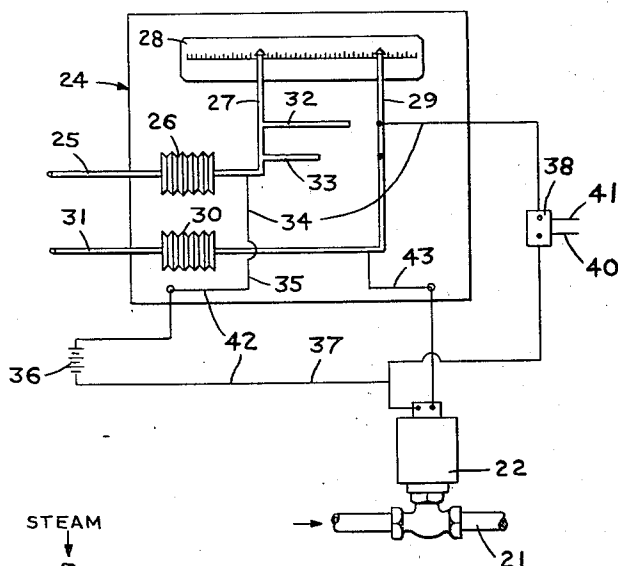


FIG. 2

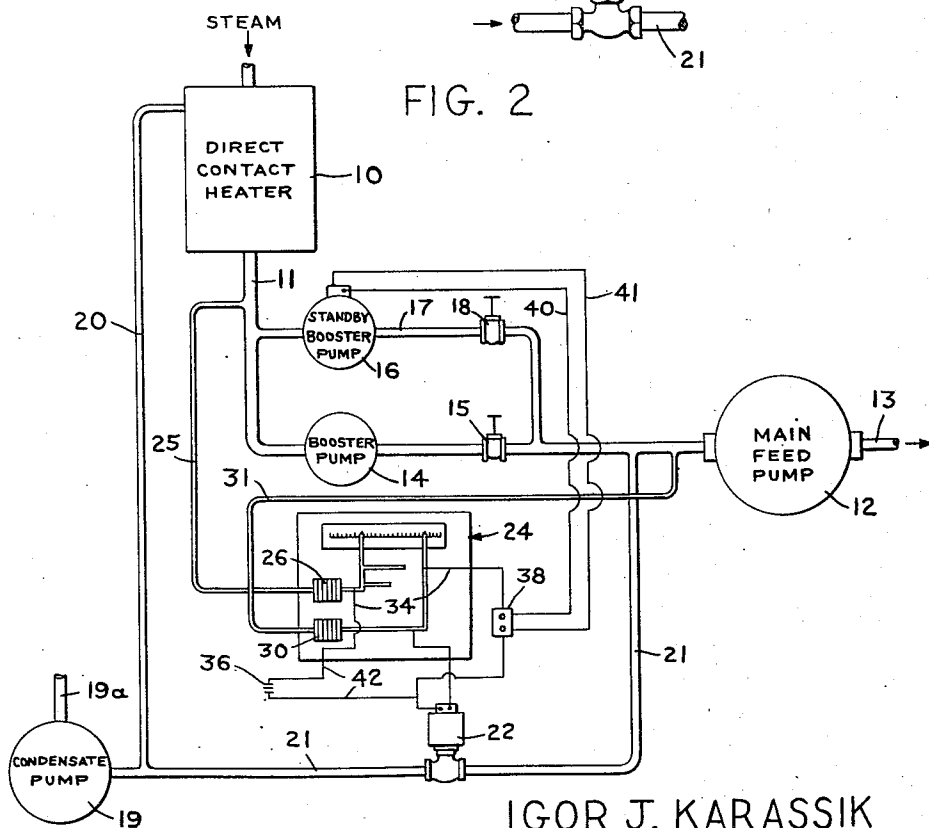


FIG. 1

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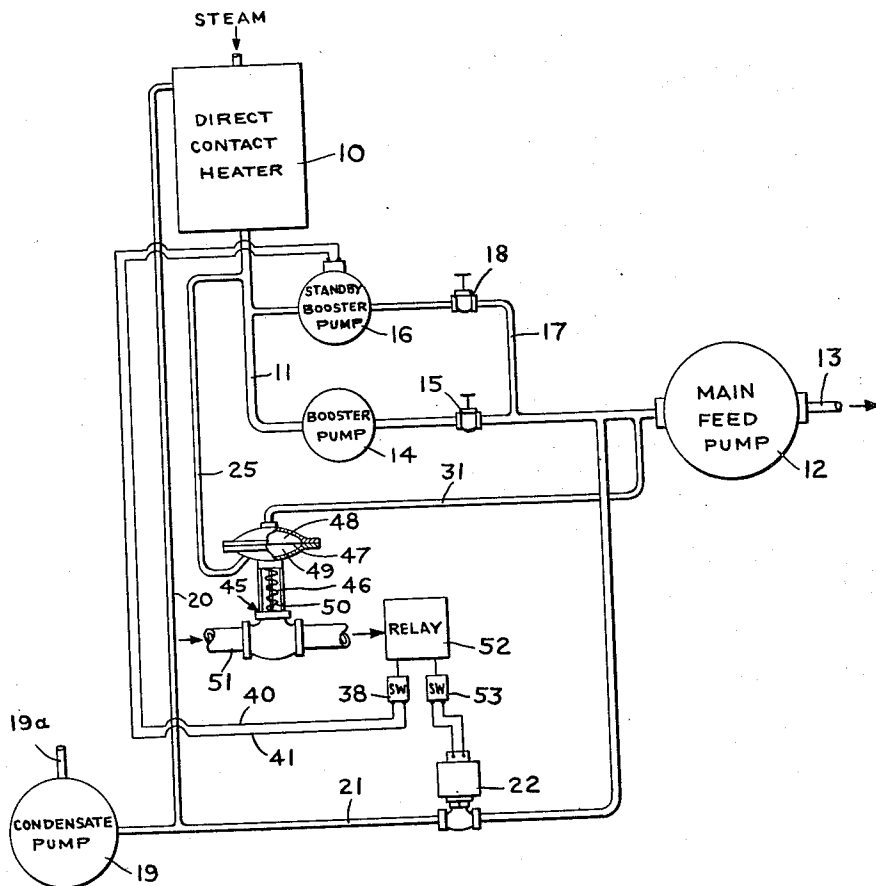


FIG. 3

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BOILER FEED PUMP CONTROL

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2 Claims. (Cl. 122—451)

The present invention relates to a boiler feedwater system of the open type, that is, one which embodies a direct contact feedwater heater.

More specifically, the invention contemplates the protection of the main boiler feed pump against flashing in a boiler feedwater system wherein a separate booster feed pump is interposed between the direct contact heater and the main feed pump suction to provide additional pressure at the main feed pump suction. The booster pump is used to maintain a sufficient pressure differential between the suction pressure at the main feed pump and the vapor pressure corresponding to the temperature of the entering feedwater to prevent flashing of the feedwater into steam in the first stage of the main feed pump to avoid damage to the pump and interruption of its pumping action.

The pressure generated by the booster pump is a reasonable criterion of the pressure differential between the main feed pump suction and the vapor pressure corresponding to the feedwater temperature at any given load, as can be seen from the following relation:

Boiler feed pump suction pressure=heater pressure+static head+net pressure of booster pump—friction losses in the piping

Since the vapor pressure of the feedwater in a feedwater system embodying a direct contact heater is equivalent to the heater pressure:

The available net positive suction head (NPSH), or the pressure differential between the pressure of the feedwater entering the boiler feed pump and the vapor pressure corresponding to the temperature of the entering feedwater at the suction of the main feed pump=the static head+the pressure of the booster pump—the friction losses in the piping.

Thus, by selecting the net pressure of the booster feed pump in a proper manner, the net positive suction head at the main feed pump suction can be made to exceed the NPSH required to avoid flashing of the feedwater into steam in the first stage of the main feed pump. This, of course, is based upon the assumption that other control means are available during transient conditions to prevent the reduction of the available NPSH by an excessive decrease in the direct contact heater pressure. Therefore, since the pressure generated by the booster pump is a reasonable criterion of the pressure differential between the main feed pump suction and the vapor pressure corresponding to the feedwater temperature at any given load, then the only other cause for a decrease in this pressure differential would be a decrease in the pressure generated by the booster pump, through failure of the pump, or of the power supply to the pump driving means.

The failure of the booster pump may occur independently of the prevailing conditions at the main feed pump since the booster pump is commonly driven by an electric motor while the main feed pump may be turbine driven. Thus, should the power supply to the electric motor driving the booster pump fail, the pump would

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automatically stop. Even when both the booster and main feed pumps are driven by electric motors, the motors may operate on different voltage circuits because of a wide difference in motor size. Here too, a failure in the power supply to the motor of the booster pump would cause failure of the pump. In addition, the booster pump may break down independently of conditions prevailing at the main feed pump through a mechanical defect in the pump end thereof.

If the pressure at the suction of the booster feed pump were to remain constant at all loads, the failure of the pump would not be important since the use of pressure switches set at specific pressure settings could transmit a pressure responsive signal to start a standby booster pump, to provide the predetermined pressure differential, or to provide an alternate source of feedwater for the main feed pump. However, in modern steam plants the direct contact heater at the suction of the booster pump may operate over a wide range of pressures and temperatures and the use of pressure switches would not be satisfactory since a given suction pressure at the main feed pump may be satisfactory for one set of load and temperature conditions, while unsatisfactory for another set of conditions.

In accordance with the present invention, a method and apparatus for controlling the pressure in a boiler feedwater system is provided to maintain a predetermined pressure differential between the suction pressure at the main feed pump and the vapor pressure corresponding to the temperature of the entering feedwater to prevent flashing of the feedwater into steam upon failure of operation of the booster feed pump. The present invention provides a pressure responsive signal indicating the pressure differential across the suction and discharge side of the booster pump or the net pressure of said booster pump, which signal is transmitted to control means operatively connected to a standby booster pump in parallel with the main booster pump to start the standby pump when this pressure signal decreases below a predetermined value. The control means are also operatively connected to valve means adapted to admit feedwater under pressure to the suction of the main feed pump from a different source when the pressure signal received decreases below a second predetermined value, below the first predetermined value.

The present invention provides a method and apparatus for detecting failure of the booster pump in a boiler feedwater system.

The present invention further provides a method and apparatus for controlling the suction pressure at the suction of a main feed pump in a feed-water system in response to pressure variations in the booster pump therein, rather than in response to variations in the temperature of the feedwater as in applicant's Patent No. 2,372,087.

The invention will be better understood from the following description when considered in connection with the accompanying drawings forming a part thereof and in which:

Figure 1 is a diagrammatic view of a boiler feedwater system embodying the control means of the present invention.

Figure 2 is an enlarged view of the control means shown in Figure 1, and

Figure 3 is another embodiment of the invention shown in Figure 1.

Referring to Figure 1, the reference numeral 10 designates a direct contact heater embodied in a boiler feedwater system having a discharge line 11 therein in communication with a main feed pump 12 for flowing feedwater thereto. The main feed pump communicates by a conduit 13 with a boiler (not shown). A booster pump 14 is disposed in feedwater line 11 to generate additional pressure at the main feed pump suction to

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maintain a predetermined pressure differential between the suction pressure at the main feed pump and the vapor pressure corresponding to the temperature of the feedwater for preventing flashing of the feedwater into steam within the first stage of the main feed pump. A check valve 15 is disposed in line 11 on the discharge side of booster pump 14 to prevent back flow of feedwater therein.

A stand-by booster pump 16 is provided in a feedwater conduit 17 in communication with conduit 11 on the suction and discharge sides of booster pump 14 for generating pressure to maintain a predetermined pressure differential at the main feed pump suction in excess of the vapor pressure corresponding to the temperature of the entering feedwater to prevent flashing of the feedwater into steam should booster pump 14 fail to provide the normal predetermined pressure differential or margin. A check valve 18 is disposed in conduit 17 on the discharge side of pump 16 therein.

A condensate pump 19 in communication with a condenser (not shown) by line 19a is provided for supplying feedwater to the direct contact heater 10 through conduit 20 in communication therewith. A bypass line 21 is provided in communication with the condensate pump and conduit 11 at the suction of main feed pump 12 to supply feedwater under pressure directly to the main feed pump should stand-by booster pump 16 fail to operate, and the predetermined pressure differential between the suction pressure at the main feed pump and the vapor pressure corresponding to the temperature of the entering feedwater decrease below a predetermined value. The flow of feedwater from the condensate pump to the main feed pump through bypass line 21 is controlled by a solenoid or motorized valve 22 disposed in line 21.

Referring to Figure 2, the reference numeral 24 designates the control means embodied in the boiler feedwater system of the present invention to maintain a predetermined pressure differential at the suction of the main feed pump above the vapor pressure corresponding to the temperature of the feedwater to prevent flashing of the feedwater into steam should the booster pump pressure decrease or fail to operate, and to maintain a predetermined pressure differential above said corresponding vapor pressure when the stand-by booster pump pressure decreases or fails to operate. Control means 24 comprises a capillary tube 25 connected at one end to the suction of booster pump 14 and at the other end to an expansible bellows 26 having a movable pointer 27 attached thereto. Bellows 26 is so calibrated that the attached pointer 27 moves along an indicating scale 28 which reads the suction pressure at the booster pump 14 in p. s. i. A similar pointer 29 is movably attached to a bellows 30 similar to bellows 26. Bellows 30 is connected by capillary tube 31 to conduit 11 on the discharge side of booster pump 14 beyond line 17 entering therein. Bellows 30 is so calibrated that the attached pointer 29 moves along the indicating scale 28 to indicate the discharge pressure of the booster pump in p. s. i. The distance along scale 28 between pointers 27 and 29 represents at all times the net pressure generated by the booster feed pump 14.

Extension arms 32 and 33 are connected to the suction pressure indicating pointer 27. The length of the extension arms are such that contact will be made by them with pointer 29 before the predetermined value of pressure differential to be developed by the booster pump 14 above the vapor pressure corresponding to the feedwater temperature at the suction of the main feed pump to prevent flashing of the feedwater into steam is reached.

An electrical circuit 34 is provided for actuating the stand-by booster pump 16. Circuit 34 comprises an electrical cable 35 connected to pointer 27 at one end thereof and a source of power 36 at the other end thereof, and an electrical cable 37 connected to the source of power and pointer 29 at the other end thereof. A starting switch

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38 is disposed in circuit 34 in cable 37 and is connected by cables 40 and 41 to the starting circuit of the stand-by booster pump 16.

When the net pressure generated by booster pump 14 remains in excess of the predetermined value of pressure differential desired, circuit 34 is deenergized. Upon the lowering of the net pressure of the pump to that determined by the length of the extension arm 32, the arm will contact the pointer 29 to close the electrical circuit 34 and energize it thereby closing starter switch 38 to energize the starting motor circuit and start the stand-by booster pump in operation. Thus, control means 24 performs the function of a switch actuated by the value of the net pressure generated by the booster pump 14. Thus, the failure of operation of booster pump 14 decreases the net pressure generated by the booster pump 14 so that electrical circuit 34 is energized and the stand-by booster pump 16 provides additional pressure at the main feed pump suction to maintain a sufficient pressure differential between the suction pressure at main feed pump 12 and the vapor pressure corresponding to the temperature of the entering feedwater to prevent flashing of the feedwater into steam.

The subsequent opening of the electrical circuit 34 does not stop the operation of the stand-by booster pump 16, but the pump must be stopped manually and the mechanism reset. This action is desirable to prevent hunting of the system.

An electrical circuit 42 comprising individual cables 35 and 43 is provided for energizing solenoid motor valve 22 to open the valve and permit feedwater under pressure to flow directly from condensate pump 19 through bypass line 21 to the suction of the main feed pump 12 bypassing the booster pump and direct contact heater. Cable 43 is connected at one end to pointer 29 and at the other end to the solenoid motor valve 22. The other terminal of the solenoid valve 22 is connected through cable 37 to the source of power 36 to complete the circuit.

Upon failure of the starting of the standby booster pump 16 to restore the desired condition, pointer 29 indicating the discharge pressure of the booster pump 14 would continue to move to the left looking at Figure 2, toward pointer 27 and arm 33 thereon.

Upon lowering of the pressure to that determined by the length of the extension arm 33, the arm contacts pointer 29 and closes electrical circuit 42. The closing of this circuit energizes the solenoid motor valve 22 to open the valve and permit the flow of feedwater directly from the condensate pump to the main feed pump, thus maintaining the pressure of the feedwater entering the main feed pump 12 sufficiently above the vapor pressure corresponding to the feedwater temperature to prevent flashing of the feedwater into steam. Thus, the present invention provides control means for maintaining a predetermined value of pressure differential on the discharge side of the booster pump in communication with the suction of the main feed pump above the vapor pressure corresponding to the feedwater temperature, should the booster pump, or standby booster pump, fail to operate due to failure of either pump or the driving means for said pumps, or should they fail independently of the conditions prevailing at the main feed pump.

Referring to Figure 3 of the drawings, a modified form of the invention is illustrated wherein a spring loaded diaphragm valve 45 is employed for obtaining the same control as provided by the embodiment of the invention shown in Figure 1. In this structure, valve 45 is provided with a valve stem 46 connected at its upper end to a diaphragm 47. A chamber 48 on one side of the diaphragm 47 communicates with pressure line 31 so as to transmit thereto the pressure at the discharge of the booster feed pump 14. A chamber 49 on the other side of diaphragm 47 communicates with the suction of the booster feed pump 14 by pressure line 25 so as to receive a pressure signal therefrom. A compression

spring 50 is provided on the valve to exert a constant pressure on diaphragm 47 in opposition to the pressure exerted thereon from the discharge pressure of the booster pump. The tension or compression of this spring 50 is determined in accordance with the desired minimum net pressure to be developed by the booster pump. The degree of opening will bear a certain proportion to the amount by which the net pressure generated by booster pump 14 falls below its designed value. Valve 45 is disposed in a control air supply line 51 in communication with a source of air under pressure (not shown) and a relay mechanism 52. The valve 45 acts as an air pilot valve and sends a variable pressure signal or air impulse to the relay mechanism 52 readily purchased on the open market.

The relay mechanism 52 is operatively connected to the starting switch 38 of the stand-by booster pump 16 so as to energize the electrical circuit of the stand-by booster pump 16 in a manner well known in the art when the net pressure developed by booster pump 14 decreases below a predetermined value. Thus, the stand-by booster pump 16 is started in operation to provide additional pressure at the suction of the main feed pump 12 to maintain a pressure differential between the feedwater entering the main feed pump and the vapor pressure corresponding to the feedwater temperature to prevent flashing of the feedwater into steam.

Relay mechanism 52 is also operatively connected to a switch 53 adapted to close the electrical circuit to solenoid valve 22 in bypass line 21. Switch 53 is set to close after a predetermined time delay when the net pressure developed by booster pump 14 falls below a predetermined value, above the pressure differential desired to be maintained between the feedwater pressure entering the main feed pump 12 and the vapor pressure corresponding to the feedwater temperature, but less than the predetermined value required to start the stand-by booster pump 16 in operation. Thus, the embodiment of the invention shown in Figure 3 provides control means for maintaining a predetermined pressure differential between the feedwater pressure entering the main feed pump and the vapor pressure corresponding to the feedwater temperature, by starting the stand-by booster pump when the net pressure of the booster feed pump 14 decreased below a first predetermined value, and for opening solenoid valve 22 to flow feedwater directly to the main feed pump 12 when the net pressure of the booster pump 14 decreases below a second predetermined value to prevent flashing of the feedwater into steam.

What is claimed is:

1. In a boiler feedwater system, a direct contact heater, a main feed pump, a feedwater conduit connected between said heater and main feed pump, a booster pump disposed in said conduit to deliver feedwater under pressure from said heater to said main feed pump, a second conduit communicating at one end with the direct contact heater and at the other end in communication with the suction side of the main feed pump a stand-by booster pump disposed in said second conduit to increase the pressure of feedwater delivered from the heater to said main feed pump, a condensate pump, a discharge conduit

in communication with said condensate pump and said heater for passing condensate therethrough to said heater, a bypass conduit in communication with said condensate pump to said main feed pump for passing condensate therethrough to said main feed pump, a solenoid valve disposed in said bypass conduit to control the flow of condensate therethrough and control means for maintaining a predetermined pressure differential between the feedwater entering the main feed pump and the vapor pressure corresponding to the feedwater temperature at the suction side of the main feed pump to prevent flashing of the feedwater into steam, said control means being operatively connected to said stand-by booster pump and solenoid valve to start the stand-by booster pump in operation when the net pressure of said booster pump falls below a first predetermined value, and to open said solenoid valve when the net pressure of said booster pump falls below a second predetermined value.

2. In a boiler feedwater system, a direct contact heater, a main feed pump, a feedwater conduit connected between said heater and main feed pump, a booster pump disposed in said conduit to deliver feedwater under pressure from said heater to said main feed pump, a second conduit communicating at one end with the direct contact heater and at the other end in communication with the suction side of the main feed pump a stand-by booster pump disposed in said second conduit to increase the pressure of feedwater delivered from the heater to said main feed pump, a condensate pump, a discharge conduit in communication with said condensate pump and said heater for passing condensate therethrough to said heater, a bypass conduit in communication with said condensate pump to said main feed pump for passing condensate therethrough to said main feed pump, a solenoid valve disposed in said bypass conduit to control the flow of condensate therethrough and control means for maintaining a predetermined pressure differential between the feedwater entering the main feed pump and the vapor pressure corresponding to the feedwater temperature at the suction side of the main feed pump to prevent flashing of the feedwater into steam, said control means comprising an electrical circuit connected to said stand-by booster pump for starting the pump in operation, an electrical circuit connected to said solenoid valve for opening said valve, a relay mechanism connected to said electrical circuits to energize said pump circuit when the net pressure of said booster pump decreases below a first predetermined value, and to energize said solenoid valve and open said valve when the net pressure of said booster pump decreases below a second predetermined value, and an operated relay actuating means operatively connected to said relay mechanism for actuating said mechanism and responsive to the net pressure of said booster pump.

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