Aug. 28, 1928.

1,682,674

W. T. HEDLUND

STEAM PLANT

Filed Sept. 2, 1925

2 Sheets-Sheet 1

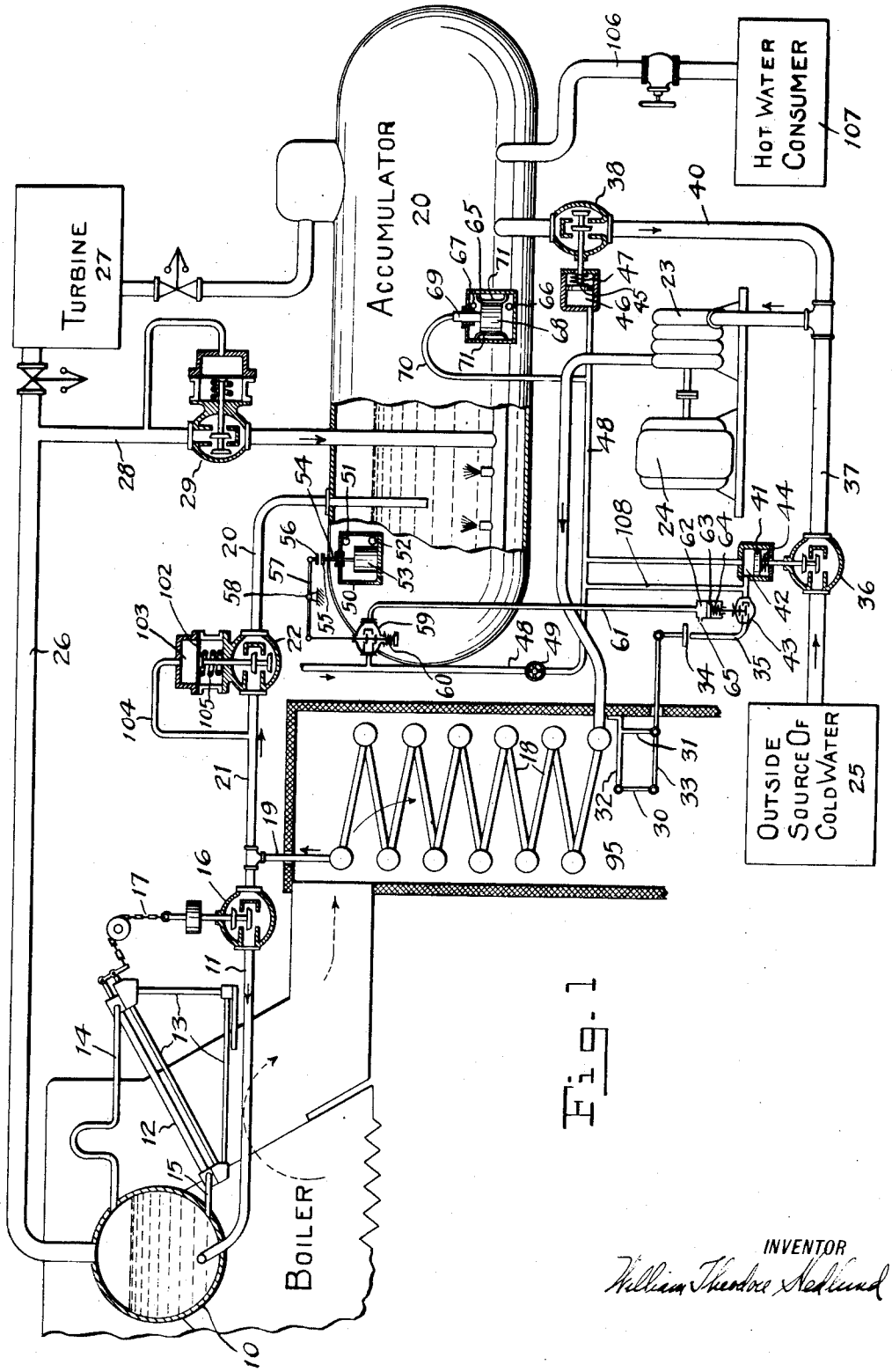

Fig. 1

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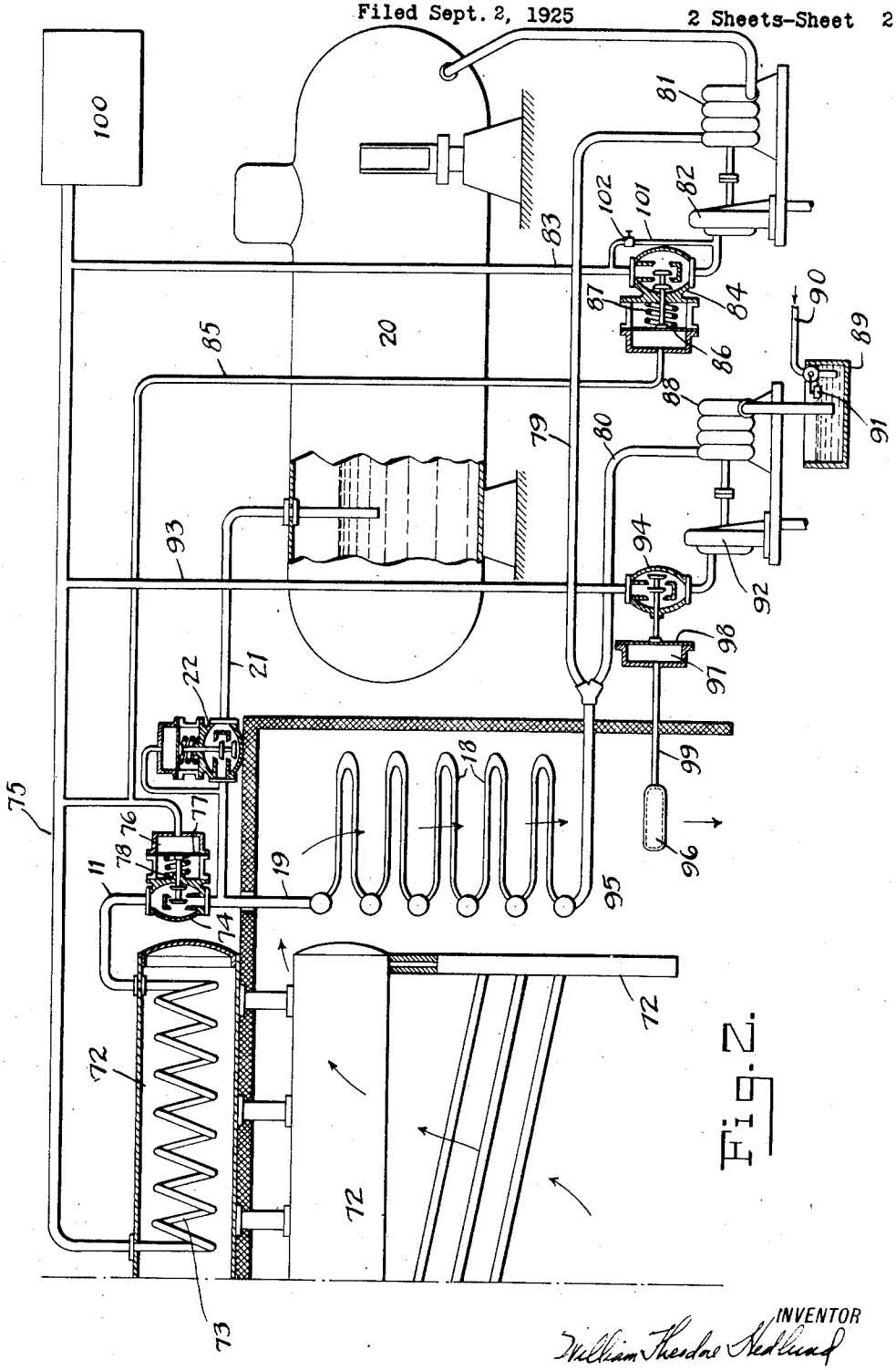

Fig. 2.

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UNITED STATES PATENT OFFICE.

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STEAM PLANT.

Application filed September 2, 1925. Serial No. 54,096.

The invention consists in several novel features of steam plant arrangement and control and has among its objects: to provide a novel steam plant; to extract the maximum amount of heat from products of combustion; to regulate feed heating in response to temperature; to provide a novel accumulator plant; to provide a wholly automatic control for an accumulator plant; to circulate cold water and accumulated hot water through the same feed preheater; to mix cold and hot water in accordance with temperature changes for supply to a boiler; and other objects which will be apparent from the following description. A new method of heating and control is also included.

Description of the invention is given with references to the accompanying drawings in which: Fig. 1 shows one modification of the invention and Fig. 2 a second modification thereof.

Referring more particularly to Fig. 1, 10 designates the steam drum of a boiler which is supplied with feed water through feed conduit 11. The flow of feed through conduit 11 is controlled in any manner. As an example, I have shown an expansible tube 12 fixed at its lower end to a stationary frame 13, and, at its upper end, movable with respect to the frame. Tube 12 is connected by means of tubes 14 and 15 with the steam and water spaces of drum 10. The free end of tube 12 operates a feed valve 16 through a chain 17, so as to maintain the water level within fixed limits. This feed control mechanism is known per se wherefore its operation need not be explained.

The feed is preheated in economizer 18 which may be any type of feed water heater. The economizer is heated by means of the flue gases of the boiler which pass from the boiler and through the waste gas flue 95 in the manner indicated by arrows. Water is supplied to conduit 11 through conduit 19 from the economizer. More feed water flows through conduit 19 than is needed in conduit 11 and the remainder flows through conduit 21 to accumulator 20. Flow through conduit 21 is controlled by an overflow valve 22 for which purpose any of various known types of overflow valves may be used. The overflow valve operates to increase its flow area upon increase of pressure in front of the same and decrease its flow area upon decrease of pressure in front of the same, thereby holding the pressure in front of the same substantially constant. In the form illustrated the overflow valve comprises a diaphragm 102 forming one side of a chamber 103 in which steam pressure acts through tube 104. Pressure in chamber 103 is balanced by a spring 105.

Economizer 18 is supplied with water by means of centrifugal pump 23, which is operated at constant speed by means of an electric motor 24.

The pump receives its supply partly from accumulator 20 and partly from an outside source of cold water 25.

Steam generated in the boiler flows through conduit 26, which supplies steam consumers of any kind, for example turbine 27. Steam is generated at a rate sometimes greater than the rate of consumption, the surplus being conducted to the accumulator. In the present instance, this is done by means of conduit 28 containing an overflow valve 29 which operates to hold a constant pressure of supply for the turbine. Conduit 28 discharges steam into the accumulator where it is condensed and the water thus formed is either regenerated to supply low pressure steam consumers such as the low pressure section of the turbine, or passes again through the economizer.

107 designates a hot water consumer supplied with water from accumulator 20 through conduit 106.

The relative amount of water taken by pump 23 from accumulator 20 and source 25 is controlled in such a manner that the greatest possible amount of heat is extracted from the flue gases so that the highest efficiency of the boiler may be obtained. To effect this purpose a device responsive to temperature is placed in the path of flue gases just beyond the economizer and is connected with control elements determining the relative supply of cold and hot water so that a constant low temperature of the flue gases leaving the steam generating plant is obtained. The illustration of the temperature responsive device in Fig. 1, which like other parts is diagrammatic, but sufficient to be entirely clear to those skilled in the art to which the invention belongs, shows two elements 30 and 31 which have different co-efficients of expansion, connected between a fixed standard 32 and a lever 33. Element 30 has a greater rate of expansion than element 31. To lever 33 is attached a baffling member 34 which controls outflow of a pressure fluid such as air or water from a conduit 35. Valve 43 in conduit 35 is normally wide open and can for

the moment be left out of consideration. Conduit 35 connects with chambers in two regulators of which one controls a valve 36 in cold water supply line 37 and the other controls a valve 38 in the accumulator water discharge line 40. Valve 36 is controlled by movement of a piston 41, on the one side of which fluid pressure acts in chamber 42 and on the other side of which a spring 44 acts. The arrangement is such that increase of pressure in chamber 42 causes closing of the valve ports. Valve 38 is controlled by movement of a piston 45 on the one side of which fluid pressure acts in chamber 46 and on the other side of which a spring 47 acts. The arrangement is such that increase of pressure in chamber 46 causes opening of the valve ports. It is thus seen that the action of valves 36 and 38 might be termed reciprocal since when one opens the other closes. Conduit 48 supplies fluid under pressure to both chambers 42 and 46, the supply to chamber 42 being partly effected through branch conduit 108 extending between conduits 48 and 35. In conduit 48 is a restriction 49 shown as a hand valve which permits variance of outflow from conduit 35 to effect changes of pressure in chambers 42 and 46.

In operation: Suppose the temperature of the flue gases increases. Element 30 being more expansible than element 31, lever 33 is rocked in anti-clockwise direction and baffling member 34 is moved further away from the end of conduit 35 so that a greater outflow of pressure fluid takes place. Due to restriction 49, this causes a lowering of pressure in chamber 42 and a lowering of pressure in chamber 46. Springs 44 and 47 then have a greater force than the fluid force on their respective pistons and valve 36 is opened more or less and valve 38 is closed more or less, thus increasing the supply of cold water to pump 23 and decreasing the supply of hot water from the accumulator. The water leaving pump 23 is then of lower temperature and on passing through the economizer reduces the temperature of the flue gases to the desired normal value.

It is to be seen that, in the arrangement shown, all the water of the accumulator plant circulates through the same economizer, thus affording a smaller plant than if two economizers are used, one for supplying feed and one for circulating water from the accumulator through flue gases and back to the accumulator, while the flue gases are run down to an efficiently low exit temperature at all times and hot water is supplied to the boiler at all times so that substantially only evaporation need take place in the boiler. Since there is a surplus flow of water through the economizer over the boiler feed water demand, steam formation in the economizer is prevented and a long life of the economizer is possible.

A further feature of the present invention includes regulation responsive to low and high water levels in the accumulator. This feature comprises means to close valve 36 when the water level in the accumulator rises above a predetermined value regardless of the fact that the temperature control may tend to open the valve and means to open valve 36 wide when the water level in the accumulator falls below a predetermined low value regardless of a tendency of the temperature control to close the valve. To illustrate a form of the first means, there is shown a float box 50 connected to the inside of the accumulator through conduits 51 and 52 and containing within the same a float 53 which normally rests in lowered position. To float 53 is connected a pin 54, having a head 55 on the same which is adapted to contact a head 56 on upward movement of the float. Head 56 is attached to a lever 57 pivoted at 58. Lever 57 operates a valve 59, normally held closed by a spring 60, and situated in a pipe 61 branched off from pipe 48, preferably ahead of restriction 49, and leading to a chamber 62 on one side of a piston 63, the opposed side of which is subject to the force of spring 64. Piston 63 controls valve 43. Valve 59 being normally closed, valve 43 is normally open under the action of spring 64. 65 designates a very minute opening leading from chamber 62 to assure an opening of valve 43 at all times except when valve 59 is open.

In operation: if the water level in the accumulator rises to such a height that float 53 is lifted, head 55 contacts with head 56 and moves the same upwardly, thereby rocking lever 57 so that its left hand end, as shown, is moved downwardly and valve 59 is opened. Communication is then established between conduit 48 and chamber 62. This causes a downward movement of piston 63 and a closing of valve 43. Closure of valve 43 causes increase of pressure in chamber 42 whereby valve 36 is closed. Simultaneously valve 38 is opened wide due to the increase of pressure in conduits 106 and 48 and consequently in chamber 46. Thus the outside supply of water is cut off and the supply of water from the accumulator to the economizer will reduce the water level in the accumulator to below the predetermined high value at which float 53 rises. Upon decrease of water level, valve 59 closes, valve 43 opens and the control is again responsive to flue gas temperature.

The low water level control device, in the illustrated form, comprises a float box 65 connected to the inside of the accumulator through conduits 66 and 67. Within float box 65 is a float 68, normally held in lifted position since the water level in the accumulator is usually higher than the float box 65. In lifted position an extension 69 on the float, which projects through the float box, holds the open end of a pipe 70 closed. Pipe 70

communicates with conduit 48. 71 designates guides for the float.

In operation; if the water level should fall so low that float 68 is lowered and opens the end of conduit 70, a release of fluid pressure occurs in conduit 48 whereby fluid pressure is released in chambers 42 and 46 and valve 36 opens wide and valve 38 closes so that a relatively large amount of cold water is supplied to the system to make up the reserve. This supply of water is independent of the control in response to temperature.

As is obvious, various changes in arrangement and various substitutions are possible within the scope of the invention. In certain cases the valve 38 may be omitted and the whole system will work quite as well. It might be desired in such case to place a check valve opening away from the accumulator in place of valve 38.

In the modification shown in Fig. 2, the steam generating unit is in the form of an indirectly heated boiler comprising a primary section 72 in which the vapor of a special heat transfer medium is vaporized and a secondary section in the form of a coil 73 in which steam is generated more or less in accordance with demand, at a rate which may differ from the rate of combustion.

Feed water is supplied to the coil 73 from economizer 18 through conduits 19 and 11, as in the previously described modification. The economizer is in this case also heated by flue gases. More water passes through the economizer than passes to the boiler, that not being needed by the boiler (as that amount is determined by constant pressure in conduit 19) passing through overflow valve 22 and into accumulator 20.

Supply of feed water to coil 73 is controlled by a valve 74 operated by steam pressure in conduit 75, which latter conduit is connected to the steam end of coil 73. Steam pressure in conduit 75 is a function of the steam demand and since feed water is to be supplied in accordance with steam demand, variations in pressure in conduit 75 can be used to determine the feed supply. When pressure in conduit 75 drops, pressure also drops in chamber 76 on one side of diaphragm 77 attached to the spindle of valve 74 and spring 78 causes movement of the valve to increase the feed supply. Conversely, rise of pressure causes a decrease of feed supply.

Supply of feed water to economizer 18 takes place through two conduits 79 and 80. Conduit 79 has its source in accumulator 20 and includes a centrifugal pump 81 driven by a steam turbine 82. Turbine 82 is supplied with steam from conduit 75 through conduit 83. In conduit 83 is a valve 84 actuated by variations of pressure in conduit 75 in such a manner that increase of pressure causes a decrease of flow through the valve. In the form illustrated, steam pressure acts through conduit 85 on diaphragm 86, opposed to which is the force of a spring 87.

Conduit 80 connects with the discharge of a pump 88. Pump 88 is supplied with cold water, as, for example, from a reservoir 89 supplied through conduit 90, flow through which is controlled by float 91 to maintain a constant level in reservoir 89. Pump 88 is driven by turbine 92 supplied with steam from conduit 75 through conduit 93. Flow through conduit 93 and consequently the speed of the turbo-pump unit is controlled by valve 94. Valve 94 is controlled in such a manner that it tends to maintain a constant temperature of flue gases in flue 95.

In the form illustrated, the means for effecting this control comprises a bulb 96 filled with volatile liquid and connected with a chamber 97, on one side of which is a diaphragm 98, through tube 99. Diaphragm 98 is connected to operate valve 94.

In operation; if the temperature in flue 95 increases in the vicinity of thermostatic bulb 96, an expansion of liquid in the bulb takes place which causes movement of diaphragm 98 so that valve 94 is opened more or less and more steam is supplied to turbine 92 so that the speed of pump 88 is increased and more cold water is supplied to the economizer whereby the temperature of the flue gases is returned to its normal low value.

Assume that the increase in temperature of flue gases was due to a momentary decrease in steam generation. Decrease in steam generation (other conditions being unchanged) results in an increase of pressure in conduit 75 which, acting through conduit 85, causes diaphragm 86 to be flexed against the force of spring 87 so that valve 84 is closed and less hot water passes from accumulator 20, through pump 81 and to the economizer. The two supply regulating devices thus cooperate to maintain a given low flue gas exit temperature.

A sudden increase in load results in a decrease of steam pressure in conduit 75 and an opening of valve 84 to supply more hot water. At the same time it causes a decrease of furnace gas temperature whereby liquid in bulb 96, tube 99, and chamber 97 contracts and valve 94 closes thus decreasing or entirely cutting off the supply of cold water.

By means of conduit 101 and valve 102 therein, a certain amount of steam is always caused to by-pass valve 84 so that a supply of water to the economizer is at all times assured.

100 designates a steam consumer supplied from conduit 75, which consumer may be of any type.

Obviously various parts of the modifications shown in Figs. 1 and 2 may be interchanged and combined.

It is to be understood that showings of valves is diagrammatic and that, in practice,

it is preferred to use more complicated valves with force multiplying means which will give more sensitive action.

Obviously the use of two or more separate economizers will fall within certain phases of the invention.

What I claim is:

1. A feed water heater adapted to be heated by a heating agency with valve mechanism to control flow through the same responsive to temperature of the heating agency and a boiler supplied with water from said feed water heater.

2. In combination, a boiler, a waste gas flue therefor, a feed water heater in said flue, means to supply cold water to said heater, control means for the first-mentioned means, a temperature responsive device in said flue and means whereby the temperature responsive device operates the control means.

3. In combination, a boiler, a waste gas flue therefor, a feed water heater in said flue, means to supply cold water to said feed water heater and means to control the supply means in accordance with variations of temperature in said flue.

4. In a steam plant, in combination, a boiler, a feed water heater therefor, means to supply cold water to said heater, means to supply hot water to said heater and automatic means responsive to variations of plant load to control the relative amounts of cold and hot water supplied.

5. In combination, a boiler, a feed water heater therefor, means to supply cold water to said heater, means to supply hot water to said heater and means responsive to temperature of gases of combustion of said boiler to determine the relative amount of cold and hot water supplied.

6. In combination, a boiler, a waste gas flue therefor, a feed water heater in said flue, means to supply cold water to said heater, means to supply hot water to said heater and means to control the relative supply of cold and hot water to maintain a constant temperature in said waste gas flue.

7. In combination, a boiler, a waste gas flue therefor, a feed water heater in said flue, means to supply cold water to said heater, means to supply hot water to said heater, control apparatus to regulate the relative amounts of cold and hot water supplied and a temperature responsive device situated in said flue in the path of gases therethrough beyond the heater and operatively connected with said control apparatus.

8. In combination, a boiler, a feed water heater, an accumulator, means to conduct cold water to the heater, means to conduct hot water from the accumulator to the heater, means to conduct water from the heater to the boiler and means to conduct water from the heater to the accumulator.

9. In combination, a boiler, a feed water heater, an accumulator, means to conduct cold water to the heater, means to conduct hot water from the accumulator to the heater, means to conduct water from the heater to the boiler, means to conduct water from the heater to the accumulator and means to control flow through the last-mentioned means to maintain a constant exit pressure for the heater.

10. In a steam plant, in combination, a boiler, a feed water heater therefor, means to supply cold water to said heater, an accumulator, means to supply hot water to said heater from said accumulator and automatic means responsive to variations of plant load to control the relative amounts of hot and cold water supplied.

11. In combination, a boiler, a waste gas flue therefor, a fed water heater in said flue, means to supply cold water to said heater, an accumulator, means to supply hot water to said heater from said accumulator, means to conduct water from said heater to said boiler, means to conduct water from said heater to said accumulator and means to control the relative supply of cold water and hot water to said heater to maintain a constant temperature in said waste gas flue.

12. In combination, a boiler, a feed water heater therefor, a source of cold water, a cold water conduit conducting water from said source to said heater, an accumulator, a hot water conduit conducting hot water from said accumulator to said heater, means to conduct water from said heater to said boiler, means to conduct water from said heater to said accumulator and means responsive to temperature of gases of combustion of said boiler to control the flow through the cold water conduit and the hot water conduit.

13. In combination, a boiler, a feed water heater therefor, a source of cold water, an accumulator, a pump, means to conduct water both from said source and said accumulator to said pump, means to conduct water from said pump to said heater, means to conduct water from said heater to said boiler and means to conduct water from said heater to said accumulator.

14. In combination, a boiler, a feed water heater therefor, a source of cold water, an accumulator, a pump, means to conduct water both from said source and said accumulator to said pump, means to conduct water from said pump to said heater, means to conduct water from said heater to said boiler, means to conduct water from said heater to said accumulator and means to control the relative amounts of water conducted from said source and said accumulator to said pump.

15. In combination, a boiler, a feed water heater therefor, a source of cold water, an accumulator, a pump, means to conduct water both from said source and said accumulator to said pump, means to conduct water from

said pump to said heater, means to conduct water from said heater to said boiler, means to conduct water from said heater to said accumulator and means responsive to temperature of gases of combustion to determine the relative amounts of water conducted from said source and said accumulator to said pump.

16. In combination, a boiler, a feed water heater therefor, an accumulator, and means responsive to water level in the accumulator to control supply of water to said feed water heater.

17. In combination, a boiler, a feed water heater therefor, an accumulator, means to supply cold water to said heater, means to conduct hot water from the accumulator to the heater, means to conduct water from the heater to the boiler, means to conduct water from the heater to the accumulator and means, normally inactive, operating upon rise of water level in said accumulator above a predetermined value to decrease the said supply of cold water to said heater.

18. In combination, a boiler, a feed water heater therefor, an accumulator, means to supply cold water to said heater, means to conduct hot water from the accumulator to the heater, means to conduct water from the heater to the boiler, means to conduct water from the heater to the accumulator and means, normally inactive, operating upon lowering of water level in said accumulator below a predetermined value to increase the said supply of cold water to said heater.

19. In combination, a boiler, a feed water heater therefor, an accumulator, means to supply cold water to said heater, means to conduct hot water from the accumulator to the heater, means to conduct water from the heater to the boiler, means to conduct water from the heater to the accumulator and means, normally inactive, operating upon rise of water level in said accumulator above a predetermined value to decrease the said supply of cold water to the said heater and means, normally inactive, operating upon lowering of water level in said accumulator below a predetermined value to increase the said supply of cold water to said heater.

20. Apparatus as set out in claim 17 wherein the normally inactive means comprises a float, a main control member and fluid pressure operated means to operate the main control member in response to movement of the float.

21. Apparatus as set out in claim 18 wherein the normally inactive means comprises a float, a main control member and fluid pressure operated means to operate the main control member in response to movement of the float.

22. In combination, a boiler, a waste gas flue for said boiler, a feed water heater in said flue, means to supply cold water to said heater, an accumulator, means to supply hot water to said heater from said accumulator, means to conduct water from said heater to said boiler, means to conduct water from said heater to said accumulator, means, normally active, and responsive to temperature in said flue, to control the relative supply of cold and hot water to said heater and means, normally inactive, operating upon rise of water level in said accumulator above a predetermined value, to decrease the supply of cold water to the heater.

23. In combination, a boiler, a waste gas flue for said boiler, a feed water heater in said flue, means to supply cold water to said heater, an accumulator, means to supply hot water to said heater from said accumulator, means to conduct water from said heater to said boiler, means to conduct water from said heater to said accumulator, means, normally active, and responsive to temperature in said flue, to control the relative supply of cold and hot water to said heater and means, normally inactive, operating upon lowering of water level in said accumulator below a predetermined value, to increase the supply of cold water to the heater.

24. In combination, a boiler, a waste gas flue for said boiler, a feed water heater in said flue, means to supply cold water to said heater, an accumulator, means to supply hot water to said heater from said accumulator, means to conduct water from said heater to said boiler, means to conduct water from said heater to said accumulator, means, normally active, and responsive to temperature in said flue, to control the relative supply of cold and hot water to said heater and means, normally inactive, operating upon rise of water level in said accumulator above a predetermined high value, to decrease the supply of cold water to the heater regardless of operation of the temperature responsive means and means, normally inactive, operating upon lowering of water level in said accumulator below a predetermined low value, to increase the supply of cold water to the heater regardless of operation of the temperature responsive means.

25. In combination, a boiler, feed preheating means therefor, means to supply cold water to the boiler through the feed preheating means, means to supply hot water to the boiler through the feed preheating means and control apparatus responsive to temperature of gases of combustion of said boiler to determine the relative amount of cold and hot water supplied.

26. In combination, a boiler, a waste gas flue therefor, feed water preheating means for said boiler situated in said flue, means to supply cold water to said boiler through said preheating means, an accumulator, means to supply hot water to said boiler through said preheating means and means responsive to temperature in said flue to con-

trol the relative supply of hot and cold water.

27. The method of producing steam which comprises mixing hot water and cold water, heating the mixture, proportioning the relative amounts of cold and hot water mixed so that the temperature of the heating agent is reduced to a definite amount and vaporizing the mixture.

28. The method of producing steam which comprises mixing cold water and hot water, vaporizing a portion of the mixed water and storing the remainder in variable quantity for subsequent remixing.

29. The method of producing steam which comprises mixing cold water and hot water, heating the whole mixture, vaporizing a portion of the mixture, storing the remaining unvaporized water in variable quantity, mixing the stored water with cold water and again heating the whole mixture.

30. The method of producing steam which comprises mixing cold water and hot water, heating the whole mixture, vaporizing a portion of the mixture, storing the remaining unevaporated water for subsequent remixing and proportioning the relative amounts of cold water and hot water mixed in accordance with temperature of the heating agent.

31. The method of feeding a boiler which comprises introducing a mixture of hot water and cold water into the boiler and controlling the relative supply of components to the mixture in accordance with temperature of gases of combustion leaving the boiler.

32. In combination, a boiler, a feed water heater, an accumulator, means to supply water to the heater, means to conduct water from the heater to the accumulator, means to conduct water from the accumulator to the boiler and means responsive to temperature of gases of combustion of the boiler to control the water supply.

33. In combination, a boiler, a feed water heater, an accumulator, means to supply water to the heater, means to conduct water from the heater to the boiler, means to conduct water from the heater to the accumulator, means to conduct water from the accumulator to the boiler, and means to control flow from the heater to the accumulator to maintain a constant exit pressure for the heater.

34. In combination, a boiler, a feed water heater, an accumulator, means to supply water to the heater, means to conduct water from the heater to the accumulator, means to conduct water from the accumulator to the boiler, means responsive to temperature of gases of combustion of the boiler to control the water supply and means to control flow from the heater to the accumulator to maintain a constant exit pressure for the heater.

35. In combination, a boiler, a feed water heater, an accumulator, means to supply water to the heater, means to conduct water from the heater to the boiler, means to conduct water from the heater to the accumulator, means to conduct water from the accumulator to the boiler, means to control flow from the heater to the accumulator to maintain a constant exit pressure for the heater and means responsive to temperature of gases of combustion of the boiler to control the water supply to the heater.

36. In combination, a boiler, a feed water heater, an accumulator, means to supply water to the heater, means to conduct water from the heater to the boiler, means to conduct water from the heater to the accumulator and means to conduct water from the accumulator to the boiler, comprising, in part, the means to conduct water from the heater to the boiler

37. A boiler, a feed water heater, a feed water accumulator and conduits connecting the boiler, feed water heater and accumulator to supply the boiler and accumulator in parallel from the feed water heater and the boiler from the accumulator through the feed water heater.

38. The method of operating a boiler plant including a boiler, a feed water heater and an accumulator which consists in withdrawing steam from the boiler in accordance with steam demand, passing water through the feed heater at a different rate than the rate of steam demand and at such rates that the flue gas temperature at the exit of the feed heater is constant, passing the surplus water discharged from the feed heater into the accumulator and storing the same for subsequent use by the boiler.

In testimony whereof I affix my signature.

WILLIAM THEODORE HEDLUND.