Feb. 19, 1935. H. HILLIER 1,991,929

FEED SYSTEM FOR STEAM POWER PLANTS

Filed Oct. 15, 1934 5 Sheets-Sheet 1

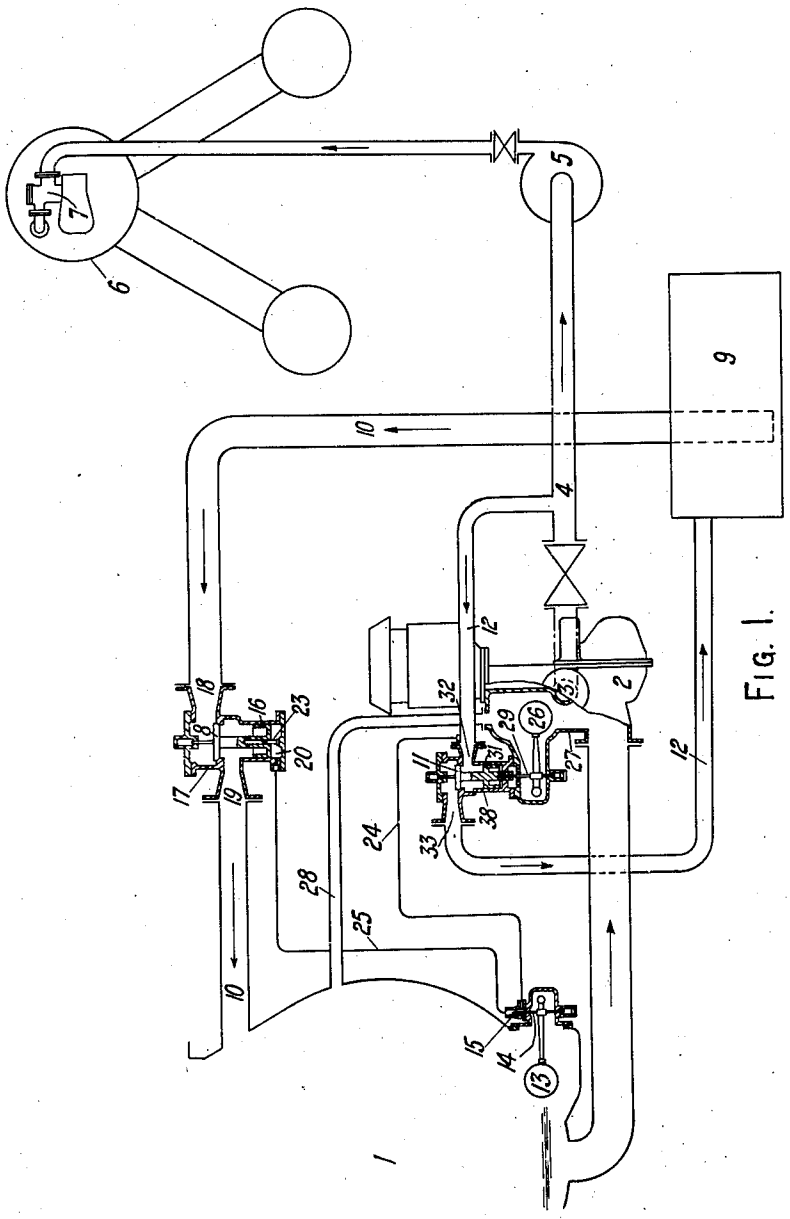


FIG. 1.

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FEED SYSTEM FOR STEAM POWER PLANTS

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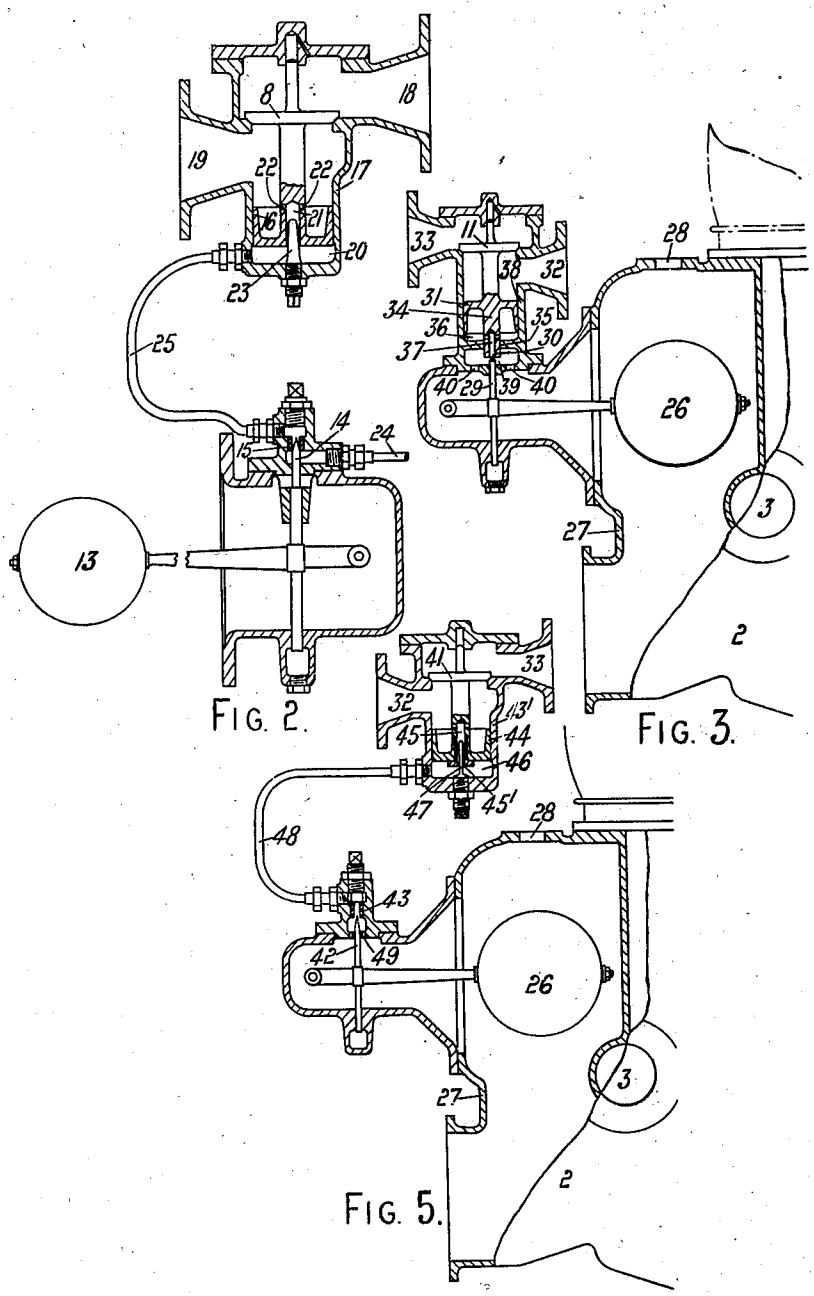


FIG. 2.

FIG. 3.

FIG. 5.

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FEED SYSTEM FOR STEAM POWER PLANTS

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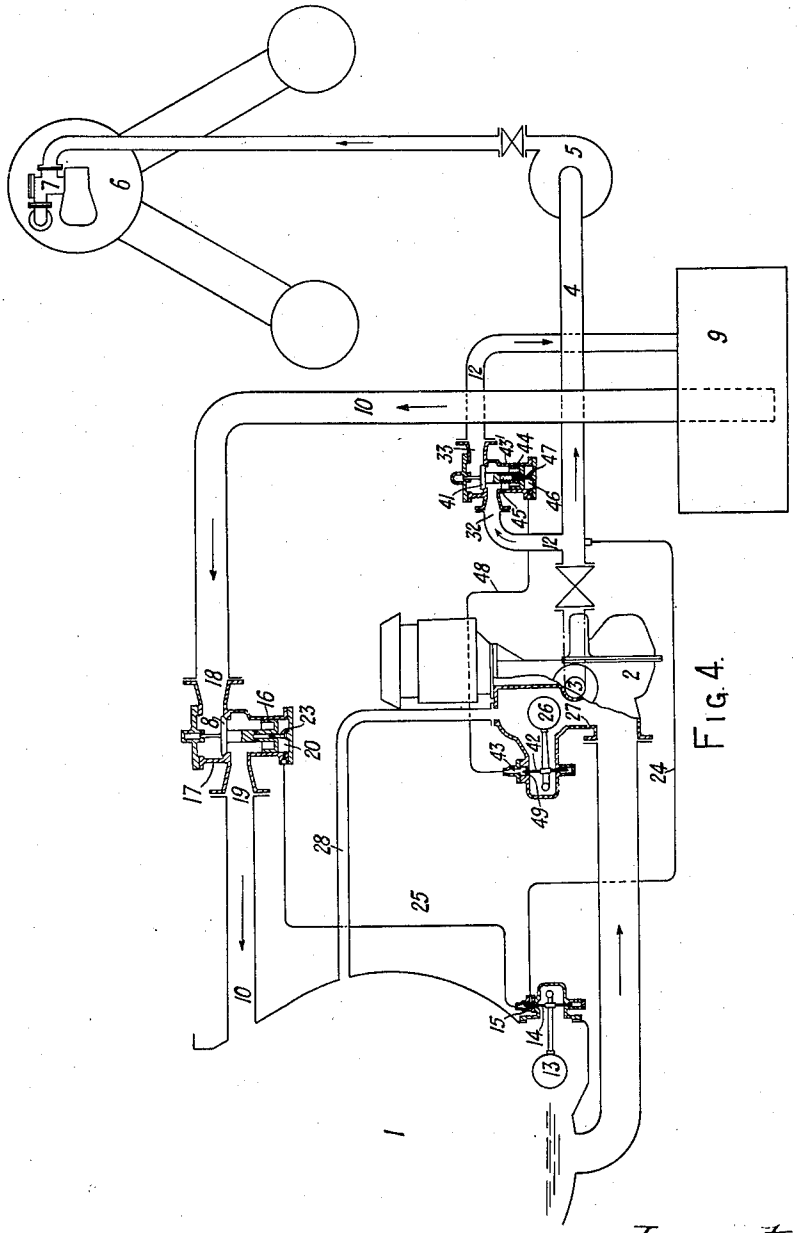


FIG. 4.

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FEED SYSTEM FOR STEAM POWER PLANTS

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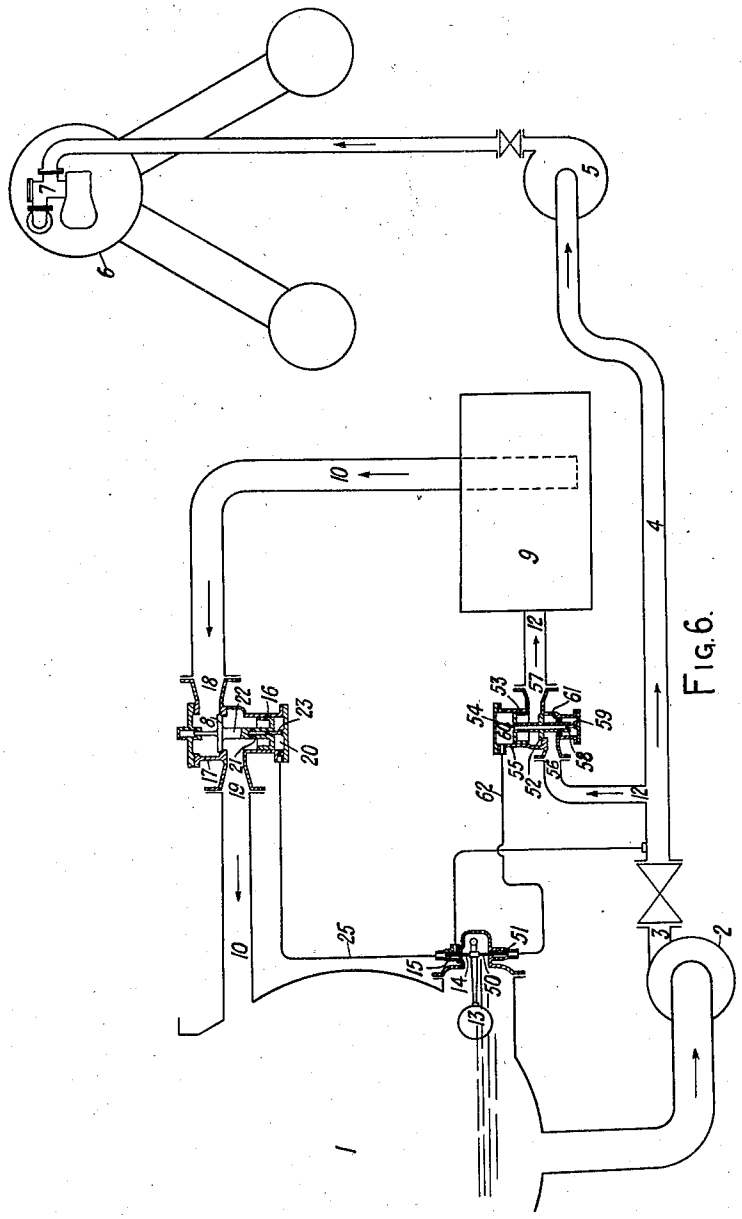


FIG. 6.

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FEED SYSTEM FOR STEAM POWER PLANTS

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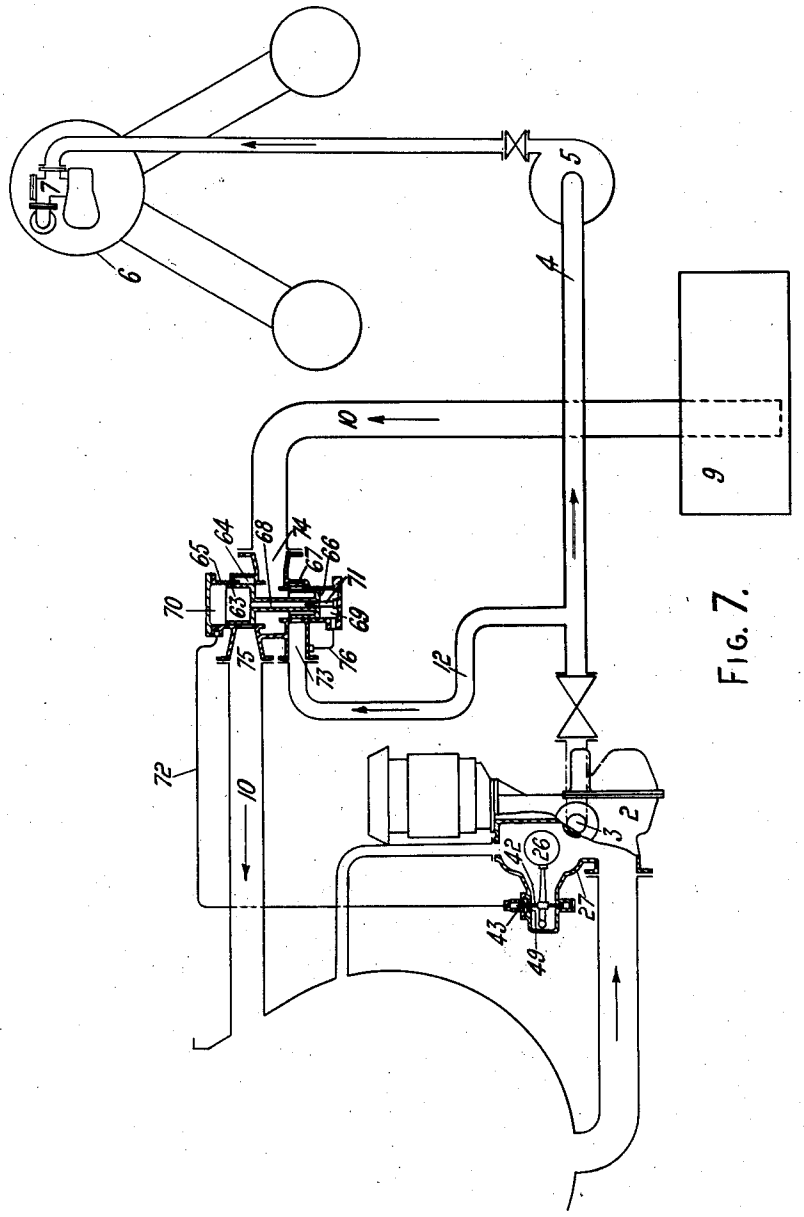


FIG. 7.

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UNITED STATES PATENT OFFICE

1,991,929

FEED SYSTEM FOR STEAM POWER PLANTS

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Application October 15, 1934, Serial No. 748,399
In Great Britain October 27, 1933

12 Claims. (Cl. 122—451)

This invention relates to feed systems for steam power plant and more particularly to apparatus for controlling the supply of water to, and withdrawal of water from, a closed feed circuit system of a steam power plant, devised to vary the quantity of water in the system in accordance with the variation between the rate of steam consumption and the rate of feed water supply.

A closed feed system comprises, in its simplest form, a condenser receiving exhaust steam, an extraction pump for withdrawing condensate from the condenser, a feed pump which discharges into the boiler, and a delivery pipe through which the discharge from the extraction pump is led to the suction side of the feed pump. The condenser is designed to remove the corrosive gases from the water, while the closed feed system ensures that the water is delivered to the boiler without absorbing any corrosive gases from the atmosphere, whereby corrosion of the boiler is avoided.

It being requisite to maintain the water levels in the condenser and in the boiler between predetermined limits, since the total weight of water in the system will vary due to changes in these water levels, losses from the system and the rate of steam generation in the boiler, it is necessary to provide means whereby water may be admitted into the system from an external source, such as a feed tank or reservoir, and whereby surplus water in excess of the quantity required may be discharged to the feed tank. The make-up water admitted into the system from the feed tank is preferably passed into the condenser wherein it is de-aerated before it passes to the boiler.

The flow of make-up water from the feed tank into the condenser, and the discharge of overflow water from the system are controlled by make-up and overflow valves, respectively.

To provide for the withdrawal of surplus water from the system it is usual to arrange a pipe between the delivery side of the extraction pump and the feed tank, the overflow valve being arranged in this pipe to control the flow of water therethrough in accordance with the rise of the water level in the condenser above a predetermined level.

Another pipe, connecting the feed tank to the condenser, allows make-up water to enter the system, the flow of make-up water being controlled by a valve interposed in this pipe and arranged to open as the condenser water level falls below a predetermined level.

In a prior construction the make-up and overflow valves were combined in one device, the said valves being operated by hydraulic pressure under the control of a pilot valve actuated by a single float. This apparatus is bulky and has been found difficult to arrange conveniently in many installations on board ship where space is usually restricted.

In another prior construction there were provided separate make-up and overflow valves each moved hydraulically in one direction in opposition to a spring, the hydraulic action being controlled by small relay valves actuated by floats.

These prior make-up and overflow valves open to their full extent immediately the water in the condenser passes the predetermined levels, with the consequence that there is a circulation of water into and out of the system which is much greater than is necessary and results in waste of pumping power. Further, the intermittent opening and closing of the overflow valve cause undesirable fluctuations in the discharge pressure of the extraction pump and interfere with the stability of the operation of the feed pump.

The present invention provides an improved arrangement for controlling hydraulically the opening and closing movements of the make-up and/or overflow valves in a closed feed system whereby the aforesaid disadvantages are eliminated.

In apparatus in accordance with the present invention the float-operated relay valve or each such valve has a tapered extremity such that the opening through the valve seat is varied gradually in the travel of the float. One such relay valve controls the passage of pressure water to or from a chamber in which works a piston unitary with the make-up valve or the overflow valve, or both. Pressure water is allowed to flow from or to the said chamber through an orifice the area through which is varied by a tapered needle valve associated with said piston, so that movement of the piston effects variation of the opening presented by said orifice from a minimum to a maximum as the make-up or the overflow valve moves from the closed position to the full open position or vice versa.

The make-up and the overflow valves may be separate and controlled by separate relay valves actuated by separate floats; or one float may be arranged to actuate two relay valves having tapered extremities and controlling separate make-up and overflow valves; or a combined make-up and overflow valve may be controlled by one such relay valve actuated by a single float.

With apparatus in accordance with the inven-

tion the opening and closing of the make-up and overflow valves are effected gradually as the water level changes in the condenser between predetermined limits, and it is possible to arrange the float gear in the most suitable position. For example, the float gear may be arranged inside the condenser, but it is preferably arranged inside the extraction pump casing, while the make-up and overflow valves controlled by the float gear may be situated remote from the float gear and connected thereto by piping.

Either the make-up valve or the overflow valve may be directly associated with a float actuating a servo valve, the other valve being controlled by a remote float-actuated relay valve.

In the accompanying drawings Fig. 1 shows a closed feed system with a make-up valve operated by a remote float-controlled relay valve and with an overflow valve controlled by a direct float-operated relay valve. Fig. 2 shows, in larger detail, the make-up valve and its associated remote float-controlled relay valve; Fig. 3 shows also in larger detail the overflow valve with its associated float-operated direct relay valve. Fig. 4 shows a modified closed feed system with the make-up and overflow valves operated by separate remote float-controlled relay valves. Fig. 5 shows in larger detail the overflow valve and its associated remote float-controlled relay valve as illustrated in Fig. 4. Fig. 6 shows a further modified closed feed system with a make-up valve and overflow valve controlled by separate remote relay valves actuated by the same float. Fig. 7 shows a further modified closed feed system with a combined make-up and overflow valve operated by a single remote float-controlled relay valve.

Referring to Figs. 1, 2 and 3, a condenser 1 receives exhaust steam from an engine (not shown). The condensate is withdrawn from the bottom of the condenser 1 by an extraction pump 2 which discharges through a discharge branch 3 and a pipe 4 to a feed pump 5 discharging to a boiler 6 through a feed regulator 7 which controls the flow of water into the boiler 6 in accordance with the boiler requirements.

A make-up valve 8 admits water from a feed tank 9 into the condenser 1 by way of a pipe 10 whenever make-up water is required by the feed system. An overflow valve 11 permits the extraction pump 2 to discharge surplus water from the system by way of the discharge branch 3 and pipe 12 to the feed tank 9. A float 13 controlling the make-up valve 8 is arranged inside the condenser 1, i. e., remote from the make-up valve 8, and actuates a relay valve 14 having a tapered extremity whereby the area of the opening through the relay valve seat 15 is varied gradually from a minimum, when the water level in the condenser 1 is at a predetermined high level, to a maximum when the condenser water level falls to a predetermined low level, and vice versa. The make-up valve (Fig. 2) comprises a valve disc 8 interposed in the pipe line 10 connecting the feed tank 9 to the condenser 1. Unitary with the valve disc 8 is a piston 16 of the same diameter as the valve disc 8 and arranged below said valve disc. The valve casing 17 is provided with an inlet branch 18 disposed above the valve disc 8 and connected to the feed tank 9, and an outlet branch 19 disposed between the valve disc 8 and the piston 16 and connected to the condenser 1. The lower portion of the valve casing 17 forms a chamber 20 in which the piston 16 works. An orifice 21 and passages 22 provided in the piston 16 form a conduit for the flow of water from the chamber 20 into the pipe 10 connected to the condenser 1. Attached to the valve casing 17 is a tapered needle valve 23 which penetrates the orifice 21 in the piston 16, the taper being such that the area for the flow of water through the orifice 21 increases as the make-up valve 8 opens. A small pipe 24 is led from the discharge of the extraction pump 2 to the inlet side of the relay valve 14, and the outlet side of the relay valve 14 is connected by a pipe 25 to the piston chamber 20. There is, therefore, a flow of water from the extraction pump discharge past the relay valve 14 into the chamber 20, whence the water flows through the orifice 21 in the piston 16 under the control of the needle valve 23 into the condenser 1. This flow of water is a minimum when the float 13 is at a predetermined high level in the condenser 1 and the make-up valve 8 is closed. The water flow through the relay valve 14 increases gradually as the float 13 falls, until it reaches a maximum when the float 13 is at a predetermined low level. The relay valve 14 is so proportioned that the make-up valve 8 is hydraulically constrained to open gradually from the closed position, when the water level in the condenser 1 is at the predetermined high level, to the full open position when the water level in the condenser 1 is at the predetermined low level, the make-up valve 8 being maintained at a corresponding intermediate position for any intermediate water level in the condenser 1 between the predetermined high and low levels. The make-up valve 8 thus controls the flow of make-up water from the feed tank 9 into the condenser 1, so that the water level in the condenser 1 does not fall below the predetermined low level.

A float 26 controlling the overflow valve 11 is arranged inside the casing 27 of the extraction pump 2 which is shaped to accommodate the float 26, the casing 27 being provided with a vent 28 back to the condenser 1 to ensure that the water level in the casing 27 will be substantially the same as the water level in the condenser 1. The float 26 controls a pilot valve 29 (Fig. 3) adapted to enter the lower end of a passage 37 in the overflow valve, or, as shown, in the stem 34 of a piston 31 unitary with the overflow valve 11. The overflow valve 11 is interposed in the pipe line 12 connecting the discharge of the pump 2 to the feed tank 9, the inlet branch 32 of the overflow valve casing 38 being arranged below the valve 11 and the outlet branch 33 being arranged above the valve 11. The piston 31 is arranged below the valve 11 with its stem 34 projecting through a guideway 35 in the bottom of the piston chamber 36. The passage 37 interconnects the piston chamber 36 with a chamber 39 in free communication with the suction of the pump 2 by way of holes 40. The pilot valve 29 controls the flow of operating leakage water which leaks from the extraction pump discharge 3 by way of the pipe 12, past the clearance between the piston 31 and the valve casing 38, into the piston chamber 36, and thence, by way of the valve-controlled passage 37, to the chamber 39, and through the holes 40 to the suction of the pump 2, the pressure in the suction of the pump 2 corresponding to the pressure prevailing in the condenser 1.

The arrangement is such that, when the float 26 is lifted, due to a rising water level, the pilot valve 29 closes the aperture 30 at the lower end of the passage 37 and thereby permits the

pressure in the piston chamber 36 to increase until the overflow valve 11 is hydraulically constrained to open and allow the pump 2 to discharge water to the feed tank 9 by way of the discharge branch 3, the pipe 12, and the valve 11. When the water level in the casing 27 falls, the float 26 lowers the pilot valve 29, releases the pressure in the piston chamber 36, and causes the overflow valve 11 to reduce the area available for the flow of feed water to the feed tank 9. The overflow valve 11 is hydraulically constrained to open gradually from the closed position, when the water level in the pump casing 27 is at a predetermined low level, to the full open position when the water in the pump casing 27 is at a predetermined high level, being maintained at a corresponding intermediate position for any intermediate water level in th pump casing between the predetermined high and low levels. The overflow valve 11 thus controls the flow of overflow water from the discharge of the pump 2 to the feed tank 9, so that the water level in the pump casing does not rise above the predetermined high level.

As shown in Fig. 2, means is provided for adjusting the position of the needle valve 23 in relation to the orifice 21 in the piston 16, and for adjusting the position of the seat 15 in relation to the needle valve 14.

In lieu of the arrangement illustrated, the remote float-controlled relay valve may be used to control the overflow valve, and the direct controlled pilot valve used to control the make-up valve.

Referring to the modified arrangement shown in Figs. 4 and 5, the float-operated relay valve 14 controls the make-up valve 8 as in the arrangement described with reference to Figs. 1–3.

The float 26 controls a relay valve 42 (Fig. 5) having a tapered extremity whereby the area of the opening through the relay valve seat 43 is varied from a maximum, when the water level in the pump casing 27 is at a predetermined low level, to a minimum when the water level in the pump casing 27 rises to a predetermined high level. An overflow valve 41 is interposed in the pipe line 12 connecting the discharge 3 of the pump 2 to the feed tank 9, the inlet branch 32 of the overflow valve casing 43′ being arranged below the valve 41 and the outlet branch 33 being arranged above the valve 41. A piston 44 unitary with the overflow valve 41 is arranged below the valve 41 and is of the same area as said valve 41. The piston 44 is provided with a passage 45 communicating with the inlet branch 32 and with the piston chamber 46. Attached to the valve casing 43′ is a tapered valve 47 which penetrates the throat 45′ of the passage 45 in the piston 44, the taper being such that the area for the flow of water through the throat 45′ decreases as the overflow valve 41 opens. A small pipe 48 is led from the piston chamber 46 to the inlet side of the relay valve 42, the flow of water past the relay valve 42 entering the pump casing 27 by way of holes 49. There is, therefore, a flow of water from the pump discharge 3 past the clearance between the piston 44 and the valve casing 43′, and by way of the passage 45 into the piston chamber 46, whence the water flows through the pipe 48 under the control of the needle valve 42 into the pump 2. This flow of water is a maximum when the float 26 is at the predetermined low level in the pump 2 and the overflow valve 41 is closed, but decreases gradually as the float 26 rises, and reaches a minimum when the float 26 is at a predetermined high level. The tapered valves 42 and 47 are so proportioned that the overflow valve 41 is hydraulically constrained to open gradually from the closed position, corresponding to the predetermined low level of the float 26, to the full open position when the float 26 is at the predetermined high level, the overflow valve 41 being maintained at a corresponding intermediate position for any intermediate level of the float 26 between the predetermined high and low levels. The overflow valve 41 thus controls the flow of surplus water from the feed system into the feed tank 9 and so prevents the water level in the condenser 1 from rising above a predetermined high level. The float 26 is preferably so arranged in relation to the float 13 that the high level of the float 13 corresponds to the low level of the float 26. As is understood, the make-up valve 8 is full open when the float 13 is at its lowest position, and is gradually closed as the float 13 rises to its highest level. If the water in the condenser rises still further, the overflow valve 41 is caused to open, until, when the float 26 has reached its highest position, the overflow valve 41 is full open. The float 26 may be so arranged that its low level is slightly above the high level of the float 13, to ensure that the make-up valve 8 will be closed before the overflow valve 41 commences to open.

The floats 13 and 26, operating the relay valves 14 and 42, are shown as located in the condenser and in the extraction pump casing, respectively. It will be understood, however, that the relay valves 14 and 42 may be accommodated side by side and operated by a single float and lever arranged in the pump casing 27 or in the condenser 1, as may be preferred.

Means are provided to permit the position of the seat 43 to be adjusted relatively to the needle valve 42.

In the further modification shown in Fig. 6 the float 13, in addition to actuating the relay valve 14, also actuates a tapered valve 50 co-operating with a seat 51 and controlling an overflow valve 52 unitary with a piston 53 having an area approximately twice that of the overflow valve and operating within a chamber 54 within a valve casing 55. The overflow valve 52 controls the flow of water from the extraction pump discharge line 4 through the pipe line 12 into the feed tank 9, the inlet branch 56 being arranged below the valve 52, and the outlet branch 57 being arranged above the valve 52 and below the piston 53. The valve 52 is provided with a tubular stem 58, a tapered needle valve 59 secured to the valve casing 55 co-operating with a passage 60 leading through the stem, valve and piston, to the piston chamber 54. Holes 61 are provided to give free access for the water in the pipe 12 to the opening between the needle valve 59 and the passage 60. The piston chamber 54 is connected by a pipe 62 to the casing of the relay valve 50. When the float 13 is in its lowest position, the make-up valve 8 is in its full open position; as the float rises to a predetermined intermediate position, the make-up valve 8 is gradually closed. As the float 13 rises above the predetermined intermediate position, the overflow valve 52 is gradually opened until it is full open, when the float 13 has reached its highest position. The relay valve 50 is so tapered that the flow of water past the relay valve 50 into the condenser 1 increases as the float rises from its intermediate position to its highest position, the flow of water

passing the relay valve being thereby increased gradually from a minimum to a maximum. The needle valve 59 is tapered so as to permit the discharge of an increasing quantity of water as the valve 52 rises, the quantity of water increasing from a minimum when the overflow valve 52 is closed, to a maximum when the overflow valve 52 is full open. The water, therefore, flows from the discharge pipe 12 by way of the holes 61, and the passage 60 under the control of the needle valve 59, to the piston chamber 54, whence it flows to the condenser 1 by way of the pipe 62, relay valve seat 51 and relay valve 50. The pressure in the piston chamber 54 is controlled by the relay valve 50 to maintain the overflow valve 52 in equilibrium at a position corresponding to the position of the float 13. The overflow valve 52 thus controls the flow of surplus water from the feed system to the feed tank 9, so that the water level in the condenser 1 does not rise above the top position of the float 13.

In the further modification shown in Fig. 7 a float 26 arranged in the extraction pump casing 27 actuates a tapered needle valve 42 which co-operates with a valve seat 43. The control of the flow of make-up water from the feed tank 9 to the condenser 1 is effected by a piston 63 co-operating with ports 64 in a valve casing 65. The flow of overflow water from the system is controlled by a piston 66 co-operating with ports 67 in the valve casing 65. The piston 66 has preferably one half the area of the piston 63 and is unitary therewith, a passage 68 being arranged between the piston chambers 69 and 70. A tapered needle valve 71 enters that portion of the passage 68 adjacent to the piston chamber 69. The piston chamber 70 is connected by a pipe 72 to the outlet from the relay valve seat 43. The valve casing 65 is provided with branches 73, 74, and 75. The extraction pump discharge line 12 is connected to the piston chamber 69 by the small pipe 76. The needle valve 42 is arranged to pass a quantity of water which decreases from a maximum, when the float 26 is in its lowest position, to a minimum when the float 26 is in its highest position. The needle valve 71 is so tapered that the quantity of water flowing through the passage 68 increases from a minimum, when the piston 66 is in the lowest position, to a maximum when the piston 66 is in its highest position. The operating water flows from the pump discharge pipe 12 by way of the pipe 76 into the piston chamber 69, the pressure in the chamber 69 being the same as in the pipe 12. The operating water flows from the chamber 69 under the control of the needle valve 71 into the chamber 70, whence it flows by way of the pipe 72 into the pump casing 27 under the control of the needle valve 42, the pressure in the piston chamber 70 being, therefore, controlled by the position of the needle valve 42. The float 26 is shown in the intermediate position with the pistons 63 and 66 in the mid position covering the make-up ports 64 and overflow ports 67, respectively. As the float falls from the intermediate position shown to its lowest position, the quantity of water flowing past the relay valve 42 is increased, and the increased quantity of operating water causes the pistons 63 and 66 to rise gradually until the make-up ports 64 are full open. In the same way, if the float 26 rises from its intermediate position to its highest position, the quantity of operating leakage water passing the relay valve 42 will be reduced gradually to a minimum and will cause the pistons 63 and 66 to fall until the overflow ports 67 are full open. Since the operating leakage water varies gradually from a minimum, when the float 26 is in the top position, to a maximum, when the float 26 is in the bottom position, the pistons 63 and 66 are hydraulically constrained in any intermediate position between the limits of their travel corresponding to the intermedite position which may be taken up by the float 26.

As will be understood, other arrangements of the component parts of the apparatus may be adopted without departure from the scope of the invention as defined by the appended claims.

I claim:—

1. In a feed system for a steam power plant, in combination with a boiler for supply of steam to the plant, a condenser receiving exhaust steam from the plant, an extraction pump for withdrawing condensate from said condenser, a feed pump discharging to said boiler, a delivery pipe connecting the discharge side of said extraction pump to the suction side of said feed pump, make-up and overflow valves controlling admission of make-up wate rto and discharge of surplus water from the system, a tapered needle valve cooperating with at least one of said first mentioned valves to control its movement under the influence of operating water, and a remote float-operated relay valve operating in series with said needle valve to control the pressure of the operating water.

2. In a feed system for a steam power plant, in combination with a boiler for supply of steam to the plant, a condenser receiving exhaust steam from the plant, an extraction pump for withdrawing condensate from said condenser, a feed pump discharging to said boiler, a delivery pipe connecting the discharge side of said extraction pump to the suction side of said feed pump, make-up and overflow valves controlling admission of make-up water to and discharge of surplus water from the system, a tapered needle valve cooperating with one of said first mentioned valves to control its movement under the influence of operating water, a remote float-operated relay valve operating in series with said needle valve to control the pressure of the operating water, and means dependent for operation on the quantity of water in the system for controlling the movement of the other of said first mentioned valves.

3. In a feed system for a steam power plant, in combination with a boiler for supply of steam to the plant, a condenser receiving exhaust steam from the plant, an extraction pump for withdrawing condensate from said condenser, a feed pump discharging to said boiler, a delivery pipe connecting the discharge side of said extraction pump to the suction side of said feed pump, a feed tank from which make-up water may be admitted to the system and to which surplus water is delivered from the system, make-up and overflow valve means controlling delivery of make-up water to and delivery of surplus water from the system, at least one tapered needle valve cooperating with said valve means to control the movement of said valve means under the influence of operating water derived from the system, and at least one float-operated relay valve arranged remotely from said valve means and in series with said needle valve, said relay valve serving in conjunction with said needle valve to control the pressure of the operating water.

4. In a feed system for a steam power plant, in combination with a boiler for supply of steam to the plant, a condenser receiving exhaust steam

from the plant, an extraction pump for withdrawing condensate from said condenser, a feed pump discharging to said boiler, a delivery pipe connecting the discharge side of said extraction pump to the suction side of said feed pump, a feed tank from which make-up water may be admitted to the system and to which surplus water is delivered from the system, make-up and overflow valves respectively controlling admission of make-up water to and discharge of surplus water from the system, a tapered needle valve cooperating with one of said first mentioned valves to control its movement under the influence of operating water derived from the system, a float-operated relay valve arranged remotely from said first mentioned valve, in series with said needle valve, said relay valve serving in conjunction with said needle valve to control the pressure of the operating water, and a float-operated valve controlling the movement of the other of said first mentioned valves.

5. In a feed system for a steam power plant, in combination with a boiler for supply of steam to the plant, a condenser receiving exhaust steam from the plant, an extraction pump for withdrawing condensate from said condenser, a feed pump discharging to said boiler, a delivery pipe connecting the discharge side of said extraction pump to the suction side of said feed pump, a feed tank from which make-up water may be admitted to the system and to which surplus water is delivered from the system, a make-up valve controlling admission of make-up water from said feed tank to said condenser, a tapered needle valve cooperating with said make-up valve to control the movement of said make-up valve under the influence of operating water derived from the system, an overflow valve controlling discharge of surplus water from said extraction pump to said feed tank, a float-operated relay valve arranged remotely from said make-up valve, in series with said needle valve, said relay valve serving in conjunction with said needle valve to control the pressure of the operating water, and hydraulic means influencing the movement of said overflow valve.

6. In a feed system for a steam power plant, in combination with a boiler for supply of steam to the plant, a condenser receiving exhaust steam from the plant, an extraction pump for withdrawing condensate from said condenser, a feed pump discharging to said boiler, a delivery pipe connecting the discharge side of said extraction pump to the suction side of said feed pump, a feed tank from which make-up water may be admitted to the system and to which surplus water is delivered from the system, a make-up valve and an overflow valve respectively controlling admission of make-up water to the system and discharge of surplus water from the system, a tapered needle valve cooperating with said overflow valve to control the movement of said overflow valve under the influence of operating water derived from the system, a float-operated relay valve arranged remotely from said overflow valve in series with said needle valve, said relay valve serving in conjunction with said needle valve to control the pressure of the operating water, and means dependent for operation on the quantity of water in the system for controlling the movement of the make-up valve.

7. In a feed system for a steam power plant, the combination claimed in claim 1 in which there are provided two needle valves cooperating, respectively, with the make-up valve and the overflow valve, two relay valves each operating in series with one of said needle valves, and two floats at different levels operating said relay valves.

8. In a feed system for a steam power plant, the combination claimed in claim 1 in which there are provided two tapered needle valves co-operating, respectively with the make-up valve and the overflow valve, two relay valves each operating in series with one of said needle valves, and a common float operating said relay valves.

9. In a feed system for a steam power plant, the combination claimed in claim 1 in which the make-up valve and the overflow valve form a unit structure having an orifice entered by the tapered needle valve.

10. In a feed system for a steam power plant, the combination claimed in claim 1 in which the relay valve and its seat are relatively adjustable.

11. In a feed system for a steam power plant, the combination claimed in claim 1 in which the needle valve is adjustable.

12. In a feed system for a steam power plant, the combination claimed in claim 1 in which the float operating the relay valve is arranged inside the casing of the extraction pump, and in which said casing is vented to the condenser.

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