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2,672,732

FEEDWATER CONTROL MEANS FOR STEAM POWER PLANTS

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2 Sheets-Sheet 1

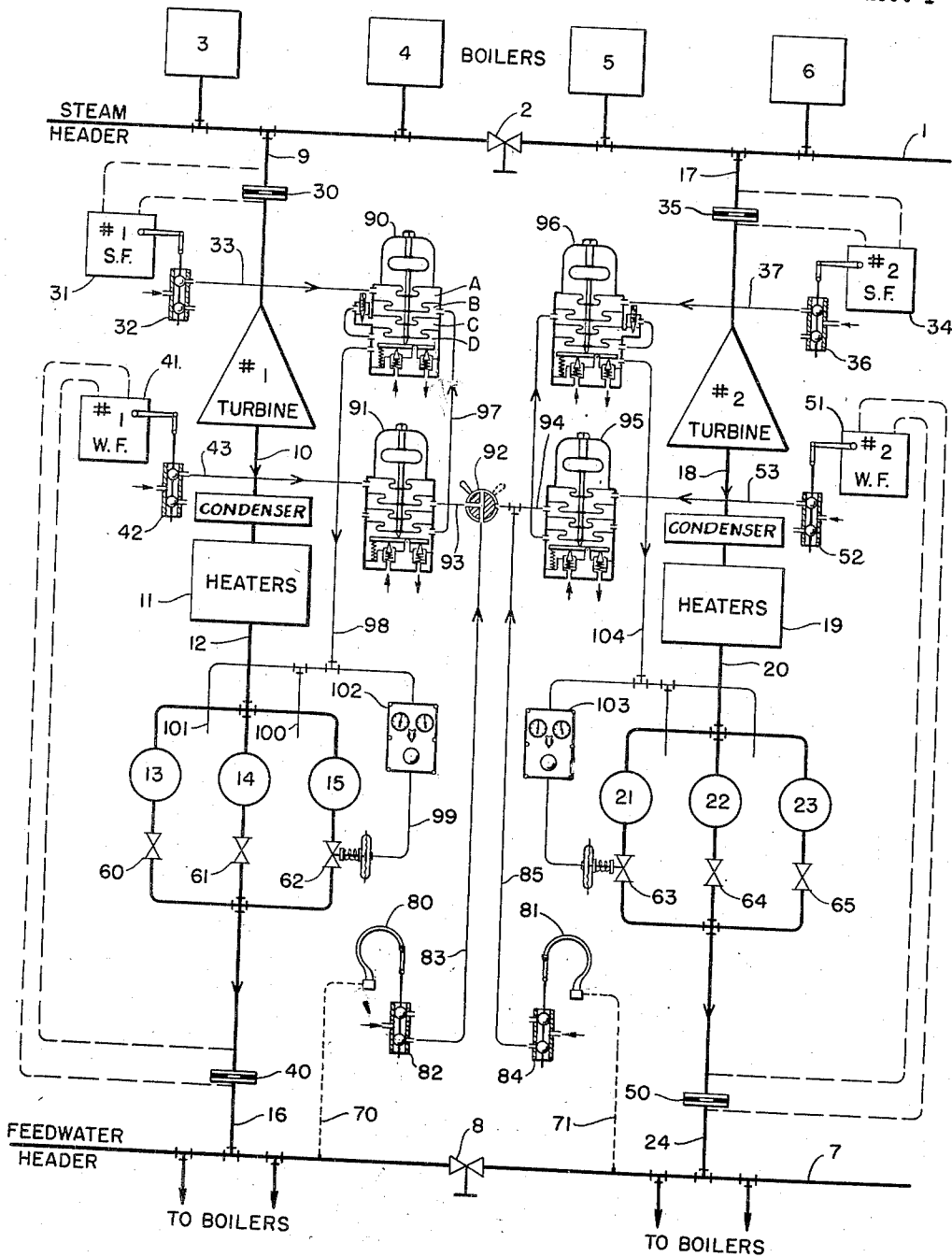


FIG. 1

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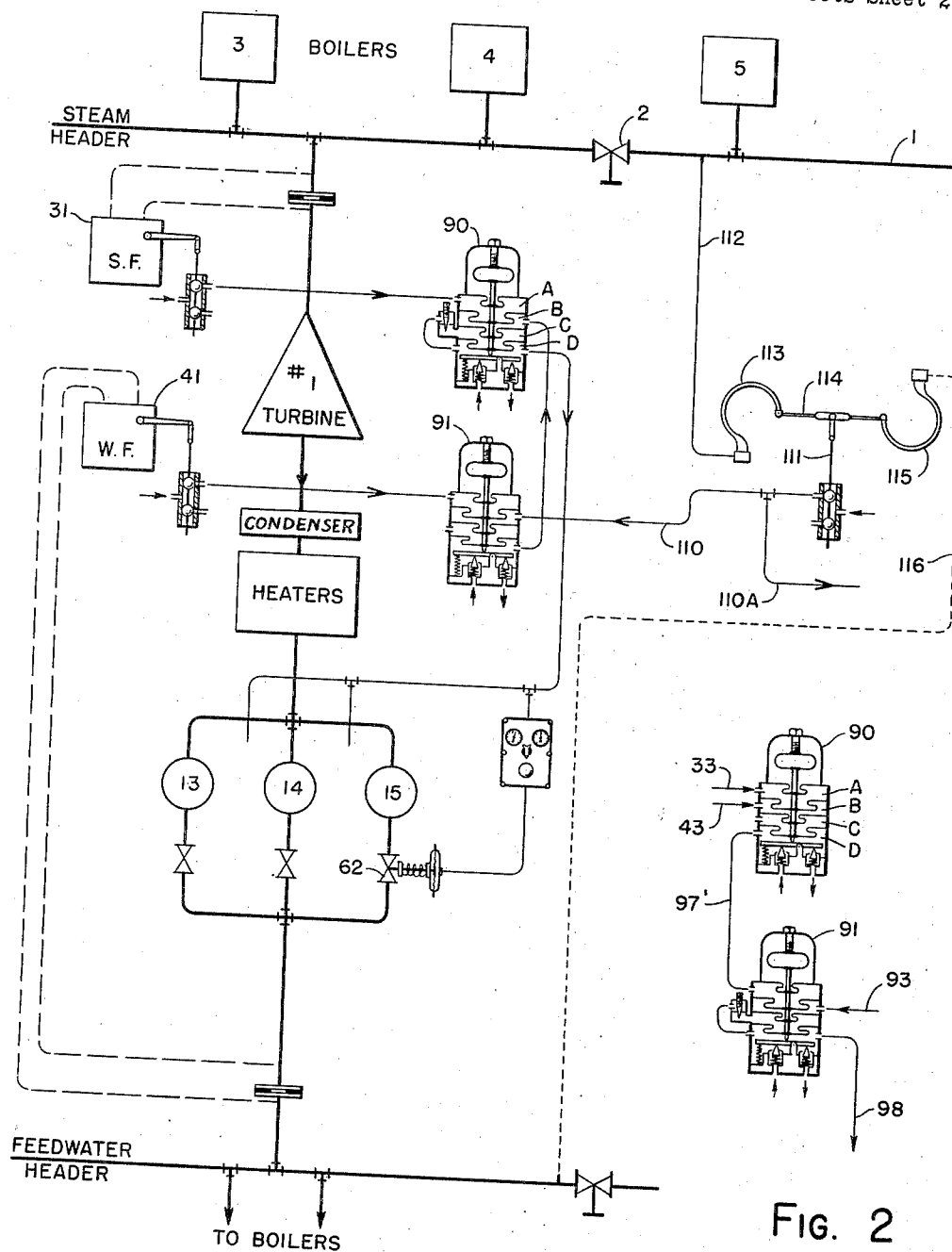


FIG. 3

FIG. 2

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2,672,732

FEEDWATER CONTROL MEANS FOR STEAM
POWER PLANTS

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9 Claims. (Cl. 60—107)

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Our invention relates to control systems and particularly to providing method and apparatus for controlling variables in the operation of power producing or utilizing apparatus responsive to one or more variable conditions of the operation.

In present day steam generating stations the arrangement may be of the unit type wherein one or more vapor generators supply steam to a single turbine from which the condensate returns as feed water to the same boilers. In other stations the header system may be employed wherein a steam header is common to all boilers and feeds all turbines; the turbine condensate cycles all supplying a feed water header common to all boilers. Our invention is particularly directed to the header system arrangement and is concerned with proper balancing of operation of the various units.

With the header system the boilers are operated to supply sufficient steam to maintain desired pressure in the steam header regardless of the number of turbines taking steam from the header or the proportioning of load between the turbines. The rate of available condensate from each turbine unit will depend upon the rate of steam flow to the respective turbine, but the operation of the deaerators, heaters, makeup, feed pumps, etc., must be kept within safe limits and the feed water header must be supplied with great enough total and at satisfactory pressure to properly supply the boilers at their individual and collective rates of operation. A principal feature of our present invention therefore lies in the control of feed water discharged from each turbine cycle to the feed water header taking into account the load on the cycle as well as the pressure condition of the feed water header.

Assume the condition of two (or more) turbines taking steam from a header common to a number of boilers. If the load is distributed fairly uniformly between the turbines, the condensate available will likewise be about equal and the sets of feed pumps supplying the feed water header will be operating at about the same rate. However, the turbines may be of unequal size, or for some reason may be unequally loaded, or operating conditions may arise whereby the turbine steam water return ratio departs from previous value; for example, by changes in blow-down rate, the rupturing of a boiler tube or the like, all tending to upset the steam-water proportioning and in some instances to place demands upon the feed water header such as to cause a reduction in feed water header pressure

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at the discharge side of all of the feed water pumps.

It is obvious that the water pumped to the header from each cycle should be in accordance with the availability of condensate (steam to the turbine) to avoid the excessive use of makeup in one cycle with excess condensate going to storage in another cycle. We therefore primarily utilize for each cycle a measure of steam flow to the cycle and a measure of feed water flow to the header in the control of pump output to the header to tend to balance each unit in itself and properly proportion the water flow out in accordance with the available condensate.

Water is used from the feed water header under the control of feed water regulators for the individual boilers to maintain in the boiler safe drum levels; the boiler water being used up by steam demand, blowdown, leaks, burst tubes, etc. If rate of water taken from the header by any or all boilers is increased, the header pressure will decrease, and vice versa. Thus feed water header pressure is an index to which all feed water pumps should respond to satisfy boiler demand. Were this the only index controlling the feed water pumped to the header, and the pumps were unevenly loaded, the unevenness might be accentuated. An increase in demand (drop in feed water header pressure) should be felt by all feed water pumps without disturbing their relative rates and thus upsetting the heating and storage cycles.

With basically different loading on the units the pumps of one unit will be handling a lower flow than for another unit and due to the pump characteristic curves this will tend to build up a higher discharge pressure. If the pressure in the header decreases for any reason the tendency will be for the pumps of the less loaded unit to hog the water demand and abstract from that unit at a rate greater than the rate of condensate supply with consequent depletion of storage. At the same time the more loaded unit will not take its share of increase and may be sending excess condensate to its own storage system.

Thus we preferably control the supply of water from each unit to the header by proportioning the water flow rate to the steam demand of that unit (and thus to the condensate availability) with readjustment on all units from feed water header pressure.

One object of our invention is to control the discharge pressure from each set of feed pumps to the header to insure that each set of pumps

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handle a quantity of water in proportion to the load on the turbine generator they serve bearing in mind also that high pressure centrifugal feed pumps must not be allowed to handle less than a predetermined minimum rate of water to prevent damage to the pump.

Another object is to control the water discharged from one cycle to the feed water header in accordance with a measure of the steam flow rate to the cycle, a measure of the water flow rate from the cycle to the feed water header, and a measure of the pressure in the feed water header.

A further object is to control the water fed from each cycle to a common feed water header in accordance with the steam usage of the related cycle and the pressure in the common feed water header.

Still another object is to control the rate of water fed from each cycle to a common feed water header in accordance with the steam supplied to the related cycle, the water passed from the cycle to the feed water header, and from a comparison of pressures in the steam header and in the feed water header.

In these drawings:

Fig. 1 is a diagrammatic arrangement of a preferred embodiment of our invention.

Fig. 2 illustrates a modification of the relays of Fig. 1.

Fig. 3 diagrammatically illustrates a second embodiment of our invention utilizing differential pressure as one control variable.

Referring now in particular to Fig. 1 we indicate at 1 a steam header having a sectionalizing valve 2 and supplied with steam from boilers 3, 4, 5, 6 which are representative of any plurality of vapor generators which may be supplying steam to the header 1. The feed water header 7 has a sectionalizing valve 8 and is arranged to supply feed water to the boilers 3, 4, 5, 6 serving the steam header 1.

Steam turbine #1 is connected to steam header 1 by the conduit 9 and exhaust steam from the turbine passes by way of a conduit 10, a condenser, heaters 11, conduit 12, feed pumps 13, 14, 15, and conduit 16 to the feed water header 7. In similar manner turbine #2 is connected to the header 1 by a conduit 17 and discharges through a conduit 18, a condenser, heaters 19, conduit 20, feed pumps 21, 22, 23, and a conduit 24 to the header 7. We have not felt it necessary to go into detail as to the usual equipment whereby the steam exhausted from the turbines is condensed and the condensate then passed through the various heaters and deaerators prior to joining the feed water conduit 7 under elevated pressure. It seems sufficient to indicate that the turbines have a steam demand upon the header 1 and eventually separately discharge their condensed steam (either with or without the addition thereto of makeup) to the feed water header 7.

The arrangement in general may be operated under the unit system if the sectionalizing valves 2 and 8 are closed or as a header system if the valves 2 and 8 are open. With the valves 2 and 8 closed, it will be seen that #1 turbine is supplied with steam by boilers 3 and 4 and discharges to that portion of the feed water header 7 which is feeding boilers 3 and 4. Likewise turbine #2 takes its steam from boilers 5 and 6 and discharges condensate to that portion of the feed water header 7 which is supplying feed water to the boilers 5 and 6.

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When operating as a header system with sectionalizing valves 2 and 8 open all boilers discharge their generated steam into the common header 1 and take feed water from a common supply header 7. In similar fashion the steam using turbines draw from the header 1 and discharge their condensate to the feed water header 7.

We are here particularly concerned with the operation of a header system. It is not important to point out the reasons why a certain station may desire to operate under the header system but it is necessary to emphasize that such operation introduces variables which must be taken into account in both the proportioning and the proper control of the various controllable elements of the system, in accordance with operating variables thereof. Some of these variable conditions have been already mentioned above, furthermore, unequal loading upon the turbines may result in incorrect loading of the various feed water pumps, which inequalities may eccentricate or snowball under certain operating conditions.

Preferably we primarily control the output of the feed water pumps of each turbine unit to proportion the water supplied thereby to the header 7, to the steam taken by the related turbine from the steam header 1, and then readjust the rate of water output from all of the pumps to satisfy a demand variable of the feed water header, preferably using feed water header pressure as an index of such demand.

Located in the conduit 9 is an orifice 30 producing a pressure differential representative of rate of steam flow to the #1 turbine and arranged to actuate a steam flow meter 31 having a pilot valve 32 continually establishing in a pipe 33 a fluid loading pressure representative of steam flow to the turbine #1. In similar fashion a steam flow meter 34 is connected across an orifice 35 in the steam conduit 17 and is arranged to position a pilot valve 36 establishing in a pipe 37 a fluid loading pressure representative of the rate of steam flow supplied to the #2 turbine.

Located in the conduit 16 is an orifice 40 arranged to actuate a water flow meter 41 which positions a pilot 42 continually establishing in a pipe 43 a fluid loading pressure representative of the rate of water flow through the conduit 16 from the pumps 13, 14, 15 to the feed water header 7. In like manner an orifice 50 is located in the conduit 24 and arranged to actuate a feed water flow meter 51 which positions a pilot 52 continually establishing in a pipe 53 a fluid loading pressure representative of the rate of water flow through the conduit 24 to the header 7.

It will be understood that one or more of the pumps 13, 14, 15 may be operating in accordance with the expected demand upon the unit and in similar fashion that one or more of the pumps 21, 22, 23 may be operating in accordance with expected demand upon that unit. Such pumps may be brought on or off automatically or by manual means under the dictates of the operator.

At 60, 61, 62 we indicate diaphragm actuated valves in the individual discharge lines from the pumps 13, 14, 15 leading to the conduit 16. Similarly valves 63, 64, 65 are located between the pumps 21, 22, 23 and the conduit 24.

Joining the feed water header 7, at opposite sides of the sectionalizing valve 8, are pressure pipes 70, 71 joining respectively Bourdon tubes 80, 81. The Bourdon tube 80 is arranged to position a pilot valve 82 continually establishing in

a pipe 83 a fluid pressure representative of the feed water pressure in the header 7. In like manner the Bourdon tube 81 is arranged to position the pilot valve 84 continually establishing in the pipe 85 a fluid pressure representative of feed water pressure in the header 7. As illustrated in Fig. 1 the pipes 70, 71 join the header 7 at opposite sides of the sectionalizing valve 8 so that, should the sectionalizing valve 8 be closed, the pressure in pipe 83 is representative of feed water pressure in that portion of the header 7 to the left of valve 8 while the pressure established in the pipe 85 is representative of the feed water pressure in that portion of the header 7 to the right of sectionalizing valve 8.

Pilot valves 32, 36, 42, 52, 82 and 84 are of the type disclosed and claimed in the patent to Johnson 2,054,464 and need not be further explained herein. Suffice it to say that a movable member is positioned to continually establish a pneumatic loading pressure representative of the variable being measured.

The pipe 33 joins the A chamber of a standardizing relay 90 such as is disclosed and claimed in the patent to Gorrie Reissue Patent 21,804. In similar fashion the pipe 43 joins the A chamber of an averaging or totalizing relay 91.

Located (on the drawing) between the pipes 83 and 85 is a transfer valve 92 shown in position for connecting the pipe 33 in communication with a pipe 93 which joins the B chamber of the relay 91. In its alternate position the transfer valve 92 may join the pipe 85 to the pipe 93. At all times the pipe 85 is connected by way of a pipe 94 with the B chamber of a relay 95 of the system for unit #2.

It will be evident, referring to the relay 91, that the A chamber thereof is receptive of a fluid loading pressure from the pipe 43 continually representative of the rate of water flow through the conduit 16 to the header 7 while the B chamber is receptive of a fluid loading pressure from the pipe 93 representative of feed water pressure in the header 7 either through the agency of the Bourdon tube 83 or of the Bourdon tube 81. The C chamber of the relay is open to the atmosphere and the output of the relay, from the D chamber, is available (through a pipe 97) within the B chamber of the relay 90 whose C and D chambers are in communication through an adjustable restriction. Thus the relay 91 is of the averaging or totalizing type producing a loading pressure in pipe 97 representative of relation between rate of water flow and header pressure. This resultant loading pressure, and the loading pressure which is representative of steam flow, are applied to the differential standardizing relay 90 which produces a control pressure effective in positioning valves 60, 61 and 62.

The output of the relay 90, from the D chamber, is available through the pipe 98 to three parallel branches 99, 100, 101 leading respectively to the diaphragm actuators of the valves 62, 61, 60. Inserted in the pipes 99, 100, 101 are manual-automatic selector valves 102, allowing individual positioning of the valves 60, 61, 62 either manually or through the agency of the pneumatic control pressure in the pipe 98.

In similar fashion for unit #2 the valves 63, 64, 65 are provided with manual-automatic selector valves 103, for allowing the valves to be manually remotely positioned or to be connected to the pneumatic loading line 104 which carries the output of the relay 96. Inasmuch as the systems for the #1 and #2 turbines are similar it is

necessary only to describe the one system for turbine #1.

The operation is as follows. Assuming the #1 turbine cycle in balance, the rate of water flow through the pipe 16 is in consonance with the rate of steam admitted to the turbine through the pipe 9, and pressure in the feed water header 7 is as desired. If demand upon the turbine increases, thereby increasing the rate of flow of steam through the conduit 9, the pilot valve 32 is so positioned as to increase the pneumatic loading pressure in the pipe 33 and thus impress a greater force within the A chamber of the relay 90. This results in an increase in pressure output in the D chamber which is impressed upon valve 62 (and 60, 61 if they are to be operated) causing the valve 62 to open somewhat and result in an increased flow of water through the pipe 16. Such increase in water flow results in an increase in the loading pressure in pipe 43 which is impressed within the A chamber of the relay 91 resulting in an increased output of the relay 91 effective through the pipe 97 upon the B chamber of the relay 90 for tending to balance the increase in pressure in the A chamber of relay 90. When the water flow rate through the pipe 16 is in proper proportion to the increased steam flow through the pipe 9 the relay 90 will again be in balance and the valve 62 will be at a throttled position to maintain such balance.

Assuming proper proportionality between the steam flow to the turbine and water flow through the pipe 16 then, if the feed water pressure decreases, as for example through sudden increase in demand upon the header 7 by the boilers, such decrease in pressure will result in an increase in the loading pressure in pipes 83, 93 effective upon the B chamber of relay 91, resulting in a decrease in pressure in the pipe 97 and B chamber of the relay 90 so that the output of the relay 90 available through the pipe 98 will be raised and the valve 62 slightly opened to result in an increase in feed water flow through the pipe 16 and pressure in the header 7. The result is to amplify somewhat the water flow effect so as to establish a new steam flow-water flow ratio and require a greater rate of water flow to produce the same effect in D-91 and B-90 to balance the same steam flow effect in A-90.

It will be apparent that the overall operation of the relays 90, 91 is a balancing of steam flow through the pipe 9 with water flow through the pipe 16 in desired proportionality and with a readjustment of the valve 62 from feed water pressure within the header 7. The arrangement is not really one of attempting to maintain a constant feed water header pressure. This would be difficult due to small storage in the feed water header to overcome time lag in control and valve movement. The feed water header pressure is used merely as an index of disturbing conditions dictating a need for changing the steam flow-water flow ratio to be maintained.

The header pressure controller would probably be adjusted to have a wide throttling range to avoid any hunting action which might otherwise be set up. The steam flow-water flow ratio controls can be made fast enough in response so as to overcome any change caused by the pressure tie-back. The result will be a header pressure which will be steadier and which will help absorb some of the differential pressures across the pump output valves at low rates and will probably help the feed water control to the individual boilers. The pressure controllers may be so ad-

justed as to prevent header pressure from going below a predetermined value but to give no correction if pressure exceeds a normal value.

With relay 91 being of the averaging or totalizing type and relay 90 of the reset or standardizing type, the system will establish a definite relationship between steam flow and water flow. If steam flow (turbine load) is reduced then water flow will be reduced a proportionate amount through throttling the valve 62. If the ratio is not correct it will result in a variation in water header pressure which will establish a new ratio of flows to be maintained. The pressure controller will be adjusted with a wide throttling range to make this part of the system rather insensitive. In this sense it does not serve as a constant pressure controller and the feed water control for the individual boilers will not be affected.

In the event of change in blow-down or tube failure or other event calling for an increase in feed pump output a corresponding change in header pressure, produced by the resultant change in the feed water regulators on the individual boilers, will result in an opening in all valves 60-65 due to change in differential pressure across them.

Usually the weight rate of water flow through conduit 16 is 10 to 15% greater than the weight rate of steam flow through conduit 9. If commercial equipment were absolutely accurate and responsive we could establish desired ratio, and maintain it, and no feed header pressure tie-back would be necessary. Such a system would, however, always try to regulate the water flow rate to maintain a fixed ratio with the varying steam flow regardless of temporary unexpected demands upon the header 7 by the boilers. Inasmuch as ratio inaccuracies as well as unexpected demands show up as variations in water header pressure, that is the logical tie-back for the system to establish the ratio to be maintained.

With the arrangements illustrated and described it is possible to operate the system of Fig. 1 either as a unit system or as a header system. If it is desired to operate the unit system then the sectionalizing valves 2, 3 will be closed and the transfer valve 92 will be in the shown position. Herein control of valves 60, 61, 62 will be in accordance with proportionality of the steam flow through the pipe 9 and the water flow to the pipe 16 with readjustment from feed water pressure in the sectionalized portion of the header 7 supplied by the pipe 16 and in turn supplying the boilers 3, 4. Similarly the valves 63, 64, 65 will be under the control of proportionality between the steam entering the #2 turbine through the pipe 17 and water entering the header 7 through the pipe 24 with readjustment from pressure of the feed water in that portion of the header 7 supplied by the pipe 24 and feeding the boilers 5, 6.

If it is desired to operate as a header system the sectionalizing valves 2, 3 are open and the pressures available through the pipes 70, 71 will presumably be the same so that the operation of the two units will be as though a single pressure pipe joined the header 7 for simultaneously impressing a loading pressure upon the B chambers of relay 90, 95.

It will be seen that the arrangement is such that, as shown, the B chamber of relay 91 may be subjected to a pressure from pipe 33 while the B chamber in relay 95 is subjected to a pressure from pipe 35 or if the transfer valve 92 is turned to its alternate position, then the pressure within

the pipe 35 is effective upon the B chambers of both relays 91 and 95. Other arrangements may be made so that either Bourdon tube 80 or 81 may be effective in controlling both systems.

In Fig. 2 we illustrate another arrangement of the relays 90, 91 of Fig. 1 which under certain circumstances may be desirably employed. The pipe 33 is connected to the A chamber of relay 90 while the pipe 43 is connected to the B chamber. Thus the steam flow rate is directly compared to the water flow rate in the relay 90 and the result, through a pipe 97', is led to the A chamber of relay 91 where it is opposed by a pressure from the pipe 93 representative of feed water header pressure. It will be understood that the meters 31, 41 and pilot valves 32, 42 may be so adjusted that the effects impressed through the pipes 33 and 43 may be equal when the rate of steam flow is equal to the rate of water flow or that the effects may be equal under some other desired proportionality of steam flow and water flow. For example the weight rate of water supplied through the pipe 16 may desirably be 10% greater than the weight rate of steam supplied to the turbine #1 through the pipe 9 and the pneumatic loading pressures effective in the pipes 33, 43 may be equal when that steam flow-water flow proportionality exists, through adjustment of the meters and their pilot valves.

When the effects available through the pipes 33, 43 are equal within the chambers A, B the pressure within the D chamber of relay 90 will be unvarying and of a value resulting, through the pipe 98, in a positioning of the valves 60, 61 and/or 62 to produce the desired rate of flow of water through the pipe 16. So long as that proportionality between steam flow rate and water flow rate is maintained the pressure within the D chamber of relay 90 will be unvarying and the valves 60, 61 and/or 62 will remain in their throttled position.

If an unbalance exists between the rate of steam flow through the pipe 9 and the correspondingly desired rate of water flow through the pipe 16 then an unbalance will exist within the chambers A, B of relay 90 and an increase or decrease in loading pressure will be effective through the pipe 97' resulting in an increase or decrease in pressure within the pipe 98 for positioning the valves 60, 61 and/or 62 in proper direction to correct the discrepancy of feed water flow rate and bring it back into desired relation to the existing weight rate of steam flow through the pipe 9.

The relay 90 in Fig. 2 is shown as a differential or averaging relay for direct comparison between two fluid loading pressures and with the C chamber open to the atmosphere. On the other hand the relay 91 is shown as a standardizing relay with a restricted tie between the C and D chambers.

The relay 91 is subjected in its A chamber only to any unbalance resulting from the steam flow-water flow comparison in relay 90 and is subjected in its C chamber to a pneumatic loading pressure representative of feed water header pressure. The adjustment of the relay 91 is such that when the relay 90 is under a balanced condition and the pressure in the feed water header is as desired there will be a predetermined loading pressure available through the output pipe 98. If the steam flow-water flow balance departs from desired relation or if pressure within the feed water header 7 departs from desired value there will be a variation in the loading pressure within the pipe 98 in proper direction

and extent to readjust the valves 60, 61 and/or 62 so as to correct the weight rate of water discharged through the pipe 16 to satisfy the feed water pressure in the header 7. It will be seen that while basically the arrangement proportions the water flow through the pipe 16 to the steam flow through the pipe 9 the dominating factor in positioning the valves 60, 61 and/or 62 is the readjusting effect through the pipe 93 representative of pressure within the feed water header 7. This is desirable to insure at all times a satisfactory pressure supply of feed water within the header 7 sufficient to protect the boilers supplied therefrom against damage which might result from an insufficient supply of feed water and to meet emergency conditions such as unexpected loss of steam and water by burst tubes or infrequent operating variations in water feed such as blowdown leakage and the like.

In Fig. 3 we show a further modification of our invention and have herein drawn only the various parts of unit #1 with the understanding that #2 duplicates as in the case of Fig. 1. The arrangement is similar except that the fluid loading pressure impressed upon the B chamber of the relay 91, through a pipe 110, is established by a pilot 111 in accordance with the differential in pressures between that of the steam header 1 and that of the feed water header 7.

Connected to the steam header 1 by a pipe 112 is a Bourdon tube 113 arranged to position one end of a floating link 114 in accordance with steam pressure values. A Bourdon tube 115 is connected by a pipe 116 with the feed water header 7 and arranged to position the other end of the floating link 114 representative of feed water pressure. Any differential in pressure between the two headers is effective in positioning the pilot 111 thereby establishing in the pipe 110 a fluid loading pressure continuously representative of departure from desired proportionality or equality between the two header pressures. It will be understood that the linkage 114 is arranged with adjustable provisions whereby the pilot 111 is in a predetermined position if the two pressures are equal or if they are in desired relation of non-equality. For example, it may be desired that pressure within the steam header be at 900 p. s. i. while that within the feed water header be at 980 p. s. i. under normal operating conditions and the linkage 114 may be so arranged that with these two pressures existing in the Bourdon tubes 113, 115 the pilot 111 will establish a predetermined pressure in the pipe 110; and departure from a relation between 900-980 p. s. i. in one direction or the other will vary the loading pressure within the pipe 110.

While we have chosen to illustrate and describe certain preferred embodiments of our invention it will be understood that these are by way of example only and not to be considered as limiting.

What we claim as new, and desire to secure by Letters Patent of the United States, is:

1. Apparatus adapted to control the operation of a steam-electric generating station having a steam header supplied by steam generating apparatus, a steam turbine taking steam from the header, a feed water header for supplying the steam generating apparatus, heating and storage equipment to which condensate from the turbine passes, and pumping means between said equipment and water header for passing water at elevated pressure to the water header, includ-

ing in combination, a rate meter of the steam passing to the turbine from the steam header, a rate meter of the water fed to the water header, a separate measuring device for determining static pressure in the feed water header, and control means for regulating the rate of water fed by the pumping means to the water header conjointly responsive to both said meters and said device.

2. Apparatus adapted to control the operation of a steam-electric generating station having a steam header supplied by steam generating apparatus, a steam turbine taking steam from the header, a feed water header for supplying the steam generating apparatus, heating and storage equipment to which condensate from the turbine passes, and pumping means between said equipment and water header for passing water at elevated pressure to the water header, including in combination, a rate meter of the steam passing to the turbine from the steam header, a rate meter of the water fed to the water header, a separate measuring device for determining static pressure in the feed water header, control means for regulating the rate of water fed by the pumping means to the water header conjointly responsive to both said meters and said device, each of the two rate meters and the measuring device individually establishing a fluid loading pressure continuously representative of measurement effected, and means interrelating the three loading pressures to establish a resultant control pressure which is instrumental in positioning said control means.

3. Apparatus adapted to control the operation of a steam-electric generating station having a steam header supplied by steam generating apparatus, a steam turbine taking steam from the header, a feed water header for supplying the steam generating apparatus, heating and storage equipment to which condensate from the turbine passes, and pumping means between said equipment and water header for passing water at elevated pressure to the water header, including in combination, a rate meter of the steam passing to the turbine from the steam header, a rate meter of the water fed to the water header, a separate measuring device for determining static pressure in the feed water header, control means for regulating the rate of water fed by the pumping means to the water header conjointly responsive to both said meters and said device, each of the two rate meters and the measuring device adapted to individually establish a fluid loading pressure continuously representative of the measurement effected, means interrelating the three loading pressures to establish a resultant control pressure which is instrumental in positioning the said control means, said interrelating means including means for comparing the two loading pressures representative of flow rates, and other means arranged to compare the resultant of the said two loading pressures with the loading pressure established by the said device to obtain a second resultant control pressure which positions the said control means.

4. Apparatus adapted to control the operation of a steam-electric generating station having a plurality of steam generators discharging to a common header, a plurality of steam turbines taking steam from said header, a feed water header supplying all of said boilers and receiving water principally as condensate from the turbines, each turbine cycle having heating and storage and pumping means prior to the water

header, including in combination, an individual rate meter for the steam to each turbine cycle, an individual rate meter for the water fed from each cycle to the water header, separate means common to the turbine cycles sensitive to a pressure condition in the feed water header, and separate control means for each cycle regulating the discharge of the pumping means of that cycle to the common feed water header, said separate control means positioned conjointly by the steam rate meter and water rate meter for that cycle and by the pressure sensitive means common to all cycles.

5. Apparatus arranged to control the operation of a steam-electric generating station having a plurality of steam generators discharging to a common steam header, a plurality of steam turbines taking steam from said header, a feed water header supplying all of said boilers and receiving water from the turbine cycles, each turbine cycle having heating and storage and pumping means prior to the water header, including in combination, an individual rate meter for the steam to each turbine cycle, an individual rate meter for the water from each cycle, control means for regulating the rate of water from each cycle to the water header, similar ratio determining means for each cycle responsive to the steam rate meter and the water rate meter of that cycle adapted to continuously ascertain any departure in steam-water flow ratio for the cycle from predetermined ratio, said ratio determining means adapted to cause a positioning of the control means to return the ratio to the predetermined ratio condition following a departure therefrom, and separate means responsive to water header pressure establishing the predetermined ratio for all cycles.

6. Apparatus adapted to control the operation of a steam-electric generating station having a plurality of steam generators discharging to a common header, a plurality of steam turbines taking steam from said header, a feed water header supplying all of said boilers and receiving water principally as condensate from the turbines, each turbine cycle having heating and storage and pumping means prior to the water header, including in combination, an individual rate meter for the steam to each turbine cycle, an individual rate meter for the water fed from each cycle to the water header, a separate device sensitive to static pressure in the steam header, a separate device sensitive to the static pressure in the feed water header, means responsive to both said devices arranged to continuously determine the differential in pressure between the steam header and the water header, and separate control means for each cycle regulating the discharge of the pumping means with that cycle to the common feed water header, said separate control means positioned conjointly by the steam rate meter and water rate meter for that cycle and by the said differential pressure determining means.

7. Apparatus adapted to control the operation

of a steam-electric generating station having a steam header supplied by steam generating apparatus, a steam turbine taking steam from the header, a feed water header for supplying the steam generating apparatus, heating and storage equipment to which condensate from the turbine passes, and pumping means between said equipment and water header for passing water at elevated pressure to the water header, including in combination, a rate meter of the steam passing to the turbine from the steam header establishing a first fluid loading pressure, a rate meter of the water fed to the water header establishing a second fluid loading pressure, a measuring device for a pressure in the feed water header establishing a third fluid loading pressure, control means for regulating the rate of water fed from the pumping means to the water header, a first relay for establishing a fourth fluid loading pressure representative of the average of the second and third fluid loading pressures, and a second relay for establishing a fifth fluid loading pressure representative of a comparison of the first and fourth fluid loading pressures for positioning the said control means.

8. The combination of claim 7 wherein the measuring device constitutes a device sensitive to the static pressure within the feed water header.

9. Apparatus adapted to control the operation of a steam-electric generating station having a steam header supplied by steam generating apparatus, a steam turbine taking steam from the header, a feed water header for supplying the steam generating apparatus, heating and storage equipment to which condensate from the turbine passes, and pumping means between said equipment and water header for passing water at elevated pressure to the water header, including in combination, a rate meter of the steam passing to the turbine from the turbine header establishing a first fluid pressure, a rate meter of the water fed to the water header establishing a second fluid pressure, a measuring device for the pressure in the feed water header establishing a third fluid pressure, a control means for regulating the rate of water fed by pumping means to the water header, a first relay for establishing a fourth fluid pressure representative of the average of the first and second fluid pressures, and a second relay for establishing a fifth fluid pressure representative of a comparison between the third and fourth fluid pressures for positioning the control means.

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