March 17, 1964 P. PROFOS 3,125,073

METHOD AND APPARATUS FOR CONTROLLING FEEDWATER SUPPLY TO A FORCED FLOW STEAM GENERATOR

Filed Dec. 23, 1960 5 Sheets-Sheet 1

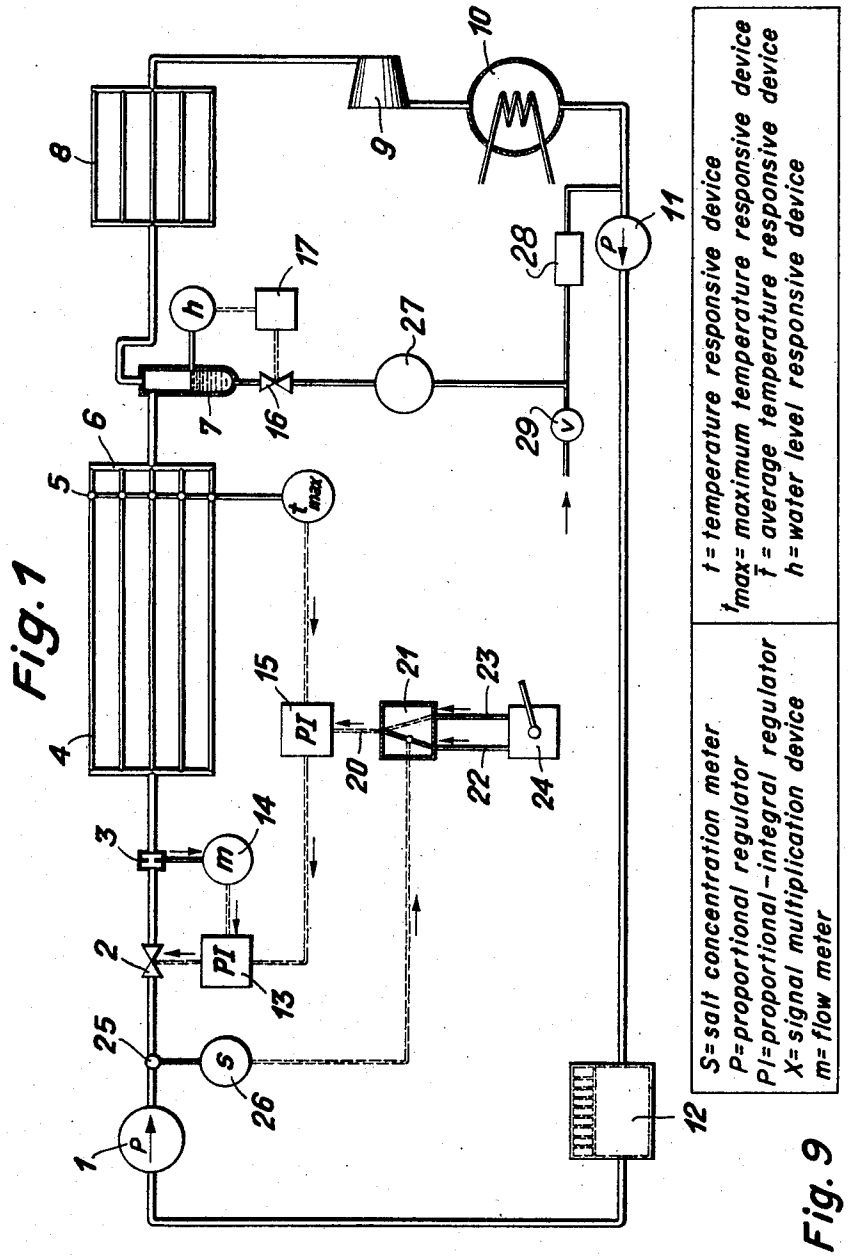


Fig. 1

Fig. 9

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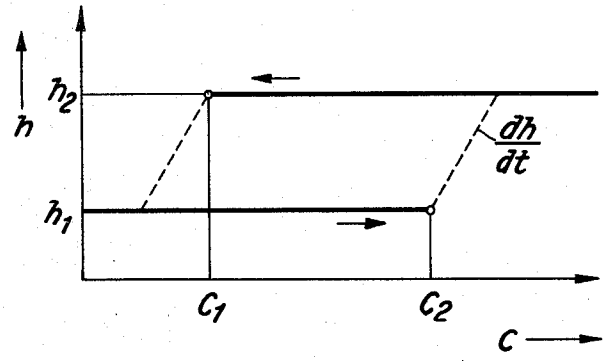


Fig. 6

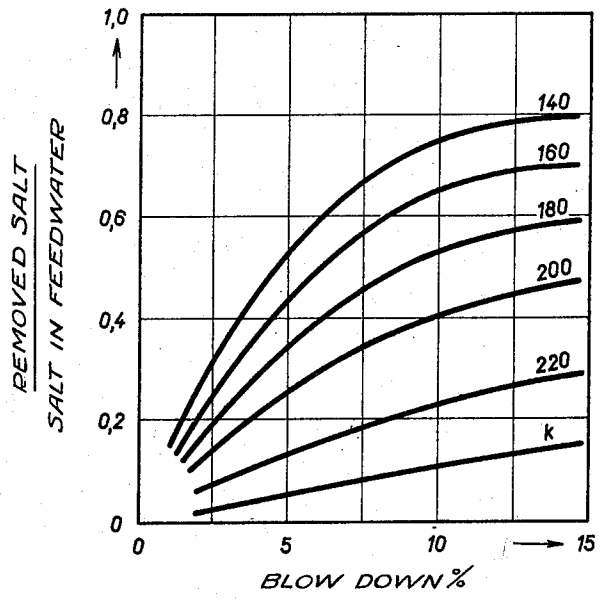


Fig. 2

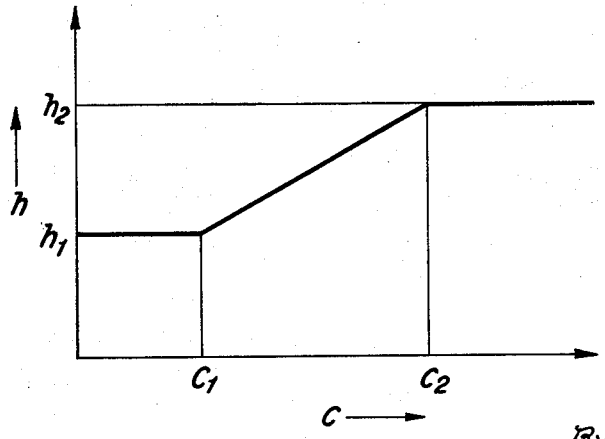


Fig. 5

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METHOD AND APPARATUS FOR CONTROLLING FEEDWATER SUPPLY TO A FORCED FLOW STEAM GENERATOR

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Fig. 3

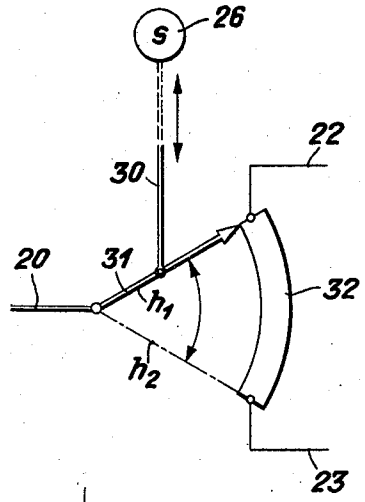
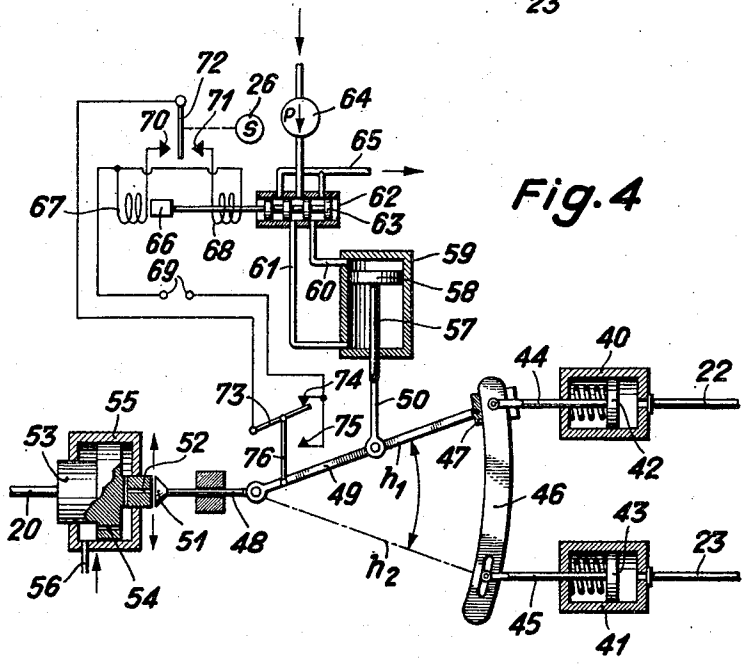


Fig. 4



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METHOD AND APPARATUS FOR CONTROLLING FEEDWATER SUPPLY TO A FORCED FLOW STEAM GENERATOR

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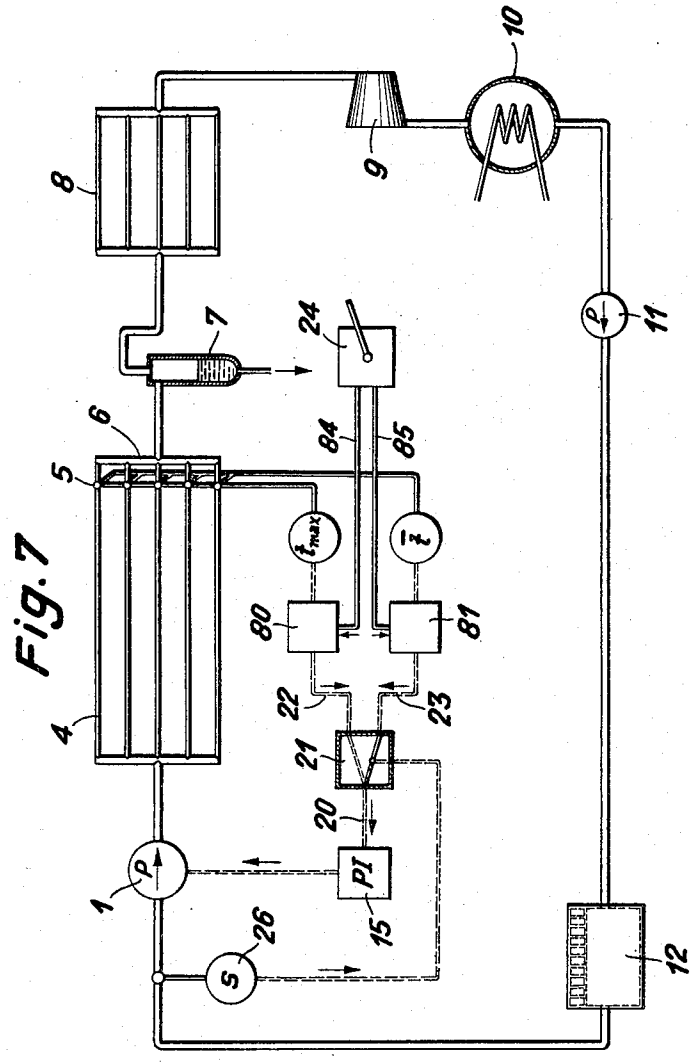


Fig. 7

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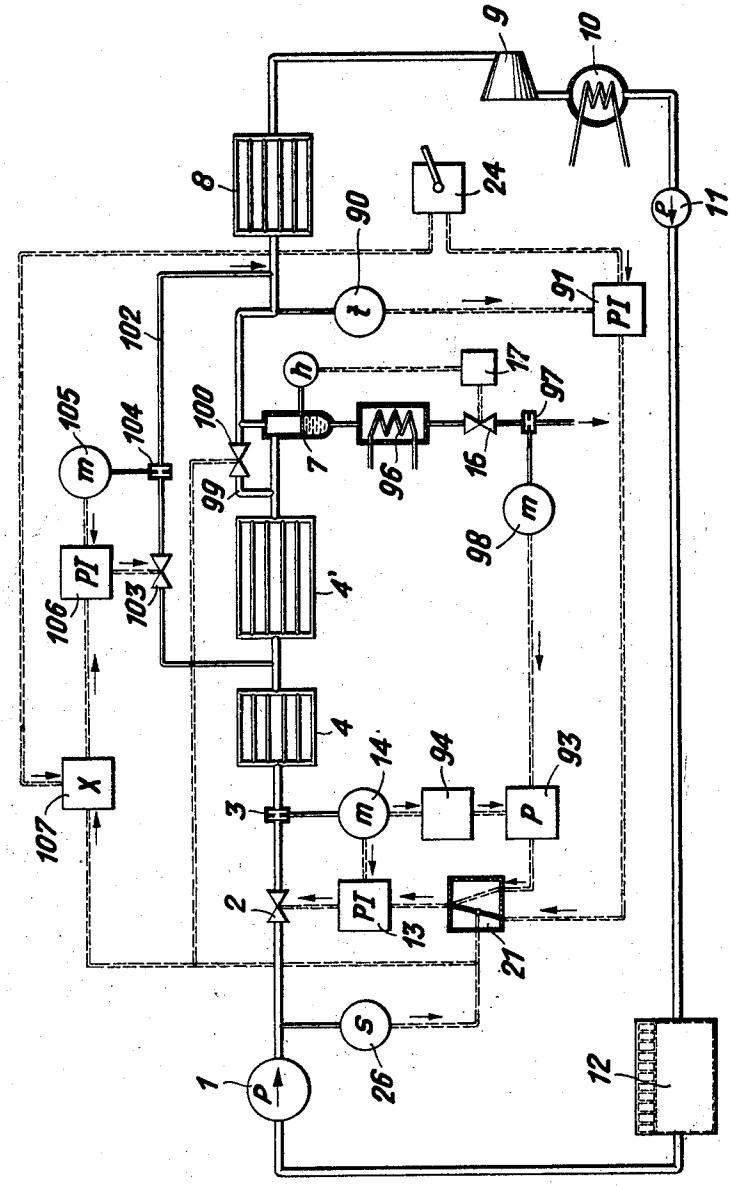
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METHOD AND APPARATUS FOR CONTROLLING FEEDWATER SUPPLY TO A FORCED FLOW STEAM GENERATOR

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Fig. 8



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United States Patent Office 3,125,073 Patented Mar. 17, 1964

3,125,073

METHOD AND APPARATUS FOR CONTROLLING FEEDWATER SUPPLY TO A FORCED FLOW STEAM GENERATOR

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Filed Dec. 23, 1960, Ser. No. 78,004
Claims priority, application Switzerland Dec. 31, 1959
10 Claims. (Cl. 122—379)

The present invention relates to a method and an apparatus for controlling the feedwater supply to a forced flow steam generator having an evaporating section and a superheating section and a water separator interposed between said sections.

It is known to provide water separators in forced flow steam generators and to control the feedwater supply so that a mixture of steam and liquid leaves the evaporating section of the steam generator. The liquid phase of the operating medium is separated in the water separator from the steam phase and is blown down. In this way salts which enter the steam generator with the feedwater, are removed from the generator together with the blowdown water so that the salts will not enter the superheater section or sections.

Blowing down of liquid operating medium containing salts is accompanied by a loss of heat energy and of operating medium, and several arrangements have been proposed to reduce this loss. With modern desalting plants continuous blowdown and losses caused thereby can be nearly completely avoided and blowing down of a relatively great amount of liquid operating medium is only necessary when the salt content of the operating medium flowing through the steam generator increases above a permissible value, for example, due to leakage in a condenser or break-through of an ion exchanger.

It is an object of the present invention to provide a method and apparatus whereby the amount of blowdown water in a forced flow steam generating plant in which a water separator is interposed between an evaporating part and a superheating part is reduced to a minimum by controlling the rate of supply of feedwater to the steam generator in response to the salt content of the operating medium of the plant whereby the rate of feedwater supply to the steam generator is increased upon an increase of the salt content above a predetermined value and the rate of feedwater supply is decreased when the salt concentration drops below a predetermined value.

In a further development of the invention the control of the rate of feedwater supply to the steam generator in response to the salt content of the operating medium is combined with a control of the feedwater supply in response to values representing certain operating conditions of the plant, such as load on or steam output of the steam generator, temperature of the operating medium passing through the steam generator, and the like.

The apparatus according to the invention includes a regulator for regulating the rate of feedwater supply and means for adjusting the set point of the regulator. The set point adjusting means is primarily actuated by control signals produced by conventional devices which are responsive to operating conditions of the steam generator and effect an increase of the rate of feedwater supply, for example, if the steam demand on the generator rises and/or if the temperature of the operating medium passing through the steam generator rises above a predetermined limit, and vice versa. According to the invention a switching device is provided in signal transmitting means between the signal producing devices and the feedwater regulator. This switching device is actuated in response to the salt content of the operating medium for

setting the device to transmit a signal corresponding to a relatively high set point of the feedwater regulator and effecting an increased rate of feedwater supply when the salt concentration is high and for switching the device to transmit a set point control signal which effects a reduced rate of feedwater supply when the salt concentration drops below a predetermined value, and vice versa.

The aforesaid switching device may include means for holding the switching device in a position for transmitting the lower set point signals as long as the salt concentration is below a certain upper limit and for changing, preferably at constant speed, the position of the switching device to a position for transmitting the higher set point signals when the salt concentration reaches said limit and for holding the switching device in the last mentioned position until the salt concentration reaches a predetermined lower limit whereupon the switching device is moved, preferably at constant speed, to the position for transmitting the lower set point signals to the feedwater regulator.

In a modification of the invention a by-pass pipe containing a valve is provided for by-passing the water separator and said valve is controlled in response to the salt content of the operating medium for opening the valve upon a drop of the salt content below a predetermined value and closing the valve according to an increase of the salt content.

The novel features which are considered characteristic of the invention are set forth with particularity in the appended claims. The invention itself, however, and additional objects and advantages thereof will best be understood from the following description of embodiments thereof when read in connection with the accompanying drawing wherein:

FIG. 1 is a schematic illustration of a forced flow steam generating plant embodying an automatic control according to the invention.

FIG. 2 is a diagram showing the removal of SiO_2 by blowdown from the operating medium of a plant as shown in FIG. 1 at different blowdown rates and operating pressures.

FIG. 3 is a diagrammatic illustration of a mechanism forming part of the plant shown in FIG. 1.

FIG. 4 is a diagrammatic part sectional illustration of a modification of the mechanism shown in FIG. 3.

FIGS. 5 and 6 are diagrams illustrating the relation between the rate of supply of operating medium to the steam generator and different salt contents of the operating medium.

FIGS. 7 and 8 are diagrammatic illustrations of forced flow steam generating plants embodying two modifications of an automatic control according to the invention.

FIGURE 9 is a key to the letter symbols used in the drawings.

FIG. 1 illustrates, by way of example, a simple embodiment of the invention. The operating medium, namely feedwater, is supplied by a feed pump 1 through a valve 2 and an orifice plate 3 to an evaporating section 4 of a steam generator. The evaporating section 4 comprises a plurality of tube lines arranged in parallel relation with respect to the flow of the operating medium therethrough. At the end of each tube line a temperature sensitive device 5 is provided. The operating medium is discharged from the tube lines into a collector 6 wherefrom the operating medium is conducted into a water separator 7. The steam phase of the operating medium is conducted from the separator 7 to a superheater 8. The superheated steam operates a turbine 9 whose exhaust is condensed in a condenser 10. The condensate is pumped by a pump 11 into a feedwater tank 12 from which the feed pump 1 receives feedwater. The blowdown water from the separator 7 is cooled in a cooler 27, purified in a

purifier 28, for example, of the ion exchange type and returned to the circuit upstream of pump 11. If needed, raw water may be supplied to the circuit through a valve 29 and the purifier 28.

The valve 2 is controlled by a regulator 13 which is responsive to the rate of flow of feedwater into the evaporating section 4, a rate of flow measuring device 14 including the measuring orifice plate 3 being provided for this purpose. The set point of the regulator 13, i.e. the desired rate of flow to be effected by the valve 2, is defined by a device 15. The latter is actuated by that one of the temperature sensitive devices 5 which senses the highest temperature. A system suitable for this purpose is disclosed in Patent No. 2,800,887. All devices 5 which sense a lower temperature at the same time are ineffective on the device 15. Rising of said highest temperature above a predetermined value causes an increase of the set point of the regulator 13, i.e., opening of valve 2 and increased feedwater supply to the steam generator and vice versa. The object of the control apparatus is to assure that slightly superheated steam leaves the tube line of the evaporator 4 producing the relatively highest temperature of the operating medium and all other tube lines of the evaporator 4 produce a lower temperature of the operating medium which contains a certain percentage of unevaporated operating medium. This unevaporated portion is separated in the separator 7 and is blown down through a valve 16 which is controlled in the conventional manner by a regulator 17 in response to the water level in the separator. Forced flow steam generators are provided with means for maintaining a desired steam pressure in the generator. These means are not shown because they are conventional and complicated and do not form part of the present invention.

The set point of the control device 15 which produces the set point of the regulator 13 also corresponds to a signal supplied to the device 15 through a conduit 20 which is connected by a switching device 21 either to a signal conduit 22 or to a signal conduit 23. The signals conducted by the conduits 22 and 23 are different and correspond to different loads on and steam output of the steam generator. The signals are produced by a load control device 24 controlling the operation of the steam generator in a conventional manner by controlling the set points of conventional regulators, not shown, for example, of the rate of fuel and rate of combustion air supply to the steam generator. An apparatus of this type is shown in Patent No. 2,962,865. Relatively low set point setting signals are conducted through the conduit 23 and relatively high set point setting signals are conducted through the conduit 22. At a suitable point 25 of the circuit of the operating medium through the plant a device 26 is connected which produces control signals corresponding to the salt concentration in the operating medium at this point. The signals produced in the device 26 actuate the switching device 21.

If the salt concentration of the operating medium circulating through the plant is at or below a predetermined concentration, the switching device 21 connects the device 15 to the signal conduit 22 which produces a higher temperature set point for the device 15 so that the latter, through the device 13 and the valve 2, effects a reduced rate of supply of feedwater to the steam generator. If the salt concentration increases above a predetermined value for any reason, for example, due to malfunction of a desalting plant, the concentration sensing device 26 actuates the switching device 21 to connect the conduit 23 to the device 15 whereby the temperature set point of the device 15 is reduced and the rate of feedwater supply is increased. Since now more operating medium is fed into the evaporating section 4, the operating medium leaving the evaporating section contains a greater portion of unevaporated liquid which is separated in the separator 7 and blown down therefrom. As soon as the salt concentration of the circulating operating medium drops below the predetermined maximum, the device 26 actuates the switching device 21 to connect the conduits 22 and 20 whereby the temperature set point of the device 15 is increased and the rate of flow set point of the device 13 is reduced.

The abscissae of the diagram FIG. 2 represent rate of blowdown from the separator 7 in percent of rate of flow of feedwater supplied to the evaporating section 4. The ordinates represent the relation between the rate of salt removal and the rate of salt passing through the evaporating section. The balance of salt passes with the steam into the superheater 8. The curves plotted in the diagram represent the relation between the rates of salt removal and of salt passing through the evaporating section at various pressures (atmospheres absolute) at various blowndown percentages. The diagram shows that, particularly when operating at high pressures, the salt-removing effect of the separator increases upon increase of the blowdown rate to about 15%. It is, therefore, of advantage to increase the blowdown rate when the salt content of the feedwater increases. The line designated by the letter *k* represents the situation when operating at the critical pressure. At this pressure the amount of salt carried over by a pound of steam into the superheater is relatively great and the total amount of salt carried into the superheater is reduced if less steam is passed into the superheater, i.e., if more water is blown down. At a lower steam pressure, for example 140 atmospheres, less salt is carried over by a pound of steam into the superheater and a reduction of the rate of steam passing into the superheater by increasing the blowdown rate above 15% has little effect on the total salt removal.

FIG. 3 shows a particular form of the switching device 21. The signal produced by the salt concentration sensitive device 26 acts on a rod 30 which is connected to and moves a wiper arm 31 of a potentiometer 32. The ends of the latter are connected to electric conduits 22 and 23 which are charged, for example, according to the position of a conventional device which is actuated according to operating conditions of the plant. Depending on the position of the arm 31, either the voltage in line 22 or the voltage in line 23, or an intermediate voltage is transmitted to the signal conduit 20 for controlling the set point of the device 15.

FIG. 4 shows a modified swtiching device 21. Hydraulic pressure is transmitted to cylinders 40 and 41 through signal conduits 22 and 23, respectively, the pressures acting on spring-loaded pistons 42 and 43, respectively. The pistons act through piston rods 44 and 45 on a movable guide 46 whose position is defined by the pistons 42 and 43. A slide 47 is movable on the guide 46 and is pivoted to one end of a lever 49 whose other end is pivoted to one end of an axially movable rod 48. The other end 51 of the rod 48 is enlarged and is placed opposite the outlet of an air channel 52 in a piston 53 which is connected to a rod 20 which transmits signals corresponding to the position of the piston 53 as set point defining signals to the device 15. The piston 53 has three parts of different diameters; the largest part is movable in a cylinder 55 and is provided with a channel 54 extending between the two faces of the large piston part. Air under pressure is introduced into the cylinder 55 through an air inlet 56.

The lever 49 is actuated by a rod 50 which is connected to a piston rod 57 extending from a piston 58 in a cylinder 59. A pipe 60 for conducting a pressure fluid is connected to one end of the cylinder 59 and a pipe 61, also for conducting a fluid under pressure, is connected to the other end of the cylinder 59. A piston valve 63 in a cylinder 62 controls the flow of a fluid under pressure supplied by a pump 64 to and from the pipes 60 and 61. Fluid relieved through the valve 63 is removed through a pipe 65. The end of a rod connected to the piston valve 63 forms an armature 66 adapted to cooperate with coils 67 and 68. One end of each of the coils is connected to one pole of a source of electricity 69, the other ends of the coils 67 and 68 are connected to contacts 70

and 71. These contacts cooperate with a movable contact 72 which is actuated by signals produced by the salt concentration sensitive device 26. The movable contact 72 is arranged in series relation with a second movable contact 73 which is adapted to engage either one of two stationary contacts 74 and 75 which are both connected to the second pole of the source 69. The contact 73 is connected by a link 76 to the lever 49 to follow the movements thereof.

If the salt content of the feedwater entering the evaporator 4 is small, the movable contact 72 engages the stationary contact 70 so that the coil 67 is energized and the armature 66 is moved to the left and places the valve 63 in its left end position, as seen in FIG. 4. The space in the cylinder 59 below the piston 58 is now connected to the pump 64 and the space above the piston 58 is connected to the outlet pipe 65. The piston 58 is in its upper end position and the lever 49 is in the position shown in FIG. 4. If the salt content of the feedwater increases above a predetermined value, the salt concentration sensitive device 26 moves the contact 72 to engage the contact 71 whereby the coil 68 is energized, current flowing through the contacts 73 and 74 which are still in engagement. The armature 66 is now pulled to the right and the piston valve 63 placed in its right end position so that the space above the cylinder 58 is connected to the pump 64 and the space below the piston 58 is connected to the outlet pipe 65. The piston 58 now moves at a constant speed which is determined by the output of the pump 62 in a downward direction. This causes downward swinging of the lever 49 and disengagement of the contacts 73 and 74 which, however, has no influence, because the valve 63 remains in the new end position. The piston 58 moves at constant speed until it arrives at its lower end position whereupon the contact 73 engages the contact 75. This, however, has no influence on the position of the piston 58 as long as the movable contact 72 does not engage the contact 70. This engagement is effected only after reduction of the salt content of the feedwater and causes movement of the piston valve to the left so that the piston 58 moves at constant speed from its lower end position into the upper end position which is shown in FIG. 4. Movement of the piston 58 causes movement of the slide 47 at the end of the lever 49 along the guide 46 so that a signal arriving through the conduit 22 or a signal arriving through the conduit 23, or an intermediate signal is transmitted to the rod 48.

The compressed air introduced into the cylinder 55 through the inlet 56 passes through the channel 54 and to the right side of the piston 53 and therefrom through the channel 52 to the outside. The air passing through the channel 54 is throttled in a constant manner and is variably throttled at the outlet of the channel 52 by the end 51 of the rod 48. The piston 53 moves to a position where the pressures at the left side and at the right side of the piston are the same. The rod 20 connected to the piston 53 thus follows the movement of the rod 48 without exerting undue pressure on the rod 48.

The abscissae in the diagram FIG. 5 represent salt concentration. The ordinates represent the set points of the control for the rate of feedwater supply which set points correspond to the position of the lever 31 in FIG. 3. The heavy line in FIG. 5 represents the set points of the control for the rate of feedwater supply when using the apparatus shown in FIG. 3. The lever 31 remains in the position h_1 until the salt concentration amounts to the value C_1 so that the set point of the control produces a relatively small rate of feedwater supply. If the salt concentration increases above the concentration C_1, the rate of feedwater supply is also increased and the lever 31 is moved towards the position h_2. If the salt concentration reaches the value C_2 and increases above said value, the lever is in the position h_2 and remains in this position so that the rate of feedwater supply is not further increased though the salt concentration may increase beyond the value C_2. As is obvious from FIG. 2, when operating at 140 atmospheres and blowing down about 15% of the operating medium passing through the evaporator, 80% of the salt contained in the feedwater is removed with the blowdown water and it is of little advantage to blow down more water. Only at very high pressures, close to the critical pressure, an increase of the blowdown rate above 15% of the feedwater supply rate substantially reduces passage of salt into the superheater, because at such high pressures the amount of salt carried along by each pound of steam is much greater than at lower pressures. Such increase of the blowdown rate, however, causes excessive losses of energy and operating medium. For this reason it is not contemplated to increase the blowdown rate above a certain value which depends on the pressure at which the steam generator is operated.

FIG. 6 illustrates the effect of the control by means of the apparatus shown in FIG. 4. If this apparatus is used, the set point of the control of the rate of feedwater supply remains at the low value h_1 until the salt concentration reaches the value C_2. When this value is reached the set point of the control of the rate of feedwater supply is increased at constant speed

$$\frac{dh}{dt}$$

This increased set point remains until the salt concentration drops below the value C_1 when the set point is adjusted at constant speed until it reaches the lower value h_1. With this operation fluctuation of the control is avoided when the salt concentrations are in the neighborhood of the limit value C_1 or C_2. Switching from one set point to another is only effected at the predetermined limits of the salt concentration and is effected at constant speed which is so slow that the control of the steam generator is not disturbed.

FIG. 7 shows a modification of an apparatus according to the invention. Parts shown in FIG. 7 which correspond to parts shown in FIG. 1 are designated by like numerals. The system shown in FIG. 7 differs from the system shown in FIG. 1 in that the switching device 21 receives set point values for the regulator 15 from two control devices 80 and 81 through signal conduits 22 and 23, respectively. The device 80 responds to the maximum temperature sensed by the temperature sensitive devices 5. The set point of the device 80, i.e. the maximum temperature to which it is responsive, is determined by the position of the general steam generator controlling device 24, the signal produced by the latter being conducted to the device 80 through a conduit 84. The device 81 is actuated according to the average temperature measured by all temperature sensitive devices 5 and receives its set point, i.e. the average temperature to which it is responsive, through a conduit 85 from the device 24. As in the apparatus shown in FIG. 1, the set points of the control of the rate of feedwater supply depend on the setting of the control device 24 which corresponds to the load on or the output of the steam generator.

At increased salt concentration the apparatus shown in FIG. 7 controls the rate of feedwater supply in dependence on the temperature of the operating medium at the outlet of that one of the tube lines 4 wherein the temperature is higher than in the outlets of the other tube lines 4, the maximum temperature being defined by a signal arriving through the conduit 84. If the salt concentration sensitive device 26 senses a relatively low salt concentration, the device 21 is switched to a position connecting the control apparatus 15 to the regulator 81 which responds to the average temperature of the steam leaving the tube lines 4. The average temperature which actuates the regulator 81 is defined by the signal arriving through the conduit 85 and is somewhat higher than the maximum temperature which actuates the device 80 which maximum temperature is that of slightly superheated steam. When the device 21 is set to transmit the set point signal pro-

duced in the device 81 the steam leaving the evaporating tubes 4 is superheated and has a higher temperature than the temperature which actuates the device 80 so that no unevaporated operating medium enters the collector 6.

With the arrangement shown in FIG. 7 only so much feedwater is supplied to the evaporator as is needed for producing the amount of steam withdrawn from the steam generator, as long as the salt concentration is below a predetermined value. There is no blowdown and losses caused thereby are avoided. If the salt concentration of the operating medium increases above the predetermined value, the regulator 15 is connected to the regulator 80 and the temperature of the operating medium leaving the evaporator is so controlled that a certain percentage of operating medium is not evaporated and is blown down from the separator 7. If this blowdown operation reduces the salt concentration to below the predetermined value, the control is switched to the regulator 81 and causes a rate of feedwater supply which is such that no unevaporated operating medium leaves the evaporator.

FIG. 8 shows another modification of an apparatus according to the invention. Parts of the apparatus shown in FIG. 8 corresponding to those of the appartus shown in FIGS. 1 and 7 are designated by the same numerals. The steam generator forming part of the system shown in FIG. 8 has an evaporator which is split into two sections 4 and 4' which are arranged in series relation with respect to the flow of the operating medium. A temperature sensitive device 90 is connected to a pipe connecting the steam space of the water separator 7 and the superheater 8 and produces a signal for actuating a regulator 91 which produces a set point signal which is conducted to the switching device 21. The latter is also connected to a regulator 93 which is actuated by control signals produced by a device 14 which is responsive to the rate of feedwater supply to the steam generator. The signal produced by the device 14 is transformed in a conventional device 94 before it reaches the regulator 93 so that the signal is changed, for example by a cam arrangement, and the signal received by the device 93 from the device 94 does not linearly correspond to the signal produced by the device 14.

A cooler 96 is interposed in the blowdown pipe of the separator 7. Downstream of the cooler 96 a valve 16 for controlling the amount of blowdown water and a measuring device 97, 98 for measuring the rate of flow of removed blowdown water are arranged. The valve 16 is controlled by a regulator 17 to maintain a predetermined water level in the separator 7 as in the example shown in FIG. 1. The device 98 produces a signal corresponding to the rate of flow of blowdown water which signal is transmitted to the regulator 93.

A pipe 99 with a valve 100 by-passes the separator 7. The valve 100 is operatively connected to the salt concentration sensitive device 26 for operation in response to the salt concentration. The valve 100 is fully opened when the salt concentration decreases to or below a predetermined limit and is closed in response to an increasing salt concentration. Therefore, no water is blown down, unless the salt content of the feedwater rises above a predetermined value.

A pipe 102 is connected to a pipe interconnecting the evaporating sections 4 and 4' and to the pipe connecting the steam space of the separator 7 and superheater 8, bypassing the evaporating section 4' and the separator 7. A valve 103 and a measuring orifice plate 104 are interposed in the pipe 102. The orifice plate 104 is connected to a device 105 which produces a signal corresponding to the rate of flow of operating medium through the pipe 102. The signal produced in the device 105 is conducted to a regulator 106 which actuates the valve 103. The regulator 106 is also controlled by signals received from a signal multiplication device 107 which multiplies signals received from the load control device 24 by signals received from the salt concentration responsive device 26. The load control device 24 produces a second signal which is transmitted to the device 91 and combined therein with the signal produced in the temperature responsive device 90. The device 91 corresponds to the device 81 in FIG. 7.

In the system according to FIG. 8 the regulator 13 controls the rate of feedwater supply to the steam generator according to a signal received from the device 91 which corresponds to the temperature of the operating medium and to the setting of the device 24, as long as the salt concentration of the feedwater is relatively low. If this is the case, the valve 100 is open and no liquid is separated in the separator 7 and blown down. When the salt concentration exceeds a predetermined value, the switching device 21 connects the regulator 13 to the regulator 93 so that the rate of feedwater supply corresponds to the relation between the rate of feedwater fed into the steam generator and the rate of blowdown water. If the blowdown water increases relative to the feed water supply to the steam generator the latter is reduced so that the steam at the outlet of the evaporator is less wet and less water is blown down. The signal ransformer 94 may determine a different relation between the rate of removed blowdown liquid and the rate of feedwater supply at different rates of feedwater supply. For example, at lower loads on the steam generator the rate of blowdown water may be increased relatively to the rate of feedwater supply for stabilizing the flow conditions through the evaporator. The multiplication device 107 and the regulator 106 effect by-passing of liquid operating medium through the pipe 102 according to the load on the steam generator and the salt concentration in the feedwater. At high salt concentration (C_2 in FIG. 5) the signal fed into the multiplication device 107 is zero so that the valve 103 is closed and no operating medium is by-passed in conduit 102. At low salt concentration (C_1 in FIG. 5) the signal fed into the device 107 may have the value one and the valve 103 may be open all the way. The amount of by-passed operating medium is defined by the set point signal emitted from the load control device 24. This signal may be such that the mixture of the steam discharged by the separator 7 and the water supplied through pipe 102 has a predetermined moisture content or temperature. In this way changes of the moisture content and temperature of the steam entering the superheater 8 which changes are caused by changes of load, can be counteracted, provided that the salt concentration of the operating medium is low. The aforedescribed arrangement reduces the normally required water injection. By opening the valve 100 in the by-pass pipe 99 operating medium can be by-passed around the separator 7 and blowdown waste as well as flow resistance in the separator 7 which causes an undesired pressure drop can be avoided.

The illustrated and described examples may be modified without departing from the scope of the present invention. For example, the salt concentration responsive device 26 may be arranged at a different point of the circuit of the operating medium than that shown. It may be arranged to be responsive to the entire flowing operating medium, as shown, or it may be responsive only to a portion of the operating medium passing through the plant. The invention is not restricted to plants in which the operating medium forms a closed circuit including a steam generator, a turbine and a condenser, but may as well be applied to a steam generator supplying consumers which do not return all or part of the operating medium to the steam generator. The temperature sensitive device 90 in FIG. 8 need not be connected to the inlet of the superheater, as shown, but may be connected to other parts of the steam generator.

The plants shown and described by way of example are simplified and include only what is necessary for explaining the invention. A steam generating plant usually includes many additional control devices which, for example, maintain the temperature of the live steam by means of water injection. The load control device 24 need not

necessarily be of a type which is actuated by hand, but may be responsive, for example, to the speed of the turbine or to the pressure of the live steam entering the turbine. The system according to the invention may be combined with the aforementioned additional control devices and the regulators of the illustrated and described examples may be influenced by additional signals for producing special effects. The regulator **15** shown in FIG. 1 may be actuated, for example, by a signal corresponding to the moisture content of the steam in addition to the signal which corresponds to the maximum temperature of the operating medium leaving the tubes of the evaporator **4**. The regulators **15**, **81** and **91** may receive signals which correspond to the amount of water injected into the superheater so that the rate of feedwater supply control is so adjusted that the amount of cooling water which must be injected into the superheater remains within desired limits. The control system according to the invention may be subjected to other influences for producing the desired result. For example, in the system shown in FIG. 1 an additional signal which depends on the salt concentration of the operating medium may be added by a conventional signal-adding device to the signal in one of the conduits **22** or **23** for changing the signal produced by the temperature sensitive device **5**.

I claim:

1. In a steam generating plant having a forced flow stem generator including a tubular evaporating section, a tubular superheating section, and a water separator interposed for flow of operating medium between said sections: a supply conduit connected to said evaporating section for supplying feedwater thereto, a salt concentration sensitive device connected to said supply conduit for sensing the salt concentration in the feedwater and producing control signals corresponding to the sensed salt concentration, control means connected to said supply conduit for controlling the rate of feedwater supply to said evaporating section, control signal transmitting means interconnecting said salt concentration sensitive device and said control means, the latter being adapted to be actuated by the transmitted control signals for increasing the rate of feedwater supply upon an increase of the salt concentration in the feedwater and for decreasing the rate of feedwater supply upon a decrease of the salt concentration in the feedwater.

2. In a steam generating plant having a forced flow steam generator including a tubular evaporator section, a tubular superheating section, and a water separator interposed for flow of operating medium between said sections: a supply conduit connected to said evaporating section for supplying feedwater thereto, a salt concentration sensitive device connected to said supply conduit for sensing the salt concentration in the feedwater and producing control signals corresponding to the sensed salt concentration, control means connected to said supply conduit for controlling the rate of feedwater supply to said evaporating section, set point adjusting signal supply means connected to said control means for adjusting the set point thereof, said set point adjusting signal supply means being connected to said salt concentration sensitive device for increasing the set point of said control means for increasing the rate of feedwater supply upon an increase of the salt concentration in the feedwater and for decreasing the set point of said control means for decreasing the rate of feedwater supply upon a decrease of the salt concentration in the feedwater.

3. In a steam generating plant having a forced flow steam generator including a tubular evaporating section, a tubular superheating section, and a water separator interposed for flow of operating medium between said sections: a supply conduit connected to said evaporating section for supplying feedwater thereto, a salt concentration sensitive device connected to said supply conduit for sensing the salt concentration in the feedwater, control means connected to said supply conduit for controlling the rate of feedwater supply to said evaporating section, control signal producing means individually responsive to values corresponding to different operating conditions of the plant and adapted to individually produce control signals corresponding to said values, signal transmitting means interconnecting said signal producing means and said control means, and switching means interposed in said signal transmitting means for effecting transmission of control signals from one or from another of said signal producing means to said control means, the latter being adapted to be actuated by the signals transmitted by said transmitting means, said switching means being operatively connected to said salt concentration sensitive device for actuation thereby to effect transmission of control signals from one of said signal producing means to said control means when the salt concentration is at a predetermined low value and to effect transmission of control signals from another of said signal producig means to said control means when the salt concentration is at a predetermined high value.

4. In a steam generating plant as defined in claim 3 and wherein said evaporating section comprises a plurality of the tube lines arranged in parallel relation with respect to the flow of the operating medium therethrough, a temperature sensitive device being connected to the outlet of each of said tube lines, one of said signal producing means being operatively connected to said temperature sensitive devices and being adapted to produce a signal corresponding to the average temperature at the outlets of said tube lines, a second of said signal producing means being operatively connected to said temperature sensitive devices and being adapted to produce a signal corresponding to the temperature of that one of the outlets of said tube lines which has the highest temperature of all outlets.

5. In a steam generating plant as defined in claim 3 and wherein one of said control signal producing means is connected to said steam generator and adapted to produce signals corresponding to the temperature of the operating medium passing through the steam generator, a second of said control signal producing means being operatively connected to said separator and to said supply conduit and adapted to produce signals corresponding to the ratio between the rate of feedwater flow to said steam generator and the rate of water separation in said separator.

6. In a steam generating plant having a forced flow steam generator including a tubular evaporating section, a tubular superheating section, and a water separator interposed between said sections: a by-pass conduit connecting said evaporating section and said superheating section and by-passing said separator, control means connected to said by-pass conduit for controlling the rate of flow of operating medium therethrough, a supply conduit connected to said evaporating section for supplying feedwater thereto, a salt concentration sensitive device connected to said supply conduit for sensing the salt concentration in the feedwater, control means connected to said supply conduit for controlling the rate of feedwater flow therethrough, said control means being operatively connected to said salt concentration sensitive device to be actuated thereby for increasing the rate of flow of feedwater through said supply conduit and for decreasing the rate of flow of operating medium through said by-pass conduit upon increase of the salt concentration above a predetermined value and for decreasing the rate of feedwater flow through said supply conduit and for increasing the rate of flow of operating medium through said by-pass conduit upon decrease of the salt concentration below a predetermined value.

7. In a steam generating plant having a forced flow steam generator including a tubular evaporating section, a tubular superheating section, and a water separator interposed for flow of operating medium between said sections: a supply conduit connected to said evaporating section for supplying feedwater thereto, a salt concentration sensitive device connected to said supply conduit

for sensing the salt concentration in the feedwater, control means connected to said supply conduit for controlling the rate of feedwater flow therethrough, at least two sources of different set point adjusting signals, signal transmitting means connected to said sources and to said control means, and switch means interposed in said transmitting means for selectively transmitting signals either from one of said sources or from another of said sources to said control means, said switch means being operatively connected to said salt concentration sensitive device for actuation thereby.

8. In a steam generating plant according to claim 7 and wherein said switch means is adapted to be moved to one extreme position for connecting said control means to one of said sources upon a predetermined salt concentration sensed by said salt concentration sensitive device and to be moved to a second extreme position for connecting said control means to a second of said sources upon a different predetermined salt concentration sensed by said salt concentration sensitive device, said switch means being adapted to be moved to intermediate positions corresponding to salt concentrations between said predetermined salt concentrations and to transmit set point adjusting signals to said control means corresponding to values which are between the values of the signals produced by said sources.

9. In a steam generating plant according to claim 7 and wherein one of said sources supplies set point adjusting signals effecting a relatively high rate of feedwater supply and a second of said sources supplies set point adjusting signals effecting a relatively low rate of feedwater supply, actuating means for said switch means being interposed between said salt concentration sensitive device and said switch means and including means adapted to hold said switch means in a position for connecting said control means to said second source as long as the salt concentration is below a predetermined relatively high value, said actuating means including means adapted to move said switch means at substantially constant speed to a position for connecting said control means to the first source when the salt concentration reaches said predetermined high value, to hold said switch means in the last mentioned position as long as the salt concentration stays above a relatively low concentration, and to move said switch means at substantially constant speed for connecting said control means to said second source when the salt concentration drops to said relatively low concentration.

10. A method of controlling the rate of feedwater supply to a forced flow steam generator having an evaporating section, a superheater section, and a water separator interposed in the flow of operating medium between said sections, comprising the steps of measuring the salt content of the feedwater, of increasing the rate of feedwater supply to the steam generator upon an increase of the salt content of the feedwater, of decreasing the rate of feedwater supply to the steam generator upon a decrease of the salt content of the feedwater, and of by-passing operating medium around the water separator upon a decrease of the salt content of the operating medium below a predetermined minimum.

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