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STEAM POWER PLANT

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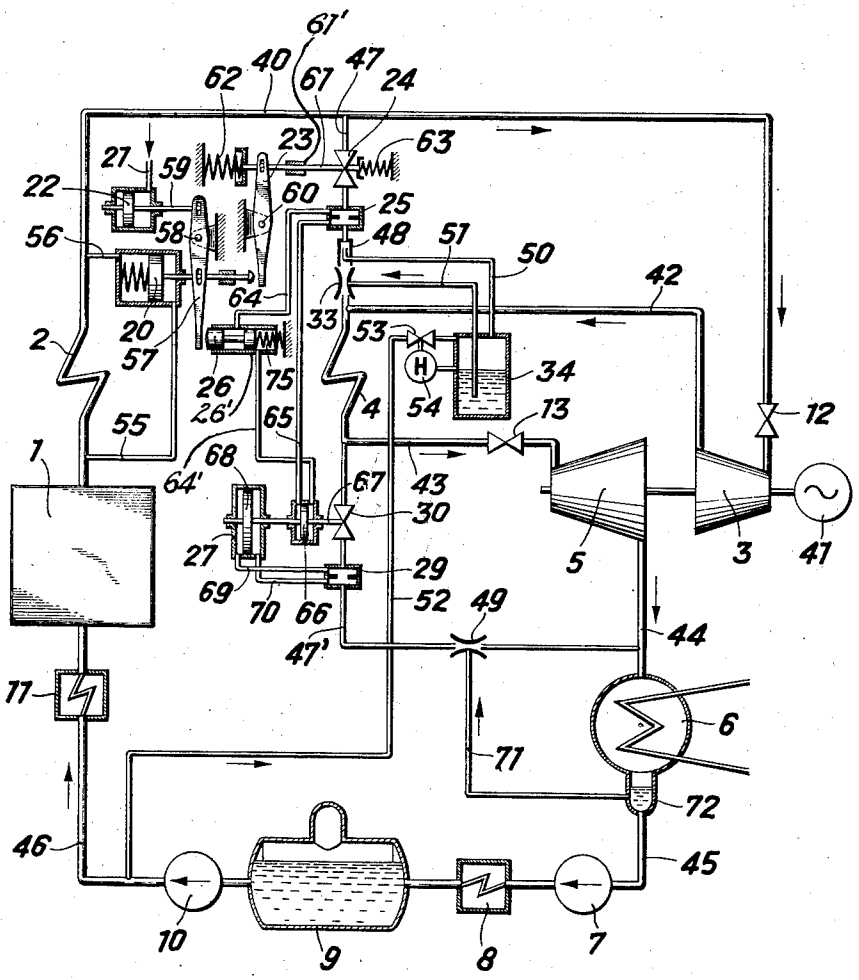

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STEAM POWER PLANT

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This invention relates to steam power plants including a steam-operated prime mover or steam-consuming machine and a steam generator comprising an evaporator and superheater, the plant further including a bypass line which branches off between the superheater and prime mover and which contains a valve operable in dependence on an operating condition of the working substance. The invention will hereinafter be described with reference to steam as the working substance, although it is not restricted thereto, and the word "team" as hereinafter used is intended to refer to vaporizable working substances generally.

In known plants of this kind, the valve is operated in dependence on the steam pressure. If, for example, the valve in the line which admits steam to the prime mover is closed, the pressure in the live steam line rises. This pressure rise is utilized to open the valve in the bypass line. When the valve controlling admission of steam to the prime mover is closed in the case of less than full-load operation, then the time required until the pressure in the steam feed line to the prime mover has risen to an amount such that the valve in the bypass line responds may be so long that the superheater is in danger of burning out owing to the amount of steam stagnating therein. To obviate this danger, the steam power plant according to the invention is characterized in that the valve in the bypass is controlled by a signal representative of steam rate of flow, which is developed or taken off in the region between the evaporator and the branching-off point of the bypass line.

In the case of interest for the invention, the bypass valve is so controlled that the amount of steam flowing through the superheater does not fall below a predetermined value, which is advantageously made variable in dependence on the load on the steam generator. The invention ensures that the superheater cannot in any case burn out, since the bypass valve opens under control of the rate of steam flow signal as soon as the steam flow drops below a minimum value. The invention also makes it possible to avoid opening of the safety valve. It is undesirable for the safety valve to open because after use it usually no longer closes so as to be steam-tight and then has to be overhauled or even replaced. In addition, steam is lost when the safety valve opens.

The invention may also be embodied in steam power plants having single or repeated re-superheating, the output of each reheater being connected to a bypass line including a valve which is also controlled by the rate of steam flow signal which is developed between the evaporator and the branching-off point of the bypass line downstream of the superheater.

According to one embodiment of the invention, the signal for control of the valve is formed by the pressure drop in at least one part of the superheater.

Further features of the invention will be apparent from the following description of one exemplified embodiment in conjunction with the accompanying drawings.

In these drawings the single FIGURE of drawings is a diagram of a steam power plant according to the invention with single-pass re-superheating. Reference character 1 denotes an evaporator and reference character 2 denotes the associated superheater. From the superheater 2 a live steam line 40 leads to the high pressure part 3 of a steam

turbine which drives an electrical generator 41. The line 40 contains a valve 12 upstream of the inlet to the high-pressure turbine 3. From the high-pressure turbine 3 a line 42 leads to a reheater 4 and from the latter a line 43 containing a valve 13 leads to the low-pressure turbine 5, also coupled to generator 41. The steam outlet of the low-pressure turbine 5 is connected by a line 44 to a condenser 6, which is in turn connected by a line 45 to a feed tank 9. The line 45 contains a condensate pump 7 and a preheater 8. The feed tank 9 is connected by a line 46 to the evaporator 1 and the line 46 contains a feed pump 10 and a preheater 11.

From the live steam line 40, a bypass line 47 branches off between superheater 2 and valve 12 and leads to the reheater 4. From the outlet of the reheater 4 a bypass line 47′ branches off and leads into the line 44 connecting the outlet of low-pressure turbine 5 to the condenser 6. The bypass line 47 contains a valve 24, a perforated diaphragm 25 for measurement of flow rate, a dynamic pressure measuring tube 48 and a Venturi tube 33. The bypass line 47′ contains a valve 30, a perforated diaphragm 29 for flow rate measurement, and a Venturi tube 49. The pressure tube 48 is connected by a line 50 to a tank 34 containing feed water for cooling purposes. The Venturi tube 33 is connected by a line 51 to the tank 34. Line 51 however opens below the level of the water in the tank. The supply of feed water to the tank 34 is effected through a line 52, which is connected to the line 46 on the high pressure side of the feed pump 10. The line 52 contains a valve 53, which is controlled by a regulating means 54 dependent on the water level in the tank 34. The Venturi tube 49 is connected by a line 71 to the condensate collector tank 72 below the condenser 6.

The valve 24 in the bypass line 47 is controlled by a signal representative of rate of steam flow. The pressure drop in the superheater 2 is used for this purpose, lines 55 and 56 respectively being connected upstream and downstream of the superheater 2. These lines lead to a cylinder containing a piston 20. Connected to the piston rod of the piston 20 is a lever 57 supported at a fixed pivot point 58. The upper end of the lever 57 in the drawing is connected by a piston rod 59 to a piston 22, into the cylinder of which there opens a hydraulic signal line 21. Line 21 is connected, for example, to a load-responsive signal generator (not shown) and thus supplies to the piston 22 a load-dependent signal. This signal serves as a reference with respect to which the rate of flow signal obtained from the pressure drop in the superheater 2 is compared. The piston rod of the piston 20 extends beyond its coupling to the lever 57 into the range of motion of one end of a lever 23. Lever 23 is pivotally supported at a point 60 and the end thereof opposite the end engageable by the rod of piston 20 is connected to the spindle or actuating member 61 of the valve 24. The spindle 61 is supported for linear motion in guides 61′ between two springs 62 and 63.

Two lines 64 and 65 lead off from opposite sides of the diaphragm 25 in the bypass line 47. Of these the line 65 is directly connected to one end of the cylinder of a piston 66. Piston 66 is connected to the actuating member 67 of the valve 30 in bypass line 47′. The line 64 is indirectly connected to the cylinder of the piston 66 by way of a control slide 26, which can interrupt the transmission of the pressure in the line 64 in the manner to be described hereinafter. The control slide 26 is positioned to be engaged by one end of lever 57, beyond the coupling therewith of the piston 20. Slide 26 also bears against a spring 75. A piston 68 is also connected to the actuating member 67 of the valve 30 and has a somewhat larger cross-section than the piston 66. To the cylinder of pistons 68 are connected two lines 69 and 70 which lead to opposite sides of the diaphragm 29 in line 47′. The pistons

66 and 68 form a comparison means, which is denoted as a whole by reference character 27.

The system operates in the following manner. In normal operation, the steam generated in the evaporator 1 and in the superheater 2 passes through the live steam line 40 to the high-pressure turbine 3, is partially expanded therein, and then flows through the line 42 to the reheater 4. Here the steam is again superheated and is then taken through the line 43 to the low-pressure turbine 5, where it is further expanded. The expanded steam is finally condensed in the condenser 6, and the condensate is taken through the preheater 8, the feed tank 9 and preheater 11 to the evaporator 1 by means of the pumps 7 and 10. During normal operation, the pressure drop in the superheater 2 is such that the piston 20 is forced by that pressure drop to the left in the drawing, taking its piston rod clear of lever 23, and the valve 24 is closed under the action of the spring 62 which shifts the spindle 61 to the right. The valve 30 is also closed, because there is no pressure drop at the diaphragms 25 and 29, spindle 67 being also moved to the right.

If for some reason the flow in the superheater is reduced, for example because the valves 12 and 13 are closed, then the piston 20 moves to the right in the drawing as a result of the lower pressure drop in the superheater 2 and the extended end of its piston rod strikes against the two-armed lever 23, so that the spindle 61 is shifted to the left and valve 24 is opened, steam then flowing out of the live steam line 40 through the bypass line 47 to the reheater 4. This flow of steam produces a pressure drop at the diaphragm 25, and this pressure drop takes effect on the piston 66. Spindle 67 moves to the left and opens the valve 30, so that the steam passes from the intermediate superheater 4 through the bypass line 47' to the condenser 6. The pressure drop at the diaphragm 25 can take effect on the piston 66 because, on the movement of the piston 20 to the right, the extended end of the lever 57 also moves the control slide 26 to the right, establishing communication between line 64 and its extension 64' via the cylinder 26' in which slide 26 moves. In this way, a steam flow is thus maintained in the superheater 2 and in the reheater 4 so that these elements cannot burn out. Feedwater or condensate is drawn in through the Venturi tubes 33 and 49 and enters the bypass lines 47 and 47' respectively and cools the steam.

Instead of using the pressure drop in the entire superheater 2 for the operation of the valve 24, in another embodiment of the invention it is sufficient to take the pressure drop from at least one part of the superheater, as for example when the superheater is divided into a number of parts. The pistons 66 and 68 of the comparison means 27 are normally so proportioned with respect to one another that substantially the same amount of steam is taken off through the bypass line 47' downstream of the reheater 4 as is supplied through the bypass line 47 upstream of the reheater 4. In special cases, the quantities can also be made different from one another.

While the invention has been described herein in terms of a number of preferred embodiments, the invention is not limited to the details of construction thus illustrated and described, but is rather set forth in the appended claims.

I claim:

1. A steam power plant comprising an evaporator, a superheater, a steam consuming machine, conduit means to conduct steam from the evaporator through the superheater to said machine, a bypass line connected into said conduit means between the superheater and machine, a valve in said bypass line, means to develop a signal representative of the rate of steam flow at a location in said conduit means between the evaporator and the connection of the bypass line into said conduit means, and means responsive to said signal to open said valve upon decline in said rate of steam flow below a specified level.

2. A steam power plant comprising an evaporator, a superheater, a steam consuming machine, conduit means to conduct steam from the evaporator through the superheater to said machine, a bypass line connected into said conduit means between the superheater and machine, a valve in said bypass line, and means to open said valve in response to decline below a specified level in the steam pressure difference between two points located upstream and downstream of each other in the sense of steam flow between the evaporator and the connection of the bypass line into said conduit means.

3. A steam power plant comprising an evaporator, a superheater, a steam consuming machine, conduit means to conduct steam from the evaporator through the superheater to said machine, a bypass line connected into said conduit means between the superheater and machine, a valve in said bypass line, and means to open said valve in response to decline below a specified level in the steam pressure difference between two points in the superheater located upstream and downstream with respect to each other in the sense of steam flow through the superheater.

4. A steam power plant comprising an evaporator, a superheater, a steam consuming machine having first and second stages, a reheater, conduit means to connect the evaporator, superheater, first stage, reheater and second stage in series for steam flow therethrough, a first bypass line connected into said conduit means between the superheater and first stage, a second bypass line connected into said conduit means between the reheater and second stage, a separate valve in each of said bypass lines, means to generate a signal representative of the rate of steam flow through said superheater, and means responsive to said signal to control the opening of said valves.

5. A steam power plant comprising an evaporator, a superheater, a steam consuming machine having first and second stages, a reheater, conduit means to connect the evaporator, superheater, first stage, reheater and second stage in series for steam flow therethrough, a first bypass line connected into said conduit means between the superheater and first stage, a second bypass line connected into said conduit means between the reheater and second stage, a separate valve in each of said bypass lines, and means responsive to variations in the steam pressure difference between two points in said superheater upstream and downstream of each other in the sense of steam flow through said superheater to control the opening of said valves.

6. A steam power plant comprising an evaporator, a superheater, a steam consuming machine having first and second stages, a reheater, conduit means to connect the evaporator, superheater, first stage, reheater and second stage in series for steam flow therethrough, a first bypass line connected into said conduit means between the superheater and first stage, a second bypass line connected into said conduit means between the reheater and second stage, a separate valve in each of said bypass lines, means responsive to variations in the pressure difference between two points in said superheater upstream and downstream of each other in the sense of steam flow through said superheater to control the valve in said first bypass line, and means responsive to the rate of flow of steam through said first bypass line to control the valve in said second bypass line.

7. A steam power plant comprising an evaporator, a superheater, a steam consuming machine having first and second stages, a reheater, conduit means to connect the evaporator, superheater, first stage, reheater and second stage in series for steam flow therethrough, a first bypass line connected into said conduit means between the superheater and first stage, a second bypass line connected into said conduit means between the reheater and second stage, a separate valve in each of said bypass lines, means responsive to variations in the pressure difference between two points in said superheater upstream and downstream of each other in the sense of steam flow through said superheater to control the valve in said first bypass line

and means responsive to said pressure difference and to the rate of flow of steam through said first bypass line to control the valve in said second bypass line.

8. A steam power plant comprising an evaporator, a superheater, a steam consuming machine having first and second stages, a reheater, conduit means to connect the evaporator, superheater, first stage, reheater and second stage in series for steam flow therethrough, a first bypass line connected between the output of said superheater and the input to said reheater, a second bypass line connected between the input and output of said second stage, first and second valves in said first and second bypass lines respectively, means responsive to the pressure difference between two points in the superheater upstream and

downstream of each other in the sense of steam flow through said superheater to control said first valve, and means responsive to steam flow through said first bypass line and to said pressure difference to control said second valve.

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