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FORCED FLOW STEAM GENERATING PLANTS INCLUDING A REHEATER

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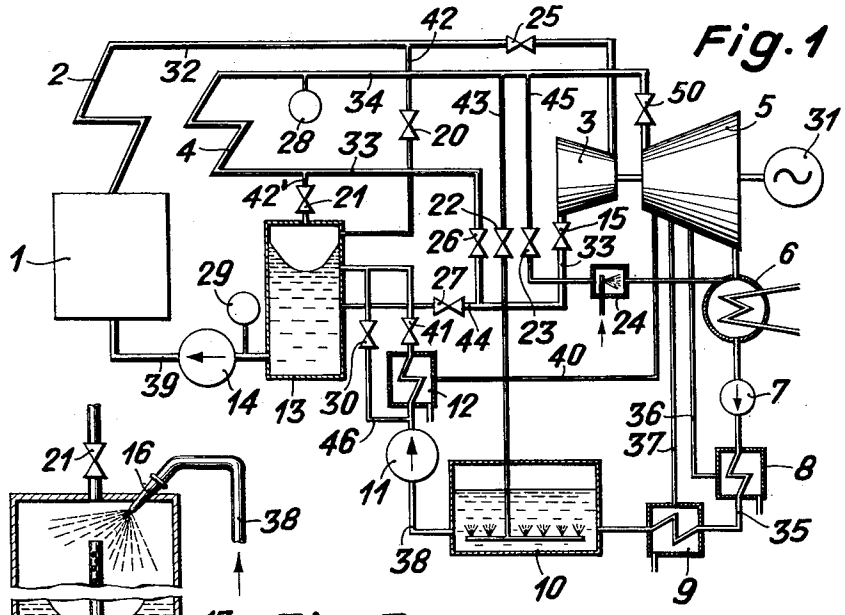

Fig. 1

Fig. 3

Fig. 2

Inventor:
Alfred Brunner.
By K. A. Mayr
Attorney.

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FORCED FLOW STEAM GENERATING PLANTS INCLUDING A REHEATER

Alfred Brunner, Winterthur, Switzerland, assignor to Sulzer Freres, S.A., Winterthur, Switzerland, a corporation of Switzerland

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The invention relates to steam generating and reheating plants including a forced flow steam generator, a reheater for reheating, for example, steam produced in the steam generator and expanded in a high pressure steam engine, and a water separator interposed in a by-pass pipe connecting the high pressure live steam pipe, which receives steam from the generator, and the pipe which conducts medium pressure steam to the reheater.

Forced flow steam generators have a very small water and steam accumulating capacity and cannot quickly follow variable loads.

It is an object of the invention to provide means for increasing the steam and water accumulating capacity of a forced flow steam generating plant in a safe and reliable manner by adapting the water separator to act as heat and feedwater accumulator. The separator is connected to the feedwater line, which supplies feedwater to the steam generator, for accumulating feedwater during periods of low load operation and for supplying additional feedwater during periods of great steam demand. A steam supply conduit is connected to the water separator for supplying controlled amounts of medium pressure steam to the separator for heating the feedwater stored in the separator. This conduit may be connected to the pipe which conducts medium pressure steam, for example steam partly expanded in a steam turbine, to the reheater, the connection being made upstream of the connection of the by-pass pipe, wherein the separator is interposed, to the medium pressure steam pipe. The part of the by-pass pipe connecting the steam space of the separator and the pipe conducting medium pressure steam to the reheater contains a flow control means for controlling the flow of steam from the separator into the reheater.

In a modified embodiment of the invention the conduit which supplies controlled amounts of medium pressure steam to the separator may be connected to a source of steam of a pressure which is higher than the highest pressure in the pipe supplying steam to the reheater. In this case the conduit may receive steam tapped from a stage of the steam engine where the pressure is relatively high and the steam directly conducted into the reheater may be taken from a stage of the steam engine where the pressure is relatively low.

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 diagrammatic illustration of a plant according to the invention.

FIG. 2 is a diagrammatic illustration of a modified plant according to the invention.

FIG. 3 is a part-sectional illustration of a heat accumulating water separator for use in connection with plants according to the invention.

Referring more particularly to FIG. 1 of the drawing, numeral 1 designates a forced flow steam generator including a superheater 2 which is connected by means

of a live steam pipe 32 to an admission valve 25 of the high pressure part 3 of a turbine driving an electric generator 31. The exhaust of the high pressure turbine part 3 is conducted through a medium pressure pipe 33 containing a valve 15 to a reheater 4. The reheated steam is conducted through a pipe 34 to a valve 50 controlling steam flow to a medium and low pressure part 5 of the turbine driving the generator 31.

The high pressure live steam pipe 32 is connected to the medium pressure pipe 33 by means of a by-pass pipe 42 in which a water separator 13 is interposed. According to the invention the separator 13 has considerable water and steam storage capacity and serves to supply steam during starting of the plant and also serves as a heat and feedwater accumulator. A by-pass valve 20 is interposed in the pipe 42 between the high pressure steam pipe 32 and the separator 13 and a flow control means 21 is interposed in the pipe 42' between the separator 13 and the pipe 33. A conduit 44 containing a valve 27 is connected to the pipe 33 downstream of the valve 15 and upstream of the connection of the pipe 42' with the pipe 33 and terminates in the water space of the separator 13. A throttle element 26 may be interposed in the pipe 33 downstream of the connection of the conduit 44 with the pipe 33 if the flow resistance of the pipe 33 between its connections with the conduit 44 and with the pipe 42' is too small to permit flow through the conduit 44. The throttling element 26 may be so designed as to also replace the valve 15.

The turbine part 5 exhausts into a condenser 6. The condensate is conducted from the condenser through a pipe 35 into a feedwater storage tank 10. A condensate pump 7 and two feedwater preheaters 8 and 9 are interposed in the pipe 35. The preheaters 8 and 9 are heated by steam tapped from the low pressure turbine part 5 through pipes 36 and 37. The storage tank 10 is connected through a pipe 38 to the separator 13. A low pressure feed pump 11 and a preheater 12 are interposed in the pipe 38, the preheater 12 being heated by medium pressure steam tapped from the turbine part 5 through a tapping pipe 40. A by-pass pipe 46 containing a valve 30 is provided to by-pass the preheater 12 and a valve 41 is interposed in the conduit 38 downstream of the preheater 12 for controlling the temperature of the water heated in the preheater 12. The water space of the separator 13 is connected through a pipe 39 containing a high pressure feed pump 14 to the steam generator 1.

The pipe 34 is connected by a by-pass pipe 43 containing a by-pass valve 22 to the feedwater reservoir 10 for conducting medium pressure steam into the reservoir 10 when starting the plant. For emergency purposes an additional by-pass pipe 45 is provided which interconnects the pipe 34 and the condenser 6 and contains a by-pass valve 23 and an injection cooler 24.

When starting the plant, the turbine admission valves 25 and 50 and the exhaust valve 15 are closed and the by-pass valves 20 and 22 or 23 as well as the flow control device 21 are open. Water is drawn by the high pressure feed pump 14 from the separator 13 and circulated through the steam generator 1, the superheater 2 and the bypass pipe 42 back into the separator 13. The water is gradually heated in the steam generator 1 and in the superheater 2. Steam developing in the separator 13 passes through the flow control means 21 into the reheater 4, cooling the latter. The steam leaving the reheater 4 either passes through the by-pass valve 22 into the feedwater reservoir 10 or through the by-pass valve 23 and the injection cooler 24 into the condenser 6.

When the plant is in normal operation the by-pass valves 20, 22 and 23 are closed and the turbine admis-

sion valves 25 and 50 as well as the exhaust valve 15 and the valve 27 are open. Most of the steam expanded in the high pressure part 3 of the turbine flows through the medium pressure pipe 33 into the reheater 4 and therefrom to the medium and low pressure part 5 of the turbine. The exhaust steam of the high pressure turbine part 3 which does not flow into the reheater 4 flows through the conduit 44 into the water space of the separator 13. When the valve 21 is closed the steam received through the conduit 44 in the separator is condensed, the condensate flowing as feedwater into the steam generator 1. If the valve 21 is somewhat opened, the portion of the medium pressure steam supplied to the separator 13 through the conduit 44 is cooled and flows as saturated steam through the valve 21 to the reheater 4. The temperature of the steam entering and also of the steam leaving the reheater 4 depends on the degree of opening of the valves 27 and 21. The temperature of the steam leaving the reheater 4 is measured by a temperature measuring device 28. By opening the valve 21 more saturated steam is drawn from the separator 13 whereby, due to the decreased temperature and increased amount of steam entering the reheater, the temperature of the steam leaving the reheater 4 is reduced. If opening of the valve 21 is not changed and more steam is admitted to the water space of the separator 13 through the valve 27, the amount of steam entering the reheater is reduced and the reheat temperature increases. In this case the water stored in the separator 13 absorbs more heat from the steam admitted through the conduit 44 and the temperature of the feedwater rises. This temperature is measured by a temperature measuring device 29 connected to the pipe 39 between the separator 13 and the high pressure feed pump 14. The amount of steam flowing through the valve 21 should not be greater than the amount of steam supplied to the separator 13 through the conduit 44. The rate of steam flow through the valve 21 is preferably smaller than the rate of steam flow through the conduit 44 because, otherwise, the increased amount of steam circulating in the medium and low pressure part of the plant causes a reduction of the thermodynamic overall efficiency of the plant.

A particular advantage of the new system is the accumulating effect of the separator 13 whereby sudden load changes can be quickly taken care of. At increased load the fire intensity in the steam generator is increased and, if necessary, also the rate of feedwater supply. Since it takes some time until increased steam production is obtained the openings of the valves 21, 30 and 41 are temporarily decreased so that more steam flows through the reheater and less or no feedwater flows through the preheater 12. Since the amount of water flowing through the preheater 12 is reduced, less steam is tapped from the medium and low pressure turbine part 5 through the pipe 40, leaving more steam for the low pressure stages of the turbine part 5. Because of reduction of the flow area or closing of the valves 30 and 41 the liquid level in the separator 13 drops. The liquid level is brought up to the previous elevation by opening the valve 41 when the steam generator 1 produces the amount of steam required to satisfy the new load. If the load is reduced the aforedescribed operations occur in the opposite direction.

The system shown in FIG. 1 is also useful if the heat supply to the reheater 4 changes, for example, if a different kind of fuel is used or if the heating surfaces of the reheater are fouled. In this case and if the reheater is located near the end of the flue, the valve 27 is opened and more steam is introduced through the conduit 44 into the separator 13 and condensed therein. Simultaneously, more feedwater is by-passed through the pipe 46 around the preheater 12 by opening the valve 30 so that less steam is tapped from the turbine through the pipe 40. The aforesaid adjustments or control steps are also useful during periods of very low steam demand.

In the modification of the system shown in FIG. 2 a separator 13 is interposed in the by-pass pipe 42 as in the system shown in FIG. 1. However, a conduit 44' which conducts partly expanded steam into the water space of the separator is not connected to the medium pressure pipe 33, but is connected to a stage of the turbine part 3 where the pressure is higher than the pressure in the pipe 33. A flow control element 27' is adjusted in response to the pressure of the steam in the pipe 32 downstream of the valve 25 and measured by a signal producing apparatus 47. The signals produced by the latter are transformed in a proportional, differential (PD) regulator 48. If the load on the turbine increases, causing dropping of the pressure downstream of the valve 25, the flow area of the valve 27' is at least temporarily reduced so that a smaller amount of partly expanded steam is supplied to the separator 13 and more steam remains in the turbine.

An essential difference between the system shown in FIG. 1 and that shown in FIG. 2 is the arrangement of the separator 13 in parallel to the feedwater circuit in the system according to FIG. 2, a pipe 51 containing a valve 52 being connected to the pipe 38 downstream of the preheater 12. The pipe 51 terminates in the pipe 39 upstream of the high pressure feed pump 13. The pipe 46 by-passing the heater 12 and the valve 41 terminates in the pipe 51 upstream of the valve 52. At increasing load, when as little steam as possible should be tapped from the turbine, the water supplied by the pump 11 is by-passed around the heater 12 and conducted into the separator 13 or by-passed therearound for obtaining desired pressure and temperature conditions in the separator 13.

The last described parallel connection of the feedwater supply conduit and of the separator 13 may also be used in the system shown in FIG. 1.

It is not absolutely necessary that the partly expanded steam is introduced into the water space of the separator 13, as is the case in the examples shown in FIGS. 1 and 2. The partly expanded steam may be introduced into the steam space of the separator if means are provided to make the surface available between steam and feedwater large enough to obtain heat transfer. An example of the aforesaid means is illustrated in FIG. 3. The conduit 44 extends through the bottom of the separator 13 upward substantially coaxial of the central vertical axis of the separator and into the steam space. The top of the conduit 44 is closed and a plurality of holes are provided in the upper portion of the conduit 44 which holes are so designed that the steam supplied through the conduit 44 passes into the separator at as little speed as possible. The holes may be shaped to obtain a defuser action, i.e., their diameter at the outside of the conduit 44 may be greater than at the inside of the conduit. A nozzle 16 extends through the top wall of the separator 13 and is connected to the pipe 38 for spraying the feedwater onto the top of the conduit 44 whereby a good transfer of the heat contained in the steam supplied through the conduit 44 to the feedwater introduced through the nozzle 16 is obtained.

I claim:

1. A steam plant comprising in combination:
- a forced flow steam generator,
- a live steam pipe receiving steam from said generator,
- a steam turbine including a high pressure part connected to said live steam pipe for receiving steam therefrom,
- a reheater,
- a medium pressure steam pipe connecting said high pressure part and said reheater for supplying medium pressure steam to said reheater,
- a water separator having a substantial steam and water space effecting a substantial heat storage capacity,
- a by-pass pipe interconnecting said live steam pipe and said water separator,
- a feedwater supply pipe connected to said steam gen-

erator for supplying feedwater thereto, said water separator being interposed in said feedwater supply pipe for accumulating feedwater,

a conduit connecting said high pressure part and said separator for supplying medium pressure steam thereto,

flow control means interposed in said last mentioned conduit for controlling the rate of flow of medium pressure steam to said separator,

a conduit means connecting the steam space of said separator and said medium pressure steam pipe, and

a flow control means interposed in said conduit means.

2. A steam plant as defined in claim 1, wherein said high pressure part of said turbine has a plurality of different pressure stages, said medium pressure steam pipe being connected to a lower pressure stage of said part of said turbine than said conduit.

3. A steam plant as defined in claim 1 wherein said conduit is connected to said medium pressure steam pipe upstream of the connection of said conduit means and said medium pressure steam pipe.

4. A steam plant as defined in claim 1, including a bypass pipe connected to said feedwater supply pipe and bypassing said water separator.

References Cited in the file of this patent

Germany (K1 14 h 4/01), 1,089,396, Sept. 22, 1960.
Germany (K1 14 h 4/01), 1,100,650, Mar. 2, 1961.