

[54] **METHOD OF REGULATING THE TEMPERATURE OF SUPERHEATED STEAM IN A STEAM GENERATOR**

[75] Inventor: **Johannes Brehler**, Hegnach, Germany

[73] Assignee: **Sulzer Brothers, Ltd.**, Winterthur, Switzerland

[22] Filed: **Jan. 12, 1972**

[21] Appl. No.: **217,301**

[30] **Foreign Application Priority Data**

Jan. 13, 1971 Germany..... P 21 01 563.4

[52] U.S. Cl..... **122/479 S, 122/487**

[51] Int. Cl..... **F22g 5/12**

[58] Field of Search..... 122/1 B, 406 G, 448 S, 122/479 S, 487

[56]

**References Cited**

**UNITED STATES PATENTS**

2,321,390	6/1943	Juzi.....	122/1
3,464,393	9/1969	Chambert.....	122/406
2,263,687	11/1941	Wunsch.....	122/479
3,064,630	11/1962	Protos.....	122/487
3,111,936	11/1963	Brunner.....	122/479

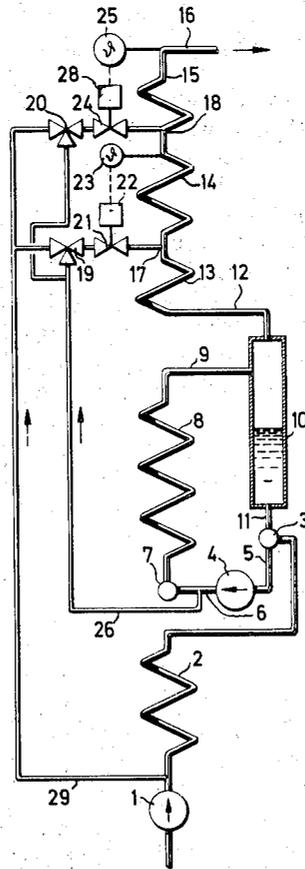
*Primary Examiner*—Kenneth W. Sprague  
*Attorney*—Hugh A. Chapin et al.

[57]

**ABSTRACT**

The water which is injected into the steam is obtained from the delivery side of the circulating pump. When the pump is inoperative, e.g. at high load, the water is obtained from a point upstream of the feed water pre-heater. Valves are also provided to regulate the amount of injected water in dependence on the steam temperature.

**6 Claims, 2 Drawing Figures**



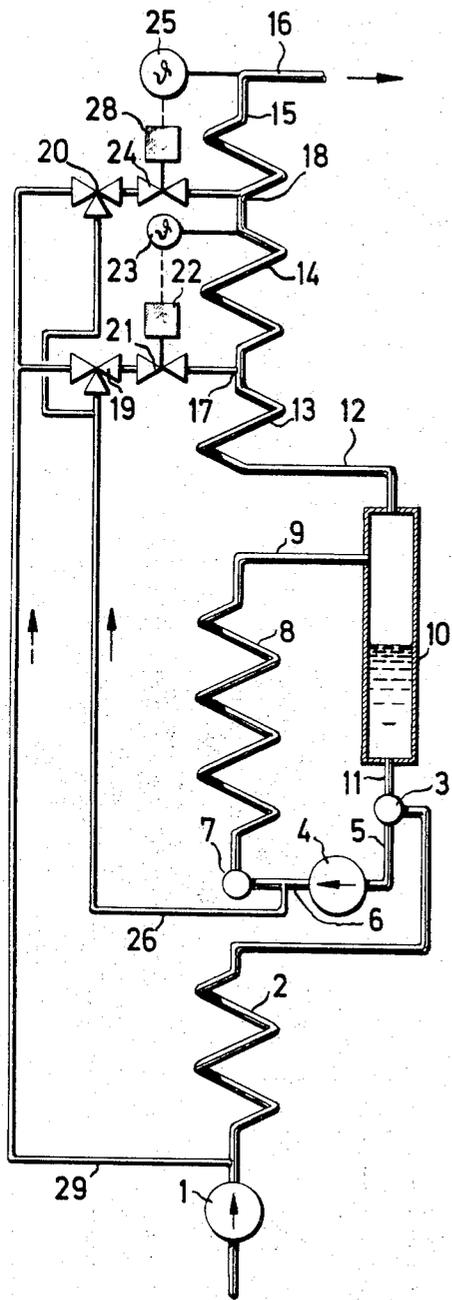


Fig. 1

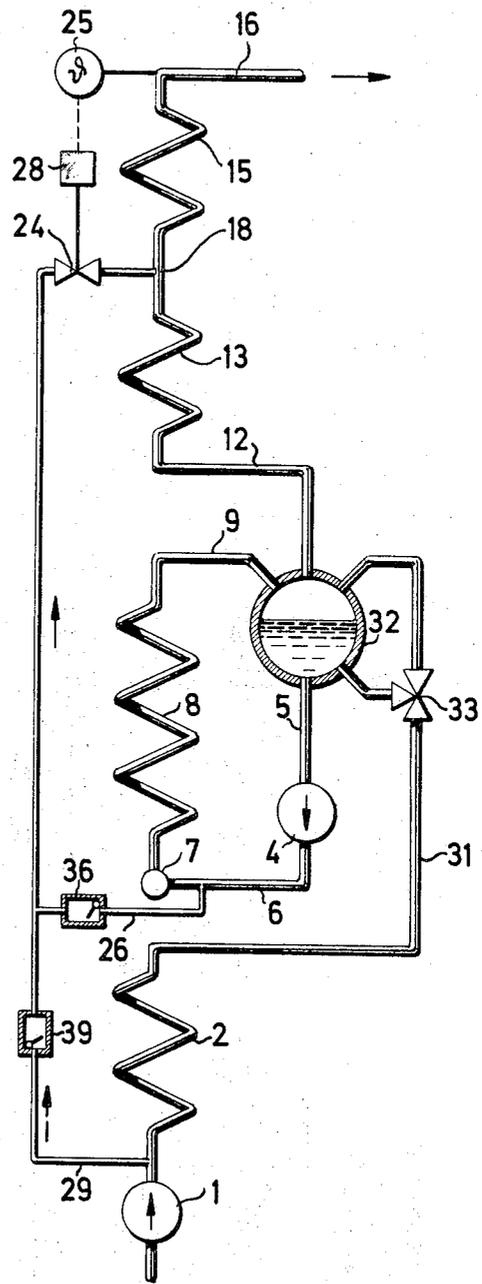


Fig. 2

## METHOD OF REGULATING THE TEMPERATURE OF SUPERHEATED STEAM IN A STEAM GENERATOR

This invention relates to a method of regulating the temperature of superheated steam in a steam generator.

Steam generators have been known to operate with a forced flow of working medium through an evaporator (as herein defined) and with a superimposed water circulation through the evaporator by means of at least one circulating pump. The pump has generally been supplied with feed water on the suction side. In the past, it has been proposed to regulate the temperature of the superheated steam produced in such steam generators by water injection at one or more positions along the high pressure superheater. Proposals have also been made to regulate the superheated steam temperature by means of water injection into the reheater. In these proposals, the water for injection has been obtained from a point upstream of the position at which the feed water enters the feed water preheater.

This method of obtaining injection water is the best for steam generators without superimposed water circulation through the evaporator. However, this method gives rise to certain difficulties in steam generators with supplementary water circulation through the evaporator. The reason for this is due to the fact that the reduction in pressure, as the working medium passes through the evaporator, is overcome by the circulating pump and not by the feed pump as in steam generators without superimposed water circulation. Accordingly, the pressure head across the evaporator is not available for the injection water. Therefore, only the pressure head across the water preheater and in the connecting ducts will be available as a pressure difference for injection purposes. As a result, in some circumstances, the pressure differential on the injection valve is no longer sufficient to feed the amounts of water required for regulating the temperature of the superheated steam. Moreover, there is the additional disadvantage that the injection water does not pass through the feed water preheater to cool the preheater so that the exhaust gas temperature and thus the exhaust of flue gas is increased. Finally, it is possible for evaporation to occur in the feed water preheater since the ratio between the flow of flue gas and the flow of feed water in the feed water preheater is detrimentally altered. If evaporation should occur, the circulating pump will be supplied with a water-steam mixture, resulting in cavitation and possible failure of the circulating pump.

Accordingly, it is an object of the invention to inject water into the superheated steam produced by a steam generator in an efficient manner.

It is another object of the invention to avoid evaporation in a feed water preheater during injection of water into the superheated steam produced by a steam generator.

It is another object of the invention to avoid cavitation in a circulating pump of a steam generator.

It is another object of the invention to pass the injection water of a steam generator through a feed water preheater to permit cooling of the preheater.

Briefly, the invention provides a method of regulating the temperature of superheated steam in a steam generator with forced flow of working medium through the evaporator (as herein defined) and with superimposed

water circulation through the evaporator by means of at least one circulating pump by injecting water obtained from the delivery side of the pump into the superheated steam while feed water is supplied to the suction side of the pump. With this method, the pressure head across the evaporator of the steam generator which may amount to seven atmospheres, will be available for water injection. Furthermore, except in the circumstances referred to below, the whole of the feed water supplied to the steam generator passes through the feed water preheater to cool the preheater.

In steam generators for very large power ratings and, in particular, for supercritical operating pressures it is sometimes not necessary to retain the circulating pump in operation under full-load conditions. The actual load value at which the circulating pump is taken into operation on a drop in load depends on the ratio of mass flow to heat flux density.

In steam generators in which there is superimposed working medium circulation in the evaporator, the evaporator pipes forming the combustion chamber walls are normally disposed in vertical configuration. Accordingly, the entire flow cross-section for the working medium is defined by the number of parallel-connected evaporator tubes and their individual cross-sections. If the generator capacity and tube cross-sections of the evaporator are in such a ratio to each other that a simple forced through-flow is sufficient within the upper load region for satisfactory cooling of the tubes, while the circulating pump has to be switched on within the lower load region, then it is possible within the upper load region that the loss in pressure between the evaporator inlet and the place of injection is not sufficient for feeding in of the required amounts of injection water. In this case, a further extraction of injection water from either the delivery duct of the circulating pump or from the feeding duct ahead of the feed water pre-heater takes place.

The preceding remarks have referred to evaporators but this term is not wholly appropriate for steam generators operating at supercritical pressures. Accordingly, the term "evaporator" as used herein is intended to include the equivalent components in supercritical steam generators, usually afforded by the tubes of the combustion chamber walls.

The invention may be carried into practice in various ways. However, two steam generators and the method by which the temperature of the superheated steam produced in each is regulated will now be described by way of example with reference to the accompanying drawings in which;

FIG. 1 illustrates a flow diagram of a forced through-flow steam generator with superimposed circulation according to the invention; and

FIG. 2 illustrates a flow diagram of a forced-circulation steam generator according to the invention.

Referring to FIG. 1, the steam generator includes a feed pump 1 which delivers feed water into a feed water preheater 2 and a mixer 3 which receives the feed water after flowing through the feed water preheater 2. The mixer 3 connects to a circulating pump 4 through a suction branch or duct 5 by which the feed water is drawn into the pump 4 and delivered through a delivery branch or duct 6 to an inlet header 7 of an evaporator 8. A discharge duct 9 connects the evaporator 8 to a water separator 10 so as to deliver the steam water mixture formed in the evaporator to the separa-

tor 10 for separation. A duct 11 connects the separator 10 to the mixer 3 to conduct the discharge water into the mixer 3 for mixing with the pre-heated feed water. A duct 12 connects the water separator 10 to a first stage 13 of a superheater to deliver the steam flow thereto, then to a second stage 14 and finally through a third stage 15 of the superheater and a live steam duct 16 to a steam turbine (not shown).

An injection water duct 26 extends from the delivery duct 6 on the delivery side of the circulating pump 4 to two injection positions 17 and 18 which are disposed between the superheater stages 13 and 14 and between the superheater stages 14 and 15, respectively. A second injection water duct 29 branches from the feed line between the feed pump 1 and the feed water preheater 2 and also extends to the injection positions 17 and 18. In addition, three-way valves 19, 20 are provided at the junctions between the two injection water ducts 26 and 29. An injection valve 21, adjusted by means of a controller 22 in dependence upon the steam temperature at the exit of the second superheater stage 14 is provided between the three-way valve 19 and the injection position 17. A temperature sensing element 23 which measures the steam temperature is connected by a signal line to the controller 22. There is a similar injection valve 24 between the three-way valve 20 and the injection position 18 which is adjusted by a controller 28 in dependence upon the steam temperature at the exit of the third superheater stage 15 as measured by a temperature sensing element 25.

When the circulating pump 4 is in operation, the three-way valves 19 and 20 are adjusted so that the injection water which flows towards the injection positions 17 and 18 is obtained through the injection duct 26 from the delivery branch 6. As the temperatures at the exits of the stages 14 and 15 rise, the amount of injection water is increased and vice versa. If the circulating pump 4 is inoperative, such as when the steam generator operates at high load, the three-way valves 19 and 20 are adjusted so that the injection positions 17 and 18 communicate with the second injection water duct 29 so that the injection water may then be obtained upstream of the feed water preheater 2. In this case also, increasing temperatures at the exits of the stages 14 and 15 increase the amount of injection water.

Referring to FIG. 2, wherein like reference numerals indicate like parts as above, a duct 31 connects the feed water preheater 2 to a boiler drum 32 to deliver a pre-heated water flow thereto. A three-way valve 33 is also provided in the duct 31 to permit adjustment of the flow of feed water so that the whole of the feed water can be directed either to the water chamber or to the steam chamber of the drum 32. The feed water flow may also be sub-divided into two part flows by utilizing the valve 33.

In operation, the water separated in the boiler drum 32 is drawn by the circulating pump 4 through the suction branch 5 and, in the same way as for the steam generator illustrated in FIG. 1, is supplied through the delivery branch 6 to the inlet headers 7. Two injection water ducts 26 and 29 are also provided in this case but non-return valves 36 and 39 are provided in place of three-way valves. The superheater in this example is sub-divided into only two stages 13 and 15 and only one injection position 18 which is between the two

stages. The amount of injection water supplied to the injection position 18 is adjusted by means of the injection valve 24. The valve 24 is controlled by a controller 28 in dependence upon the steam temperature which prevails at the exit of stage 15 as measured by a temperature sensing element 25. The temperature of the superheated steam is regulated in the same sense as described in relation to FIG. 1 for the injection position 18 but because of the presence of the non-return valves 36 and 39 injection water is automatically obtained through the second injection water duct 29 when the circulating pump 4 is shut down.

The steam generators may be provided with additional regulating means, such as, tilting burners and flue gas return ducts, operating independently of the system for regulating the temperature of superheated steam by water injection. Reheaters may also be provided. Furthermore, the number of superheater stages and injection positions can be varied. Also, two or more circulating pumps may be provided instead of a single circulating pump.

What is claimed is:

1. A method of regulating the temperature of superheated steam in a steam generator with forced flow of working medium through an evaporator from a feed pump and with superimposed water circulation through the evaporator by means of at least one circulating pump, said method comprising the steps of supplying the working medium to a suction side of said circulating pump and of injecting water obtained from the delivery side of the circulating pump into the superheated steam.

2. A method as set forth in claim 1 wherein the steam generator includes a feed water preheater up-stream of the evaporator and which further includes the step of injecting water obtained from upstream of the feed water preheater in place of water from the delivery side of the circulating pump when the pump is inoperative.

3. A steam generator comprising  
a feed water preheater;  
a feed pump for delivering feed water to said preheater;  
an evaporator downstream of said preheater;  
a circulating pump interconnected between said preheater and said evaporator, said pump having a suction duct for drawing with into said circulating pump and a delivery duct for expelling water to said evaporator;  
a superheater downstream of said evaporator; and  
means for injecting water into said superheater from said delivery duct.

4. A steam generator as set forth in claim 3 wherein said means includes a duct connected between said delivery duct and said superheater, and a valve in said duct for controlling the flow of water therethrough.

5. A steam generator as set forth in claim 4 which further comprises a temperature measuring means connected between said superheater and said valve for controlling said valve in response to a measured temperature of steam in said superheater.

6. A steam generator as set forth in claim 3 which further comprises a duct connected between said preheater and said feed pump and connected to said superheater to deliver feed water thereto, and a valve in said duct for controlling the flow of water therethrough.

\* \* \* \* \*