

Aug. 26, 1958

A. LIEBERHERR

2,848,983

VAPOR OR STEAM GENERATING PLANT WITH RESUPERHEATERS

Filed Dec. 20, 1954

Fig. 1.

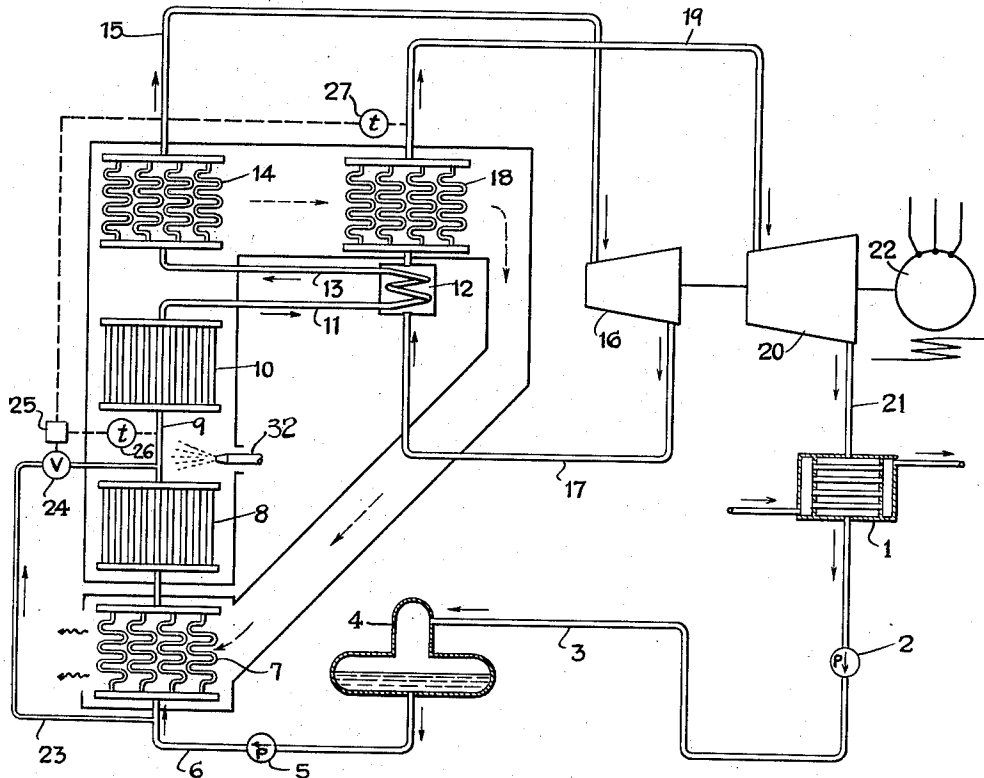


Fig. 2.

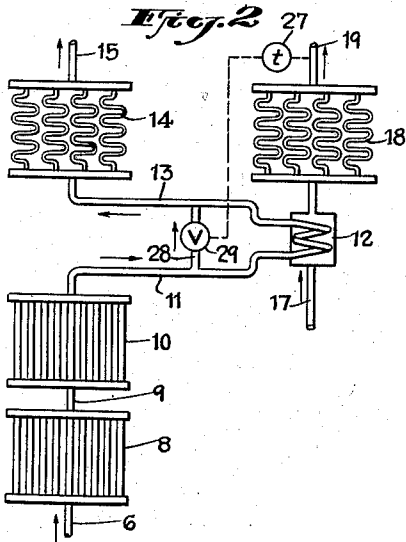
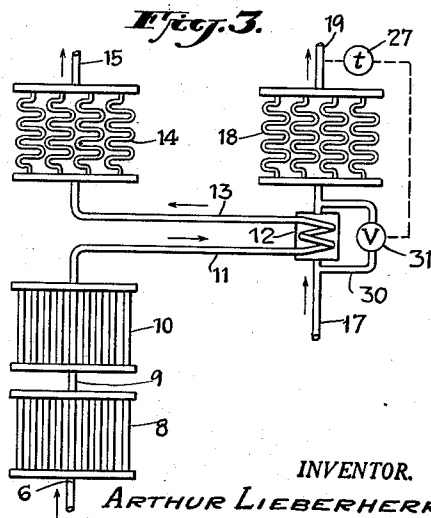


Fig. 3.



INVENTOR.

ARTHUR LIEBERHERR.

BY

K. B. May

ATTORNEY.

1

2,848,983

VAPOR OR STEAM GENERATING PLANT WITH RESUPERHEATERS

Arthur Lieberherr, Winterthur, Switzerland, assignor to Sulzer Freres, Societe Anonyme, Winterthur, Switzerland, a corporation of Switzerland

Application December 20, 1954, Serial No. 476,189

Claims priority, application Switzerland
December 23, 1953

4 Claims. (Cl. 122—479)

The present invention relates to a vapor generating power plant including resuperheating means interposed between the high pressure and the low pressure part of a turbine plant, the resuperheating means comprising a resuperheater heated by the combustion of fuel and a resuperheater heated by a medium which has been heated by the combustion of fuel, the second resuperheater being arranged upstream of the first-mentioned resuperheater. The indirectly heated second resuperheater is used for controlling the temperature of the resuperheated vapor.

The vapor power plant according to the invention includes a forced flow vapor generator which is provided with two superheaters arranged in series with respect to the vapor flow, the indirectly heated resuperheater mentioned in the paragraph next above being interposed between the two superheaters for receiving heating vapor from one superheater and discharging the cooled heating vapor into the other superheater. The arrangement according to the invention affords convenient regulation of the temperature of the resuperheated steam in modern steam power plants which are equipped with a forced flow steam generator and are operated at subcritical or supercritical pressure.

It has been proposed to arrange a steam heated regulating resuperheater upstream of a combustion gas heated resuperheater with respect to the flow of the steam to be resuperheated. In such plants, wet steam is taken from the upper drum of a natural circulation boiler and used for heating the regulating resuperheater. The wet steam condenses and the condensate flows by gravity from the regulating resuperheater back into the upper boiler drum. Such an arrangement cannot be used in modern steam power plants. The steam entering the regulating resuperheater has a temperature which is far above the condensation temperature of the wet steam, so that there is no heating but a cooling of the steam to be resuperheated, and there is no condensation of wet steam. Condensation is needed in the aforementioned conventional arrangement because otherwise a circulating pump must be provided to return the heating steam to the tube system of the steam generator.

The aforesaid difficulties are avoided, if the regulating resuperheater is interposed in the steam flow between two superheaters to receive heating steam from one superheater and to discharge it into the other superheater. The operating medium may be so much superheated in the first of the two superheaters, that its temperature is sufficiently high to heat the steam to be resuperheated. Since the entire amount of the steam produced in the steam generator is available as heating steam, a large amount of heat can be transferred to the steam to be resuperheated. Because the primary side of the regulating resuperheater is arranged in series with the superheaters of the steam generator, no circulating pump is required.

There are many possibilities for regulating the temperature of the steam to be resuperheated by means of

2

the regulating resuperheater. Of particular advantage is an arrangement in which water is injected into the tube system of the steam generator upstream of the regulating resuperheater for controlling the temperature of the heating steam. The water injection can be actuated automatically or by hand. A preferable arrangement includes a conduit through which heating steam by-passes the regulating resuperheater, and a regulating valve in this conduit. As a modification, a by-pass conduit may be provided, through which a portion of the steam to be resuperheated by-passes the regulating resuperheater, a regulating valve being provided in the by-pass conduit for the steam to be resuperheated.

The system according to the invention has many advantages. The heating steam for the regulating resuperheater can be taken from the tube system of the steam generator at a point at which the steam temperature affords construction of the regulating resuperheater of ferritic steel. The resuperheating means, which include a steam heated resuperheater and a combustion gas heated resuperheater, can be so constructed that the temperatures in the former afford construction of the steam heated resuperheater of more or less highly alloyed ferritic steel, and only the combustion gas resuperheater need be made of considerably more expensive heat resisting steel, for example, austenitic steel. In this case, the heating steam would be taken from a point of the steam generator tube system at which the steam temperature is not more than 550°, depending on the degree of alloying of the ferritic steel. The resuperheater can be further simplified by constructing the steam heated superheater of low alloyed steel. Low alloyed steel contains not more than 0.5% molybdenum and small traces of chromium, and need only be heated for stress-relieving anneal at circa 650°–700° C., but not for normalizing at higher temperatures. Though the temperature of the heating steam must be below 500° C., if low alloyed ferritic steel is used for constructing the indirectly heated resuperheater, the required high resuperheat temperature can be obtained without difficulty by means of the combustion gas heated resuperheater which need not be very large even if it is arranged in the part of the steam generator which is shielded from radiant heat. The combustion gas heated resuperheater may be placed, for example, in the boiler flue, i. e. in a zone in which the temperature of the combustion gases is relatively low. In this manner, the directly gas heated resuperheater is well protected, without special cooling arrangements, also during starting of the generator and at low loads. No provisions are needed for protecting the gas heated resuperheaters as they are required in conventional arrangements.

The invention is not limited to plants having only one resuperheating means. If the plant has two directly heated resuperheaters, a steam heated regulating resuperheater may be arranged upstream of at least one of the directly heated resuperheaters. The second directly heated resuperheater may be controlled, for example, by a swinging burner, or may also be controlled by means of an indirectly heated regulating resuperheater arranged upstream of the second gas heated resuperheater.

In the present specification and in the claims, the words "vapor" and "steam" are used for indicating the gaseous phase of the operating medium. The invention is applicable to plants using steam from water as well as vapor from liquids other than water.

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 embodi-

ments thereof when read in conjunction with the accompanying drawing, in which

Fig. 1 is a diagram of a plant according to the invention;

Fig. 2 diagrammatically shows a modified part of the plant according to Fig. 1;

Fig. 3 diagrammatically illustrates a further modification of a part of the plant shown in Fig. 1.

The same numerals designate the same parts in all figures.

Referring more particularly to the drawing, the operating medium is drawn from a condenser 1 by means of a condensate pump 2 and is conducted through a conduit 3 into a feed water reservoir 4. A feed pump 5 pumps water from the reservoir 4 and raises the pressure of the water to the highest pressure of the plant. The feed water is conducted through a conduit 6 into a first heater 7 which is heated by combustion gas produced by burning fuel in a device 32 and is generally known as an economizer. The preheated water enters a second heater 8 which is adjacent to the fuel burning means 32 and exposed to radiant heat and in which the water is converted into primary steam, which is conducted through a pipe 9 into a third heater 10 which is also heated by the products of combustion produced by the fuel burning means 32 and which serves as primary or first superheater. At least a portion of the heater 10 is exposed to radiant heat produced by the fuel burning means. The steam superheated in the first, relatively small superheater 10 is conducted through a conduit 11 into the primary side of a heat exchanger serving as an indirectly heated regulating heat exchanger 12. The heating steam leaves the heat exchanger 12 through a conduit 13 and is once more superheated by products of combustion in a second superheater 14, which supplies primary steam through a conduit 15 to the high pressure part 16 of a turbine plant. The secondary steam exhausting from the turbine 16 is conducted through a conduit 17 into the secondary side of the indirectly heated regulating resuperheater or heat exchanger 12 from which the resuperheated steam is conducted into a combustion gas heated resuperheater 18. The steam, which now has the desired resuperheat temperature, is conducted through a conduit 19 to the low pressure stage 20 of the turbine plant. The steam exhausting from the turbine plant is conducted through a conduit 21 into the condenser 1. The high pressure part 16 and the low pressure part 20 of the turbine plant have a common shaft driving an electric generator 22.

There are several possibilities for regulating the heat exchanger 12. It is of particular advantage to divert some water from the feed line 6 through a conduit 23 and to inject the diverted water into the pipe 9 downstream of the heater or evaporator 8, the amount of injected water being controlled by a valve 24. The latter is actuated by a conventional device 25. This device is actuated by a thermostat 26 which responds to the temperature of the medium flowing through the pipe 9 after water has been injected therein. The device 25 also responds to a thermostat 27 which is actuated by the temperature of the resuperheated steam downstream of the directly heated resuperheater 18.

If, for example, the temperature of the steam resuperheated in the resuperheater 18 drops, the thermostat 27 actuates the device 25 and thereby the valve 24 in such manner that less water is injected into the conduit 9. Consequently, the operating medium is more heated in the superheater 10 and can transmit more heat to the steam to be resuperheated and increase its temperature. The valve 24 is opened if the temperature acting on the thermostat 27 increases. The thermostat 26 is primarily for the purpose of stabilizing the water injection control. Whereas the thermostat 27 indicates the effect of a change of the amount of injected water

and actuates the device 25 only after a certain lapse of time, the thermostat 26 responds immediately to the effect of a change of the amount of injected water and will delay or limit the actuation of the valve 24, thus preventing overregulation.

Since the indirectly heated resuperheater 12 is preferably made of ferritic steel, particularly of low-alloyed ferritic steel, and is of welded construction, the heating surfaces of the superheaters 10 and 14 will be so chosen that the temperature of the steam leaving the superheater 10 is below, for example, 500° C. at normal load conditions.

Fig. 2 shows a modified arrangement for controlling the regulating resuperheater 12. A by-pass conduit 28 connects the conduits 11 and 13 which are connected with the primary side of the regulating resuperheater 12, a valve 29 being provided in the by-pass conduit 28, which valve is controlled according to the temperature measured by the thermostat 27. If the temperature of the resuperheated steam increases, the valve 29 is opened, so that a greater portion of the high pressure heating steam by-passes the resuperheater 12, reducing the amount of heating steam flowing through the resuperheater and consequently reducing the temperature of the resuperheated steam. The valve 29 is closed if the temperature of the resuperheated steam decreases.

A third modification of the control of the regulating resuperheater 12 is illustrated in Fig. 3. The steam to be resuperheated can be by-passed through a conduit 30 around the secondary part of the resuperheater 12. A valve 31 arranged in the by-pass conduit 30 is controlled according to the temperature measured by the thermostat 27. The valve 31 is opened if the temperature of the resuperheated steam increases, and a portion of the steam to be resuperheated flows into the gas heated resuperheater 18 without prior heating in the regulating resuperheater 12, so that the temperature of the total amount of steam at the outlet of the resuperheater 18 is reduced. The valve 31 is closed when the temperature of the resuperheated steam drops.

The plants illustrated in the drawing may be modified in various ways without departing from the scope of the present invention. The turbine plant may consist of more than two parts, and consequently more than one resuperheater may be provided. The additional resuperheaters, too, may be controlled by the provision of a regulating resuperheater combined according to the invention with a gas heated superheater. The invention is not limited to plants having a forced flow steam generator, but can be applied to plants having other types of conventional steam boilers.

What is claimed is:

1. In a vapor generating plant operating under the reheat cycle and under variable load conditions, a forced flow vapor generator comprising fuel burning means generating radiant heat and combustion gases, a first relatively small superheater exposed to radiant heat from said fuel burning means and a second superheater exposed to the combustion gases for superheating primary vapor, a resuperheater exposed to said combustion gases for resuperheating secondary vapor, a heat exchanger for indirectly exchanging heat between the primary vapor and the secondary vapor, said heat exchanger including a conduit interposed between said first and second superheater for conducting primary vapor as a heating medium from said first superheater through said heat exchanger to said second superheater, said heat exchanger including a compartment accommodating said conduit and having an inlet for receiving secondary vapor which is to be resuperheated and having an outlet connected with said resuperheater for conducting partially resuperheated secondary vapor from said compartment into said resuperheater, an inlet pipe connected with said first superheater, injecting means connected with said inlet pipe for injecting liquid into the primary vapor entering

5

said first superheater for lowering the temperature of the superheated primary vapor entering said heat exchanger for controlling the heat exchanged in said heat exchanger between the primary vapor and the secondary vapor and for simultaneously protecting said superheater against overheating by the radiant heat.

2. In a vapor generating plant according to claim 1 temperature responsive means connected with said inlet pipe between the connection of said injecting means with said inlet pipe and said first superheater, said temperature responsive means being connected with said injecting means for increasing the amount of liquid injected into said inlet pipe when the temperature of the primary vapor entering said first superheater exceeds a predetermined value.

3. In a vapor generating plant according to claim 1 temperature responsive means connected with the outlet of said resuperheater and connected with said injecting means for decreasing the amount of liquid injected into said inlet pipe when the temperature of the secondary vapor leaving said resuperheater falls below a predetermined value.

4. In a vapor generating plant operating under the reheat cycle and under variable load conditions, a forced flow vapor generator comprising fuel burning means generating products of combustion, a first and second superheater exposed to said products for superheating primary vapor, a resuperheater exposed to said products for resuperheating secondary vapor, a heat exchanger for indirectly exchanging heat between the primary vapor and the secondary vapor, said heat exchanger including a conduit interposed between said first and second superheater for conducting primary vapor as a heating medium from said first superheater through said heat exchanger to said second superheater, said heat exchanger

6

including a compartment accommodating said conduit and having an inlet for receiving secondary vapor which is to be resuperheated and having an outlet connected with said resuperheater for conducting partially resuperheated secondary vapor from said compartment into said resuperheater, an inlet pipe connected with said first superheater, injecting means connected with said inlet pipe for injecting liquid into the primary vapor entering said first superheater for lowering the temperature of the superheated primary vapor entering said heat exchanger for controlling the heat exchanged in said heat exchanger between the primary vapor and the secondary vapor, first temperature responsive means connected with the outlet of said resuperheater and connected with said injecting means for decreasing the amount of liquid injected into said inlet pipe when the temperature of the secondary vapor leaving said resuperheater falls below a predetermined value, and second temperature responsive means connected with said inlet pipe downstream of the connection of said injecting means with said inlet pipe and connected with said injecting means for increasing the amount of liquid injected into said inlet pipe when the temperature of the primary vapor entering said first superheater exceeds a predetermined value.

References Cited in the file of this patent

UNITED STATES PATENTS

1,931,948	Armacost	Oct. 24, 1933
2,579,027	Walter et al.	Dec. 18, 1951
2,602,433	Kuppenheimer	July 8, 1952
2,649,079	Van Brunt	Aug. 18, 1953
2,685,280	Blaskowski	Aug. 3, 1954

FOREIGN PATENTS

581,458	Great Britain	Oct. 14, 1946
---------	---------------	---------------