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MULTISTAGE STEAM GENERATOR

Filed May 22, 1930

Fig. 1

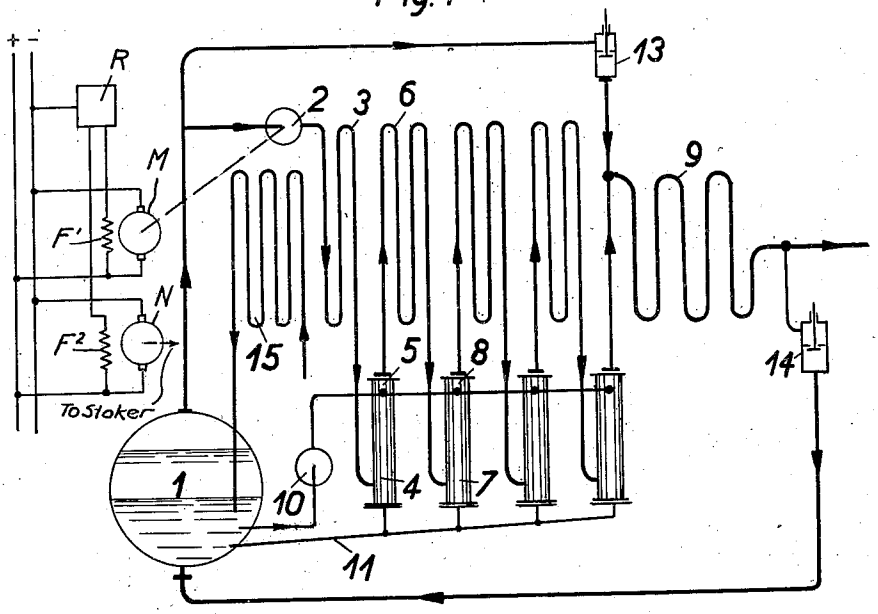
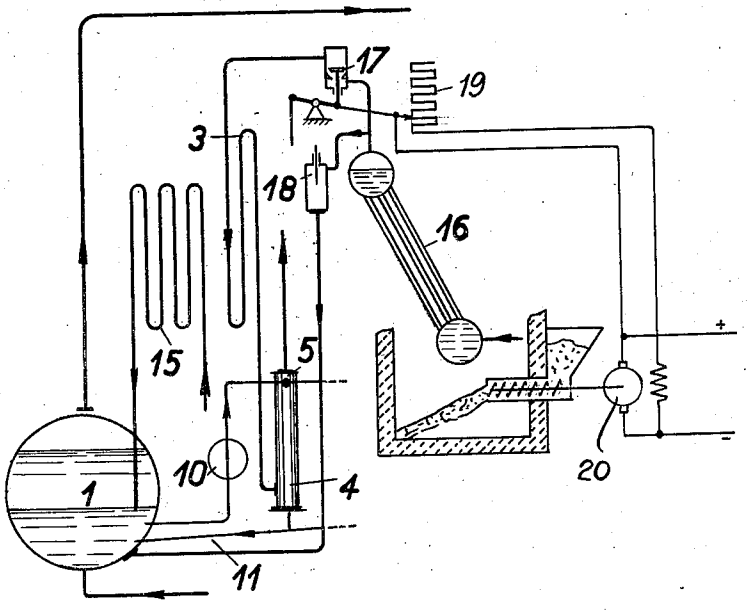


Fig. 2



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MULTISTAGE STEAM GENERATOR

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7 Claims. (Cl. 122—31)

This application is a continuation in part of my application, Serial No. 268,493, filed April 9, 1928.

This invention relates to steam generators, and has particular relation to multi-stage injection steam generators in which the steam that is to be delivered by the generator is produced from a small quantity of excitation steam by superheating it, and injecting the superheated excitation steam into water to convert the water into steam, and subsequently again superheating the so generated steam and again injecting it into water to produce a still larger quantity of steam, repeating the process in further stages until the required amount of steam is generated.

Among the objects of the inventon is to provide an improved steam generator of the foregoing character in which the supply of the exciting steam to the superheaters is regulated in response to the supply of heat to the superheaters so as to vary the amount of exciter steam supplied to the heaters in accordance with the variations of the amount of heat supplied to the superheaters.

The objects of the invention will be best understood from the following description of exemplifications thereof, reference being had to the accompanying drawing, in which

Figs. 1 and 2 are diagrammatic views illustrating two embodiments of the invention.

If, in injection-type steam generators, provision is made for supplying a sufficient quantity of exciting steam and for the circulation of sufficient steam through the superheater tubes, such steam generator will by itself take care of variations in the load just like ordinary water tube boilers, regulation of the firing being necessary only if the variations of the load are large and of long duration.

Because of the special characteristics of multistage injection steam generators, special advantages accrue if the firing in such steam generators is regulated, and the regulation is also extended to the generation of the steam. In multi-stage injection steam generators, the total quantity of steam generated G is given by the formula:—

$$G=a(1+b)^n$$

where G is the amount of steam generated; a, the amount of exciter steam supplied to the first vaporizer stage; b, the average amount in kilograms of fresh steam produced in each stage per kilogram of heating steam; and n, the number of stages. The total amount of steam generated may thus be regulated by varying the amount of exciter steam a. Since, however, in multi-stage injection steam generators, the heating tubes are only traversed by superheated steam and sufficiently large amounts of steam must pass through these tubes to carry away the heat given off by the combustion gases to the tube walls, the amount of this flowing steam, and with it the amount of exciting steam, can only be decreased or increased to the extent that the firing decreases or increases.

In accordance with the invention, the amount of exciting steam is regulated in response to the firing action. With such arrangement the exciting steam may be produced in any one of different ways. For instance, the exciting steam may be drawn by means of a heat pump from the steam space of a reservoir and pressed into the superheater of the injection vaporizer, or the exciting steam may be generated in a separate boiler and the amount of the exciting steam used controlled by a valve in the connection between the exciting steam generator and the first superheater.

The steam generator embodying one form of the invention, as shown in Fig. 1, comprises a reservoir 1 holding preheated water and steam. Steam is drawn from this reservoir by a heat pump 2 and pressed into the superheater pipe 3 of the first injection stage, the superheated steam being injected into a vaporizing vessel 4. The superheated steam flowing into the vaporizing vessel 4 evaporates finely divided water injected into the vessel at the water inlet 5 and converts the water into steam. The exciting steam and the fresh steam so generated in the first vaporizing vessel then flow into the superheater pipe 6 of the second stage, and after being superheated, enter into the vaporizing vessel 7 of the second stage, where the superheated steam again converts water injected at the water inlet 8 of the second vaporizing vessel. This process is repeated in each of the four vaporizer stages, as shown in Fig. 1, until the required amount of steam has been generated. The steam from the steam outlet of the last vaporizer stage then flows in the direction indicated by the arrows into a main superheater 9 from which the superheated steam is delivered to consuming apparatus, such as turbines.

Water for injecting into the individual vaporizing vessels is drawn from the water space of the reservoir 1 by means of a water pump 10 which imparts to the water the required injection pressure. Excess water that is not evapo-

rated flows back to the water space of reservoir 1 through pipe 11.

A non-return valve 14 leading from the outlet end of the superheater 9 to the water space of the reservoir 1 allows excess steam to return to container 1 and enables circulation of steam in the superheater tubes when the steam consumption is low. If the steam demand exceeds the supply of steam from the vaporizer stages, non-return valve 13 allows steam from the reservoir to enter into the superheater 9 and there supplement the steam coming from the vaporizer stages. Fresh water may be supplied to the reservoir 1 through a water preheater 15, as indicated.

In accordance with the invention, the amount of exciting steam fed to the vaporizer stages from the reservoir 1 is made dependent upon the firing of the fuel which supplies heat to the superheater tubes. The regulation of the exciting steam supply may be affected by the same means that are used to regulate the firing. With chain grate or stoker firing, for example, the device employed for controlling the speed of the grate or the speed of the screw drivers, may also control the speed of the heat pump 2 which supplies the exciting steam. This is indicated in Fig. 1 by the arrangement of the motor M for driving the heater pump 2 and motor N for driving the fuel feed device, such as the chain grates or screw drivers. Both motors are shown supplied from an electric supply line and have fields F1 and F2 for controlling the motor speeds that are regulated by a common regulator R in accordance with the operating condition of the plant. In pulverized fuel furnaces, the regulating means for the pump 2 may be actuated by the pulverized fuel admission apparatus in a similar manner. In cases where fuel admission is controlled by hand, the regulation of the amount of exciting steam admitted to the generators may be controlled in accordance with the fuel regulation by hand adjustment.

In the embodiment of the invention shown in Fig. 2, the exciting steam for the injection vaporizers is supplied by a separate exciting steam generator 16 made in the form of a small boiler. The exciting steam boiler 16 is designed to deliver a constant amount of steam, somewhat larger than the maximum amount required by the first superheater 3 of the several superheater stages, arranged and operating like the several superheater stages as shown in Fig. 1. The water is supplied to the vaporizing vessels of the superheater stages from the reservoir 1 by means of a water pump 10, likewise as shown in Fig. 1, the water to the reservoir being similarly delivered through a preheater 15.

The pressure in boiler 16 is maintained somewhat higher than the steam pressure required before the first superheater 3. The amount of exciting steam delivered from the exciting steam generator 16 to the first superheater 3 of the vaporizer stages is shown controlled by means of a valve 17. Like in the arrangement described in connection with Fig. 1, this valve is regulated in accordance with the firing plant. This is indicated diagrammatically by the arrangement whereby the valve 17 is actuated in interdependence upon, and in accordance with, the operation of the field regulator R of the fuel feed motor M of the plant. Other regulating arrangements known in the art may be used for regulating the admission of exciting steam from the separate exciter to the vaporizer stages. Excess of steam produced in the exciting steam generator 16 not used up by the vaporizer stages is passed by the automatic relief valve 18 into the water space of the reservoir 1 where it is condensed. The relief valve 18 is loaded either by a spring or a weight and allows steam to pass when the pressure exceeds an upper limiting, for which it is set. Since the multi-stage injection steam generators have a large number of stages (about 6 to 10), only very small exciting steam quantities are required (about 3 to 10 per cent of the total generated). Accordingly, the amount of excess steam passing to the reservoir 1 is very small and is easily taken up by the water within the reservoir.

By regulating the amount of supplied exciting steam in accordance with the firing or the heat supplied to the heater tubes, it is possible to maintain a practically constant super-heating temperature of the heating steam and of the heating tubes, since b, the amount of new steam raised in each stage per kilogram of heating steam, remains constant if the exciting steam amount a varies in proportion to the amount G of total generated steam.

The invention is not limited to the particular details of construction shown and described above, since many modifications and variations thereof will suggest themselves to those skilled in the art. It is accordingly desired that the appended claims be given a broad construction commensurate with the scope of the invention.

I claim as my invention:—

1. In a steam generator, a vaporizer comprising a plurality of serially arranged vaporizer stages, each stage comprising an evaporating vessel having a water inlet and a steam outlet, and arranged to evaporate water therein upon injection of superheated steam and deliver the generated steam at the steam outlet, means for supplying water to said evaporating vessel, superheater tubes connected to the vessel to superheat received steam and inject the superheated steam into said vessel converting water therein into steam, a source of exciting steam under pressure connected to the superheater tubes of the first vaporizer stage for supplying exciting steam thereto, the superheater tubes of each following vaporizer stage being connected to the steam outlet of the vaporizer vessel of the preceding stage and the generated steam being delivered at the last vaporizer stage, heating means for supplying heat to said superheater tubes, and means for regulating the supply of heat to said superheater tubes and the supply of exciting steam to said superheater tubes in correlated manner to increase and decrease the supply of exciting steam with increase and decrease, respectively, of heat supplied to the superheater.

2. In a steam generator, a vaporizer comprising an evaporating vessel having a water inlet and a steam outlet, and arranged to evaporate water therein upon injection of superheated steam and deliver the generated steam at the steam outlet, a reservoir for holding preheated water and steam, a connection between said reservoir and said evaporating vessel for supplying to said vessel water to be evaporated, a superheater connected to said evaporating vessel to superheat received steam and deliver it superheated to said evaporating vessel for converting water therein into steam, a pump connected between the steam space in said reservoir and said superheater for

supplying exciting steam under pressure to said superheater, regulated heating means for supplying a regulated amount of heat to said superheater, and means for correlating the operation of said pump to the regulation of said heat supply to vary the supply of exciting steam in accordance with variation of the heat supply.

3. In a steam generator, a vaporizer comprising a plurality of serially arranged vaporizer stages, each stage comprising an evaporating vessel having a water inlet and a steam outlet, and arranged to evaporate water therein upon injection of superheated steam and deliver the generated steam at the steam outlet, means for supplying water to said evaporating vessel, superheater tubes connected to the vessel to superheat received steam and inject the superheated steam into said vessel converting water therein into steam, a pump for supplying exciting steam under pressure to the superheater tubes of the first vaporizer stage, the superheater tubes of each following vaporizer stage being connected to the steam outlet of the vaporizer vessel of the preceding stage and the generated steam being delivered at the last vaporizer stage, regulated heating means for supplying a regulated amount of heat to said superheater tubes, and means for correlating the operation of said pump to the regulation of said heat supply to vary the supply of exciting steam in accordance with variation of the heat supply.

4. In a steam generator, a vaporizer comprising a plurality of serially arranged vaporizer stages, each stage comprising an evaporating vessel having a water inlet and a steam outlet, and arranged to evaporate water therein upon injection of superheated steam and deliver the generated steam at the steam outlet, superheater tubes connected to the vessel to superheat received steam and inject the superheated steam into said vessel converting water therein into steam, a reservoir for holding preheated water and steam, a connection between said reservoir and said evaporating vessels for supplying to said vessels water to be evaporated, a pump connected between the steam space of said reservoir and the superheater tubes of the first vaporizer stage for supplying thereto exciting steam under pressure, the superheater tubes of each following vaporizer stage being connected to the steam outlet of the vaporizer vessel of the preceding stage and the generated steam being delivered at the last vaporizer stage, regulated heating means for supplying a regulated amount of heat to said superheater tubes, and means for correlating the operation of said pump to the regulation of said heat supply to vary the supply of exciting steam in accordance with variation of the heat supply.

5. In a steam generator, a vaporizer comprising an evaporating vessel having a water inlet and a steam outlet, and arranged to evaporate water therein upon injection of superheated steam and deliver the generated steam at the steam outlet, a reservoir for holding preheated water and steam, a connection between said reservoir and said evaporating vessel for supplying to said vessel water to be evaporated, a superheater connected to said evaporating vessel to superheat received steam and deliver it superheated to said evaporating vessel for converting water therein into steam, an exciting steam generator connected to said superheater for producing exciting steam under pressure sufficient to produce flow of steam through the superheater into the evaporating vessels, regulated heating means for supplying a regulated amount of heat to said superheater tubes, means for regulating the supply of steam from said exciter generator to said vaporizer to vary the supply of exciting steam in correlation to variation of heat supplied to the superheater, and a valved connection between said exciter generator and the water space of said reservoir for conveying excess steam from said exciting generator to said reservoir.

6. In a steam generator, a vaporizer comprising a plurality of serially arranged vaporizer stages, each stage comprising an evaporating vessel having a water inlet and a steam outlet to evaporate water therein upon injection of superheated steam and deliver the generated steam at the steam outlet, and superheater tubes connected to the vessel to superheat received steam and inject the superheated steam into said vessel converting water therein into steam, a reservoir for holding preheated water and steam, a connection between said reservoir and said evaporating vessels for supplying to said vessels water to be evaporated, an exciting steam generator connected to the superheater tubes of the first vaporizer stage for producing exciting steam under pressure sufficient to produce flow of steam through the successive vaporizer stages, the superheater tubes of each following vaporizer stage being connected to the steam outlet of the vaporizer vessel of the preceding stage and the generated steam being delivered at the last vaporizer stage, regulated heating means for supplying a regulated amount of heat to said superheater tubes, means for regulating the supply of steam from said exciter generator to said vaporizer in correlation to the regulation of the supply of heat to said superheater to vary the supply of exciting steam in response to variation of heat supplied to the superheater, and a valved connection between said exciter generator and the water space of said reservoir for conveying excess steam from said exciting generator to said reservoir.

7. The process of generating steam by initially superheating exciting steam and admixing preheated water to the initially superheated steam to generate an increased amount of steam in an initial stage, applying said increased amount of steam in a plurality of additional successive stages of superheating the received steam and admixing water thereto to successively increase the amount of generated steam to a multiple of said exciting steam, and regulating the steam generation by varying the supply of exciting steam in correlated manner with the variation of the supply of heat to said superheating stages.

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