

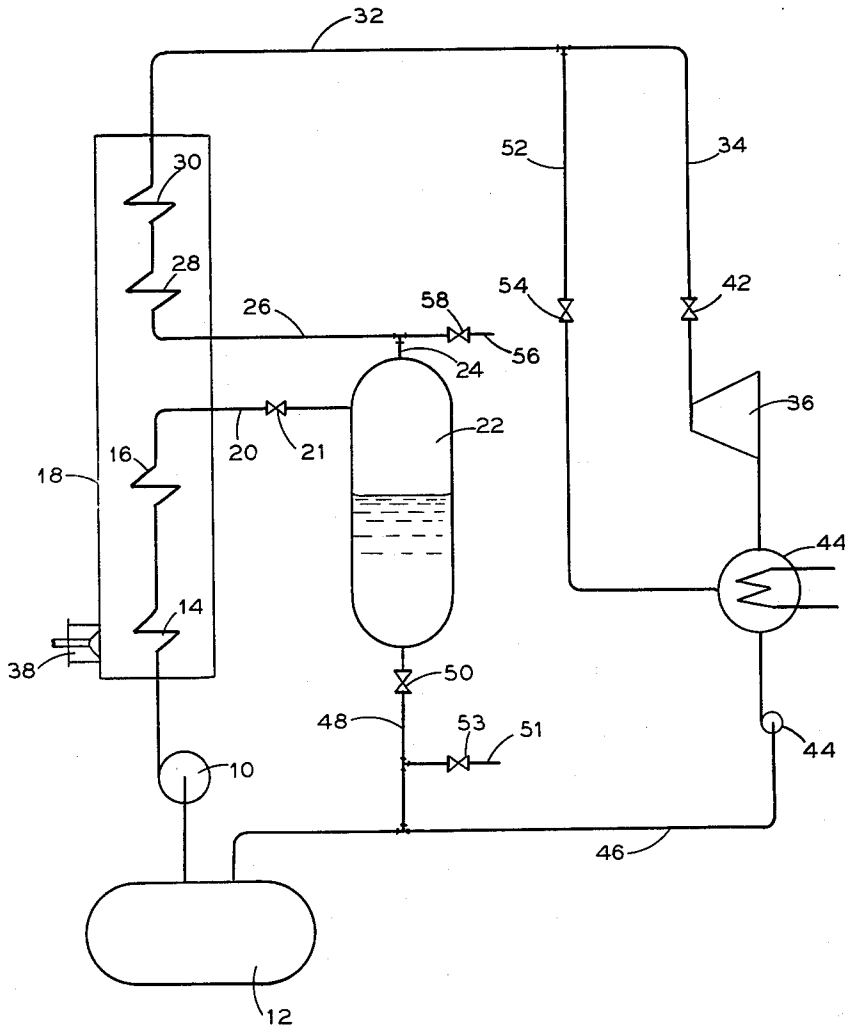
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START-UP SYSTEM FOR FORCED FLOW VAPOR GENERATOR

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3,259,111 START-UP SYSTEM FOR FORCED FLOW VAPOR GENERATOR

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This invention relates in general to the construction and operation of a power plant of the type having a forced flow vapor generator and more particularly to a system for starting up a forced flow once-through vapor generating and superheating unit.

The general object of the present invention is the provision of a system for starting up a forced flow vapor generating unit so constructed and arranged as to simplify starting procedure, to minimize the time required for starting up, to provide adequate protection of the vapor superheating section of the unit and of the turbine. More specifically, the invention is directed to improvements in the construction and operation of a start-up system of the type described in U.S. Patent No. 2,989,038, in which the discharge from the vapor generating section of a once-through boiler is passed into a flash chamber or drum, the water from the flash drum is conducted to the inlet end of the vapor generating section of the boiler, the vapor from the flash drum is passed through the vapor superheating section of the boiler and then condensed for return to the vapor generating section, and provisions are made for bypassing the flash drum when the working medium is properly conditioned for rolling and loading the turbine.

In accordance with the present invention, during normal operation of a forced flow vapor generator, vaporizable fluid is successively passed through a vapor generating section, a receiver and a superheating section to a vapor turbine. The start-up system of the invention involves passing vaporizable fluid under substantial pressure through the vapor generating section in indirect heat transfer relation with heating gases, then passing the heated fluid to the receiver while reducing the pressure of the fluid to cause part of it to flash into vapor, and then separating the vapor portion of the fluid in the receiver and successively passing it through the superheating section and a condensing device for return to the vapor generating section, while recirculating the remaining fluid from the receiver to the vapor generating section. The rate of heating gas flow and of vaporizable fluid flow is progressively increased until predetermined conditions of fluid temperature and pressure for starting the turbine are attained, then recirculation of fluid from the receiver to the vapor generating section and from the superheating section to the vapor generating section is discontinued so that all the fluid passes through the vapor generating section to the receiver for mixing therein and then passes through the superheating section to the turbine. While the loading of the turbine is gradually increased, the pressure of the fluid in the receiver and superheating section is gradually raised to correspond with the pressure in the vapor generating section. This system permits elimination of much of the conduit and valve work of U.S. Patent No. 2,989,038, while continuously utilizing the receiver during starting up and normal operation.

In the drawing, I have diagrammatically illustrated a power plant including a vapor turbine and a once-through vapor generator, together with apparatus required for starting up and maintaining normal operation of the generator in accordance with the system of the invention.

During normal operation of the power plant system illustrated, feedwater at a suitable temperature is with-

drawn by a boiler feed pump 10 from a hot well or feed-water reservoir 12 and forced under a substantial positive pressure through tubes forming serially connected vapor generating sections 14 and 16 of a once-through boiler 18, with sections 14 and 16 preferably being located mainly in a radiant heat absorbing section of the boiler. Streams of fluid discharging from vapor generating section 16 are passed through a conduit 20 to a vessel or receiver 22 for mixing therein so that the enthalpy, and thereby the temperature of the fluid, will be substantially uniform upon discharge from the receiver. Conduit 20 contains a pressure reducing valve 21 which is normally in a fully open position. After mixing in the receiver 22, the fluid is passed through conduits 24 and 26, then successively passes through vapor superheating sections 28 and 30, preferably located in a convection heat pass of the boiler. Vapor discharging from superheating section 30 passes through conduits 32 and 34 to a vapor turbine 36. Burners 38 are arranged to supply high-temperature heating gases to boiler 18 for indirect heat exchange with the fluid flowing through the vapor generating and superheating sections. The final superheater outlet temperature is maintained constant by controlling the firing rate of the burners, and vapor flow to turbine 36 is controlled by a valve 42 contained in conduit 34. The vapor, after passing through various stages of the turbine 36, is condensed in a condenser 44, with a pump 45 returning the condensate to the hot well 12 by way of a conduit 46.

In a typical start up of the above-described boiler, about one quarter full load water flow is established through pump 10 and vapor generating sections 14 and 16 before firing is commenced, with all of such flow passing through conduit 20 and pressure reducing valve 21 to receiver 22 and with valve 21 being positioned to maintain the pressure of the fluid in the vapor generating sections at a high level and to effect a substantial reduction in fluid pressure as it passes to receiver 22. Receiver 22 is provided with a drain conduit 48 connected to the return line 46 and containing a regulating valve 50, with the conduit 48 and valve 50 being so sized as to permit water outflow from the receiver at a rate corresponding to water inflow to the receiver while maintaining a water level therein, thereby preventing carry-over of water to the superheater sections of the unit.

After minimum flow is established, firing is commenced and gas temperature entering the superheater is held to approximately 1000° F. As the water temperature increases due to firing, a portion of the water passing through the pressure reducing valve 21 will flash into steam due to the lower pressure at the discharge side of the valve and in the receiver 22. The remaining water drains from the bottom of receiver 22 through conduit 48 for return to hot well 10 by way of conduit 46. A feed-water supply connection 51, containing a regulating valve 53, opens into drain line 48.

Steam separated in receiver 22 discharges therefrom through conduits 24 and 26, then successively passes through the tubes of superheater sections 28 and 30, cooling the tubes to a safe metal temperature, then flows to condenser 44 by way of a turbine by-pass line 52, containing a control valve 54. Condensate is returned to the hot well 12 through pipe 46.

By means of the described arrangement it is possible to restrict the cooling fluid in the vapor generating sections 14 and 16 to water and in the superheating sections 28 and 30 to vapor. The pressures maintained in the vapor generating and superheating sections can be suitably regulated by the valves 21, 42 and 54. During the starting-up period, the pressure maintained in the steam generating sections 14 and 16 will be substantially higher than the pressure initially in the steam superheating sections 28 and 30. Some of the flashed vapor passing

through the superheating sections can be used for warming up the turbine during the starting-up period and in that case the valve 42 is barely opened.

When the quantity and desired conditions of vapor in the turbine by-pass 52 are reached, the turbine 36 may be rolled and loaded. To increase the load on the turbine, the pressure in the vessel 22 is raised by opening the pressure reducing valve 21. As the unit is brought up to pressure, the pressure in the steam generating and superheating sections will tend to approach each other. At some load, about 20% to 30% of full load, the reducing valve 21 will be fully opened, valves 50 and 54 will be closed and valve 42 will be opened. Above this load, flashing in the vessel 22 ceases and a water level therein is no longer maintained, with the vessel now serving to mix the fluid passed thereto before discharge to the vapor superheating section 28.

If it should be desirable to protect the tubes in the vapor superheating section during the initial portion of the starting-up period, vapor may be regulably supplied from an outside source through a pipe 56 connected to pipe 26 and controlled by valve 58.

While in accordance with the provisions of the statutes, I have illustrated and described herein the best form and mode of operation of the invention now known to me, those skilled in the art will understand that changes may be made in the form of the apparatus disclosed without departing from the spirit of the invention covered by my claims, and that certain features of the invention may sometimes be used to advantage without a corresponding use of other features.

What is claimed is:

1. The method of starting a power plant system in which, during normal operation, vaporizable fluid is successively passed through a heating zone, a receiving zone, and a superheating zone to a vapor turbine, said method comprising passing a vaporizable fluid under a substantial pressure through the heating zone while passing heating gases in indirect heat-transfer relation with the fluid, passing the fluid so heated to the receiving zone while reducing the pressure of the fluid to cause part of it to flash into vapor, effecting separation of the vapor portion of the fluid in the receiving zone and then passing it through the superheating zone, while recirculating the remaining fluid from the receiving zone to the heating zone, condensing the vapor discharge from the superheating zone and recirculating it to the heating zone, increasing the

rate of heating gas flow and of vaporizable fluid flow through said zones until predetermined conditions of fluid temperature and pressure for starting the turbine are attained, discontinuing the recirculation of fluid from the receiving zone to the heating zone and from the superheating zone to the heating zone so that all of the fluid from the heating zone passes to the receiving zone for mixing therein and then passes through the superheating zone to the vapor turbine, while raising the pressure of the fluid in the receiving and superheating zones and loading the turbine.

2. The method of starting a power plant system in which, during normal operation, vaporizable fluid is successively passed through a heating zone, a receiving zone, and a superheating zone to a vapor turbine, said method comprising passing a vaporizable fluid under a substantial pressure through the heating zone while passing heating gases in indirect heat-transfer relation with the fluid, passing the fluid so heated to the receiving zone while reducing the pressure of the fluid to cause part of it to flash into vapor, effecting separation of the vapor portion of the fluid in the receiving zone and then passing it through the superheating zone, while recirculating the remaining fluid from the receiving zone to the heating zone, condensing the vapor discharge from the superheating zone and recirculating it to the heating zone, progressively increasing the rate of heating gas flow and of vaporizable fluid flow through said zones until predetermined conditions of fluid temperature and pressure for starting the turbine are attained, discontinuing the recirculation of fluid from the receiving zone to the heating zone and from the superheating zone to the heating zone so that all of the fluid from the heating zone passes to the receiving zone for mixing therein and then passes through the superheating zone to the vapor turbine, while raising the pressure of the fluid in the receiving and superheating zones and gradually loading the turbine.

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