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VAPOR GENERATING ORGANIZATION AND METHOD

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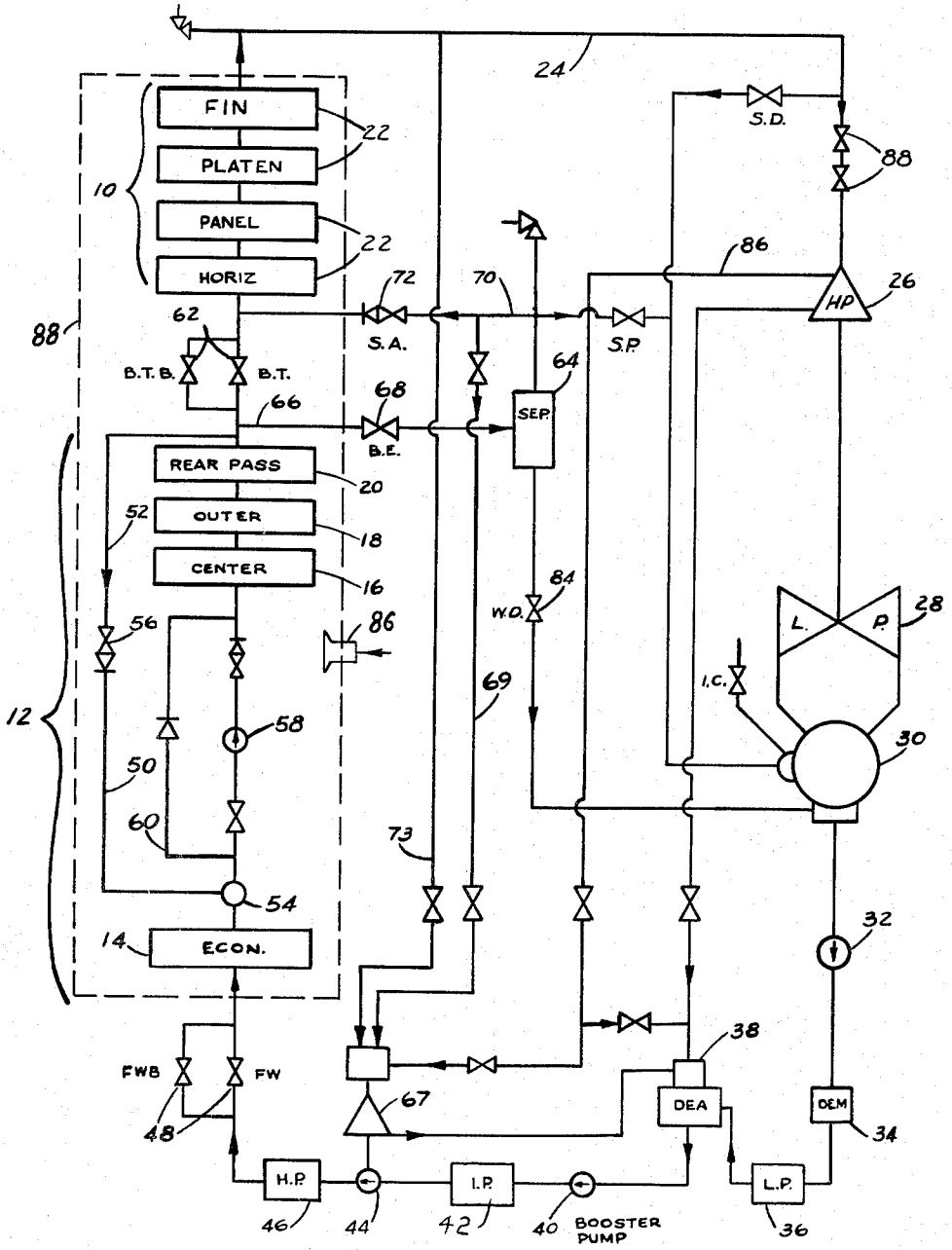

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VAPOR GENERATING ORGANIZATION AND METHOD

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This invention relates generally to the art of vapor generation and is particularly concerned with a forced through-flow vapor generator and operating method as concerned therewith.

In accordance with the invention there is provided a forced through-flow vapor generator so organized that both a cold start and a hot restart may be accomplished without the requirement of or without the use of auxiliary startup feed pumps and without the need of auxiliary steam for operating the turbine drive of the main feed pump. In accordance with the invention the forced through-flow vapor generator includes a through-flow circuit which has what may be generally termed a superheater portion comprised of a plurality of superheater sections in series flow relation and a vapor generating portion which includes the economizer, furnace wall and gas pass wall tubes as well as other heat exchange surface if so desired. These various heat exchange sections in the vapor generator section of the circuit are in series flow relation and the through-flow is conveyed through the entire through-flow circuit by means of the turbine driven main feedwater pump and the electric motor driven booster pump which is in series with this main feedwater pump and is upstream thereof. A recirculation system is superimposed on a portion of the through-flow circuit which may include the major portion of the steam generating section of the through-flow circuit and includes the furnace wall tubes which comprise the portion of the through-flow circuit having the highest rate of heat absorption during startup and operation of the vapor generator. This recirculation system is effective to provide and insure that adequate flow is maintained in this portion of the through-flow circuit during low load operation and during startup. Intermediate the superheater section and the vapor generating section of the through-flow circuit there is provided a valve organization to control flow between these sections and in bypass relation with this valve organization is a bypass system which includes a flash tank the upper region of which is connected with the through-flow system downstream of the valve organization. A suitable valve means is provided in this connection. The connection of the flash tank with the through-flow circuit upstream of the valve organization is provided with a suitably adjustable throttle valve. The lower region of the flash tank is connected with the condenser which forms part of the vapor generating system and a control valve is provided in this connection.

As a result of the particular generator design employed with the present invention and wherein there is superimposed upon the through-flow circuit of the generator a recirculating system that is operative to insure adequate flow through the highest heat absorption portions of the circuit at low loads and during startup, the through-flow required at startup is very substantially reduced particularly during the initial phase of startup, as contrasted with the forced through-flow vapor generator circuits which do not embody this recirculating system.

It is because of this relatively low through-flow requirement at startup that, with the organization and method of the present invention, startup may be accomplished without the use of separate startup pumps and without the requirement for auxiliary steam to drive the turbine for the main feed pump. The electric motor driven booster pump (required for proper operation of the main feed pump) is of limited head but can supply this low through-flow requirement at the initial stage of startup. This pump is activated and a limited through-flow, such as 5 percent, established through the throttle valve and into the flash tank. The recirculating system is in operation at this time, and the fires are lit so that the fluid in the vapor generator portion of the through-flow circuit is heated with the valve means intermediate the vapor generator portion and superheater portion of the circuit being closed. The throttle valve leading to the separator is adjusted to maintain the pressure in the vapor generating portion of the through-flow system above saturation pressure for the particular temperature and as the temperature rises steam will be developed in the flash tank as a result of the throttling action and the flashing of a portion of the liquid to vapor. A conduit connects the upper region of the flash tank to the turbine drive for the main feed pump, and this steam as it is developed is conveyed to this turbine drive and the main pump thereby activated. By means of this initial starting of the main feed pump and the booster pump which is in series therewith, the pressure is elevated in the vapor generating portion of the circuit. Steam is also conveyed from the flash tank to the superheater portion of the circuit to warm the piping thereof and to initially roll the turbine. After the temperature and pressure in the vapor generating portion of the circuit has reached a desired value, the throttle valve leading to the flash tank is closed and the valve means intermediate the vapor generating portion and superheating portion of the circuit are opened and used to control the pressure in the vapor generating portion. The continued activation of the turbine for the main feed pump is achieved by conveying steam from the outlet of the superheater to this turbine drive.

Hot restart for the vapor generator organization after a hot trip is accomplished by closing the valve means between the vapor generating and superheating portion of the circuit so that the pressure in the vapor generating portion is maintained at its desired value. Recirculation is provided and the fires are lit. The pressure in the superheater portion is lowered (it being at a high value at the time of the hot trip) by conveying steam from the superheating portion to the turbine drive for the main feed pump. There is sufficient steam in the superheater to initiate activation of the main feed pump, and the flow established thereby passes into the flash tank. Since the fluid in the unit is hot some or all of this fluid is flashed into steam in passing through the throttle valve and into the flash tank, with this steam being conveyed through the superheaters. Heat is imparted to the fluid in the through-flow circuit and when the temperature of the fluid upstream of the valve means reaches its desired value, the throttle valve will be closed and the valve means will be opened as in the manner of the cold start.

Accordingly, it is an object of this invention to provide an improved forced through-flow vapor generator and method with relation thereto.

Another object of the invention is to provide an improved method for cold start of a forced through-flow vapor generator.

Still another object of this invention is to provide an improved method of hot restart of a forced through-flow vapor generator.

Other and further objects of the invention will become apparent to those skilled in the art as the description proceeds.

With the aforementioned objects in view, the invention comprises an arrangement, construction and combination of the elements of the inventive organization in such a manner as to attain the results desired as hereinafter more particularly set forth in the following detailed de-

scription of an illustrative embodiment, said embodiment being shown by the accompanying drawing wherein the single figure is a diagrammatic representation in the nature of a flow diagram of an improved power plant embodying the present invention.

Referring now to the drawing wherein like reference characters are used throughout to designate like elements, the illustrative and preferred embodiment of the invention as depicted therein includes a supercritical vapor generator that supplies vapor to a turbine arrangement which in conventional practice drives an electric generator. The supercritical vapor generator of the invention is divided into what is termed a superheater section designated generally 10 and within which at least a major portion of the superheating of the supercritical fluid is effected and a vapor generating section designated generally 12 and wherein the supercritical fluid is heated generally somewhat above the critical temperature. The vapor generating section of the through-flow system includes the economizer 14, the furnace center wall tubes, the outer furnace wall tubes and the rear pass tubes 16, 18 and 20, respectively. The through-flow is conveyed serially through these various heat exchange sections and on into the superheating section of the through-flow circuit which is made up of a number of heat exchange bundles 22 connected in series flow relation as disclosed.

The vapor egressing from the final superheater section through conduit 24 is conveyed to the turbine stage 26 with this being the high pressure turbine stage and from this high pressure turbine stage the vapor is conveyed to the low pressure turbine stage 28 and then to the condenser 30. Condensate is pumped by the condensate pump 32 from this condenser through the demineralizer 34, low pressure heater 36 and into the de-aerator 38. From the de-aerator the feedwater is pumped by means of the feedwater booster pump 40, which is an electric motor driven pump, through the intermediate pressure heater 42, the main feedwater pump 44, the high pressure heater 46 and then through the flow control valve 48 and into the through-flow circuit of the vapor generator. The electric motor driven feedwater booster pump 40 is required for proper operation of the main feedwater pump 44 since these high capacity, high head pumps have what is termed a "net positive suction head" problem wherefore they require a predetermined positive inlet pressure in order to function in the manner that they are intended and designed.

The supercritical vapor generator of the invention includes a recirculation system designated generally 50 superimposed on a portion of the through-flow circuit including the portion of the circuit of highest heat absorption during startup and at low load operation. The recirculating system includes the recirculating conduit 52 connected at its inlet with the through-flow circuit downstream of the rear gas pass tubes 20 and at its outlet with the mixing vessel 54 where the hot recirculated fluid is mixed with the relatively cold fluid coming from the economizer. Disposed within the conduit 52 is a suitable stop and check valve 56. Also forming part of the recirculated system is the recirculating pump 58, disclosed connected into the through-flow circuit and having a suitable bypass 60 with valves being provided upstream and downstream of the pump and with a check valve being provided in the bypass. This recirculation system is effective to provide a predetermined minimum flow through the portion of the through-flow circuit upon which it is superimposed, and the system may be organized to automatically provide a flow that is at least equal to the flow prevailing at a predetermined load. For example, it may become effective to start to recirculate between 70 and 80 percent of full load and as the load is decreased the recirculating system will insure that the flow through this portion of the through-flow circuit is equivalent to that where it becomes effective. For a detailed explanation of the theory of the recirculating system that forms a part of the combined circulation steam generator of the invention, reference is made to co-pending application Serial No. 127,395 filed July 27, 1961 (now Patent No. 3,135,252) in the name of Willburt W. Schroedter.

In the operation of the vapor generator there is some superheating that takes place in the vapor generating section 12. It is preferred that the transition zone be in the outer wall tube portion or heat exchange section of the through-flow circuit and thus the tubes that line the rear gas pass, i.e. the heat exchange section identified as 20, will act to provide an initial superheat of the supercritical fluid.

Intermediate the vapor generator section 12 and the superheater section 10 of the through-flow circuit there is provided valves 62 which control the flow through these sections and which are employed during startup. There is provided in bypass relation with these valves an arrangement for generating low pressure steam during the startup process and which arrangement includes the flash tank 64 connected with the through-flow circuit upstream of the valves 62 by means of the conduit 66 within which is disposed the throttle valve 68. The upper region of the flash tank is connected with the through-flow circuit downstream of the valves 62 by means of the conduit 70 within which is disposed the valve arrangement 72. The main feed pump 44 is driven by the steam turbine 67 and in order to supply steam to this turbine during startup conduit 69 connects the inlet of the turbine with the upper region of flash tank 64. A suitable valve is provided in this conduit 69. The inlet of the turbine 67 is also connected with the outlet of the vapor generator by means of the valved conduit 73.

During a cold start the recirculating pump 58 is activated, the electric motor driven booster pump 40 is activated to provide a minimum amount of through-flow, such as 5 percent of maximum continuous rating, and the fires are lit to heat the fluid in the steam generator portion of the through-flow circuit. At this time the valves 62 are closed and the throttle valve 68 adjusted to maintain the presssure at the outlet of the steam generating portion 12 of the through-flow circuit at a value that is above the saturation pressure for the temperature of the fluid at this location. This minimum through-flow is thus conveyed through the throttle valve 68 into the flash tank 64. The level in the flash tank is maintained at a desired value by means of the valve 84. When the temperature rises sufficiently, a portion of the through-flow will flash to steam. This steam is conveyed from the flash tank 64 through the conduit 69 to the turbine 67 that drives the main feed pump 44. (Since the booster pump 40 is a relatively low head pump, it is inadequate, per se, to supply sufficient fluid flow during startup for proper cooling of the heat exchange sections of the steam generating section 12. It is the combination of the recirculating system as employed with the vapor generator of the invention that permits the startup to be effected by means of the electric motor driven booster pump.) By thus activating the main feed pump this pump then becomes effective to increase the feedwater pressure to the through-flow circuit and in the vapor generating section thereof over that supplied by the electric motor driven booster pump. The valve 68 is adjusted in a manner to insure that the pressure at the outlet of the vapor generating portion 12 of the through-flow circuit is above the saturation pressure for the temperature at this location. Thus with the two pumps in series and in combination the pressure in the vapor generating portion of the through-flow circuit is progressively raised to its desired supercritical value. More steam is progressively formed in the flash tank 64 within which the pressure is also raised. Accordingly, more steam becomes available to the turbine drive for the main feed pump wherefor the pressure may continue to be raised. In addition, sufficient steam becomes available to be conveyed from the flash tank through the conduit 70 to the superheater portion 10 of the through-flow

circuit and on to the turbine for heating and rolling the same. The fire is regulatingly increased to give the desired heat input.

When the pressure and temperature have attained a desired value upstream of valves 62, the throttle valve 68 is closed and valves 62 are manipulated. These valves are operated in a particular manner to maintain the desired pressure in the steam generating portion 12 of the through-flow circuit and to control the flow into the superheater portion 10 in the desired manner. For a detailed explanation with regard to the theory and operation of the valve organization 62 as well as the throttle valve 68 with relation thereto reference is made to my co-pending application Serial No. 267,512, filed concurrently herewith and entitled "Economic Combination and Operation of Boiler Throttle Valves." When the valve 68 is closed and the valves 62 are opened, the supply of steam for the turibne drive 67 for main feed pump 44 is transfered from the conduit 69 to the conduit 73 with this steam then being that egressing from the final section of the superheater of the vapor generator. Steam generation is progressively increased and turbine 26 progressively loaded.

After a predetermined load is reached, the supply of steam to the turbine 67 that drives the main feedwater pump 44 is obtained through the conduit 86 which is connected with a suitable extraction point of the high pressure turbine 26 with this arrangement giving the greatest cycle efficiency. At and above some given load the turbine 67 receives all of its steam through this conduit 86 while below this given load it may receive steam both from conduit 86 and conduit 73.

Accordingly, it will be seen that with the organization and the method of the present invention the startup from a cold condition is effected without the use of special motor driven startup pumps and without the need of supplying auxiliary steam to the turbine drive for the main feed pump.

In providing a hot restart of the unit after a hot trip of the turbine control valves 88, the restart operation is effected by conveying steam from the superheater to the turbine 67. In this hot restart operation the valves 62 are closed in order to maintain the high pressure that prevails within the vapor generating section 12 of the through-flow circuit, such as for example 3500 lbs./sq. inch. In order to restart the vapor generator-turbine organization it is necessary to lower the pressure in the superheater with this pressure initially being at a high value such as the aforementioned 3500 lbs./sq. inch and with it having to be lowered substantially before admitting steam to the turbine 26. Thus there is a quantity of steam in the superheater that may be used to drive the turbine 67 for the main feed pump. The recirculation system is activated, the fires lit, booster pump 40 is activated and the pressure is lowered in the superheating section 12 of the through-flow circuit by conveying steam through conduit 73 to the turbine drive 67 whereby there is provided a relatively low through-flow effected by thus activating the main feed pump 44. This through-flow (which is insufficient, per se, for protecting the heat exchange surface but with the recirculating fulfilling this requirement) is passed through the throttle valve 68 and since the fluid is hot even before firing, steam becomes available almost immediately in the flash tank 64 to replace that being provided to the feed pump turbine through the conduit 73. This steam is conveyed through conduit 70 into the superheater section 10 of the through-flow circuit. Heat is imparted to the through-flow circuit and accordingly the temperature of the fluid at the outlet of the vapor generating section 12 of the through-flow circuit is progressively raised. The pressure in the vapor generating section 12 of the through-flow circuit is maintained at its predetermined high value such as 3500 lbs./sq. inch by throttle valve 68, and the fire is regulatingly increased to increase the temperature of this fluid with the amount of steam that is developed in the flash tank also increasing and with steam being supplied to the main turbine 26. When the temperature in the vapor generating section 12 of the through-flow circuit reaches a desired value, the valve 68 is closed and valves 62 opened as previously mentioned so the loading of the turbine progresses with the manipulation of these various valves preferably being in accordance with the operation set out in my co-pending application Serial No. 267,512, filed concurrently herewith and entitled, "Economic Combination and Operation of Boiler Throttle Valves." When the valve 68 is closed and the valves 62 manipulated for the passage of fluid from the vapor generating section 12 to the superheating section 10 of the through-flow circuit, the regulation of flow to the superheater section is controlled by these valves 62 and the pressure in the steam generating section 12 is maintained at its desired value by means of manipulation of these valves. The firing is progressively increased and the loading of the turbine is progressively increased with the amount of steam generated and supplied to the turbine also being progressively increased. When a predetermined load of the turibne is reached, the supply of steam to the turbine drive 67 for the main feed pump 44 is transfered from the line 73 to the line 86 with the steam then being obtained from a suitable extraction point of the turbine 26. With this hot restart procedure the pressure in the vapor generating section is maintained at the predetermined high value that prevailed at initiation of the startup. The main feedwater pump 44 is activated immediately at startup by receiving steam from the superheater during the depressurization of the superheater. It is through this activation of the main feed pump that the relatively low through-flow is provided at the high head (this head being the same as that which prevails during normal operation of the unit) that prevails in the vapor generating section 12 of the through-flow circuit at this time. Because of the recirculation system a relatively low through-flow is permitted with the main feed pump together with the booster pump being effective to provide this low flow at the initiation of the startup. With this hot restart the vapor generator is very rapidly put back into operation.

Accordingly, the hot restart is effected also without the use of auxiliary startup pumps or the requirement for supplying auxiliary steam to the turbine drive 67 for the main feed pump and with the startup procedure for a hot restart being both quick and simple.

It will be appreciated that the various heat exchange sections of the through-flow circuit are comprised of tubular members. The heat exchange sections 22 and the economizer 14 are preferably in the form of tube bundles or tubular panel with the tubes being bent in a sinuous manner as is conventional. The tubes that make up the center, outer and rear wall heat exchange wall sections are preferably tubular members that extend longitudinally of these walls with the tubes on the particular walls being in side-by-side relation and connected intermediate the inlet and outlet headers. All of these heat exchange sections are disposed so as to receive heat produced by the burning of fuel with the burner for the burning of fuel being shown diagrammatically and being designated 86. The dotted line 88 is to diagrammatically represent the various heat exchange sections as disposed within the vapor generator enclosure.

While I have illustrated and described a preferred embodiment of my invention it is to be understood that such is merely illustrative and not restrictive and that variations and modifications may be made therein without departing from the spirit and scope of the invention. I therefore do not wish to be limited to the precise details set forth but desire to avail myself of such changes as fall within the purview of my invention.

What I claim is:

1. A forced once-through flow vapor generator having a through-flow circuit, a recirculating system including pump means superimposed on a predetermined portion of said circuit including the portion having the highest rate of heat absorption during startup and operative to insure adequate flow therethrough for protection of the heat exchange surface, a main feed pump, a turbine drive for said main feed pump, a booster feed pump in series with and upstream of said main feed pump and driven by an electric motor, said booster feed pump being of relatively low head and being insufficient per se to provide sufficient flow through the circuit for protection of the heat exchange surface during startup, a flash tank, means connecting the flash tank with the through-flow circuit and operative to convey fluid from the through-flow circuit to the flash tank and throttle the same so that a portion of it flashes into steam, means for initiating activation of the main feed pump turbine drive for startup consisting of means supplying steam thereto from the flash tank, whereby startup of the unit may be accomplished by the main feed pump and booster pump, per se, and without a heat source outside the vapor generator.

2. A force through-flow vapor generator comprising a through-flow circuit having first and second heating portions in series flow relation with valve means interposed intermediate these portions, a recirculating system including pump means superimposed on at least the region of the first heating portion having highest heat absorption during startup, a main feed pump, a turbine drive for said pump, an electric motor driven booster feed pump in series with and upstream of said main feed pump, a flash tank communicating with the through-flow system upstream of said valve and downstream of said first heating section, means establishing said communication and including a throttle valve interposed between the flash tank and the through-flow system, whereby fluid from the through-flow system is introduced into the flash tank at reduced pressure with a portion thereof being flashed to steam, means for initiating activation of the main feed pump turbine drive for startup consisting of means supplying steam thereto from the flash tank, whereby startup of the unit may be accomplished by the main feed pump and booster pump, per se, and without a heat source outside the vapor generator.

3. In a once-through flow supercritical vapor generator having a furnace and a through-flow circuit that includes a plurality of heat exchange sections connected in series flow relation, means for firing said furnace, a steam turbine driven main feed pump operative to force the through-flow through said circuit and an electric motor driven booster pump upstream of and in series with said feed pump, a recirculating system including pump means superimposed on the portion of the through-flow system that has the highest heat absorption during startup, a valve disposed in the through-flow circuit downstream of said recirculating system and a flash tank effectively connected with said circuit upstream of said valve with a throttle valve in this connection between the flash tank and the through-flow circuit, the improved method of starting said unit comprising closing said valve in the through-flow circuit and establishing a fluid circulation by means of said recirculating system, providing a through-flow of fluid by means of the booster pump with the through-flow passing through the throttle valve and into the flash tank, burning fuel in said furnace and imparting heat to the through-flow with the heat developed from this burning fuel being utilized as the sole source of heat for said fluid, maintaining the pressure in the through-flow circuit upstream of the valve in said circuit by means of said throttle valve and at a value above the saturation pressure corresponding to the fluid temperature passing from the circuit and into the flash tank, flashing a portion of the fluid in the flash tank to steam as the temperature of the fluid passing through the throttle valve is progressively raised, initially driving the turbine for the main feed pump via conveying steam from the flash tank to this turbine thereby activating said pump and by means of this main feed pump in combination with the booster pump progressively raising the pressure in the through-flow system upstream of said valve until said pressure and temperature reach a predetermined desired value after which fluid is conveyed through said valve.

4. The method of starting a supercritical vapor generator having a furnace and a through-flow circuit through which the working medium of the vapor generator is passed, a recirculating system superimposed on said through-flow circuit and including pump means with said system having its inlet connected downstream and its outlet connected upstream, respectively, of the portion of the through-flow circuit which has the highest heat absorption rate during startup, means firing said furnace, a steam turbine driven main feedwater pump and an electric motor driven booster feed-water pump upstream of said main feedwater pump, said method comprising establishing a recirculation through the recirculation system and establishing by means of the feedwater booster pump a minimum through-flow through at least a portion of the through-flow circuit and at a pressure substantially below the normal operating pressure of the unit, burning fuel in said furnace and heating the through-flow utilizing the burning fuel as the heat source and without the need or use of a separately fired heater, withdrawing said through-flow from the through-flow circuit and into a zone of lower pressure whereat a portion of the through-flow is flashed to steam after it has been heated to a sufficiently high temperature, conveying steam from this zone to the turbine drive for the main feedwater pump as the initial motive fluid therefor during startup and thereby activating said pump, continuing to raise the pressure and temperature of the fluid in the through-flow circuit to a desired value to produce a final vapor of a predetermined temperature and pressure, and when vapor of a desired temperature and pressure is produced in the vapor generator, supplying steam from this source to the steam turbine drive of the main feed pump and discontinuing the supply of steam thereto from said zone while continuing to recirculate fluid through the recirculating system until a predetermined load on the generator is developed.

5. In a supercritical forced through-flow vapor generator having a furnace and a through-flow circuit that includes a first section and a second section in series flow relation with valve means interposed therebetween, said first section including the portion of the through-flow circuit of highest heat absorption during startup, a recirculating system including pump means superimposed upon at least a portion of said first section including said heat exchange surface of highest heat absorption during startup, means for firing said furnace, a steam turbine driven main feed pump and an electric motor driven booster feed pump in series therewith and upstream thereof, a flash tank connected with the through-flow circuit upstream of said valve means and with a throttle valve being contained in this communication, means connecting the upper region of the flash tank with the through-flow system downstream of said valve means and with the turbine drive for the main feed pump, the startup method comprising establishing a recirculating of fluid through said recirculating system, providing a minimum through-flow by means of the booster pump with said valve means closed, burning fuel in said furnace and imparting heat to said through-flow with the heat developed from said burning fuel being utilized as the sole source of heat for the through-flow, regulating said throttle valve to maintain the pressure in the through-flow circuit upstream of said closed valve means at a value above saturation pressure corresponding with the fluid temperature at this location, conveying this minimum flow through the throttle valve and into the flash tank with a portion of this flow being flashed to steam when sufficient heat is contained in this fluid, ini-

tially activating the turbine drive for the main feed pump by conveying steam from the flash tank to this turbine drive and increasing the feedwater pressure supplied to the boiler by means of the main feed pump over that supplied by the electric motor driven booster pump, as sufficient steam becomes available in the flash tank also conveying steam therefrom through the remainder of the through-flow circuit downstream of said valve means, when the pressure and temperature of the fluid upstream of said valve means reaches a predetermined value gradually opening said valve means and closing said throttle valve, and transferring the supply of vapor for the feed pump turbine drive from the flash tank to the source produced in and egressing from the through-flow circuit.

6. In a supercritical forced through-flow vapor generator which is provided with a furnace and a recirculation system including pump means associated with the portion of the circuit of the vapor generator of highest heat absorption during startup so that through-flow may be very much decreased over what otherwise would be required during the startup process and wherein a flash tank is employed for startup purposes with relatively low pressure steam being produced in the flash tank during the startup period with the vapor generator having a steam turbine driven main feed pump and an electric motor driven booster feed pump in series with and upstream of the main feed pump and with there being means for firing the furnace, the improved method of starting up the unit comprising establishing a minimum through-flow by means of the motor driven booster pump and which through-flow would be, per se, insufficient for protection of the heat exchange surface of the vapor generator that has highest heat absorption during startup, supplementing the through-flow by recirculating fluid through said recirculation system and in such quantity as to insure adequate flow for protection of said heat exchange surface of highest heat exchange, imparting heat to the unit solely via firing of the furnace and producing steam in the flash tank, initiating activation of the turbine drive for the main feed pump by conveying steam from the flash tank to this turbine drive thereby activating said pump, increasing the pressure in the generator by means of the main feed pump and increasing the firing rate and upon producing steam of sufficient temperature and pressure in the vapor generator transferring to this steam supply from the flash tank steam supply for the motive fluid for the turbine drive of the main feed pump.

7. In a once-through flow vapor generator having a through-flow circuit including a superheater section separated from the remainder of the circuit by valve means, a recirculation system including pump means superimposed on a portion of said remainder of the circuit including the portion that has the highest rate of heat absorption, a valve bypass around said valve means and which bypass has incorporated therein a flash tank with a throttle valve being incorporated in the bypass intermediate the flash tank and the section of the bypass upstream of the valve means, a turbine driven main feed pump, the hot restart method after a hot trip comprising closing said valve means to maintain the pressure in the through-flow circuit upstream thereof at a predetermined value, reducing the pressure in said superheater portion by conveying vapor therefrom to the turbine drive for the feed pump thereby activating said feed pump and establishing a minimum flow through the circuit portion upstream of the valve means, activating said recirculation circuit and imparting heat to the through-flow with the through-flow being conveyed through the throttle valve into the flash tank where a portion there of is flashed into steam, conveying steam from the flash tank through the superheater portion of the through-flow circuit, progressively increasing the temperature of the fluid upstream of the valve means until it reaches a predetermined value and thereafter opening said valve means and closing said throttle valve.

8. In a once-through flow supercritical vapor generator the improved method of hot restarting said generator after a hot trip comprising reducing the pressure in the superheater portion of the vapor generator while maintaining the pressure in the portion of the generator upstream of the superheater portion with this reduction in pressure being accomplished by conveying steam from the superheater portion to a turbine drive for the main feed pump thereby activating said main feed pump, conveying the through-flow from said upstream circuit portion while maintaining the pressure therewithin and flashing a portion of this through-flow to vapor, conveying this vapor through the superheater portion of the vapor generator, imparting heat to the through-flow maintaining, independent of the through-flow, a recirculation of fluid through the portion of said upstream portion which is subjected to highest heat absorption during startup and after the temperature of the through-flow in said upstream circuit portion reaches a desired value discontinuing the flow to the flash tank and passing the through-flow in bypass relation with said tank and from said upstream portion to said superheater portion.

9. A supercritical vapor generator comprising a through-flow circuit that has first and second heat exchange portions in series flow relation, valve means interposed intermediate these portions, a recirculation system superimposed on at least the highest heat absorption portion of the through-flow circuit upstream of said valve means and including pump means operative to provide a recirculation of fluid through said system, a flash tank, means connecting said flash tank with said through-flow circuit upstream and downstream of said valve means, a throttle valve in said upstream connecting means, a prime mover receiving the output of said generator, a steam turbine driven main feed pump and an electric motor driven booster pump in series therewith and upstream thereof with said pump means being connected to force working medium through the through-flow circuit, means for initiating activation of said main feed pump drive for startup consisting of means supplying steam thereto from the flash tank, and means for supplying steam to the main feed pump drive after startup is well along including conduit means supplying steam from the through-flow circuit downstream of said valve means to said drive and conduit means supplying bleed steam from the prime mover to said drive, and valve means in each of said conduit means.

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