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[54] **VAPOR GENERATOR START-UP SYSTEM**
13 Claims, 5 Drawing Figs.

[52] **U.S. Cl.** **60/104,** 60/105, 122/406
[51] **Int. Cl.** **F01k 3/14**
[50] **Field of Search** .... 122/406 (SU); 60/104—107

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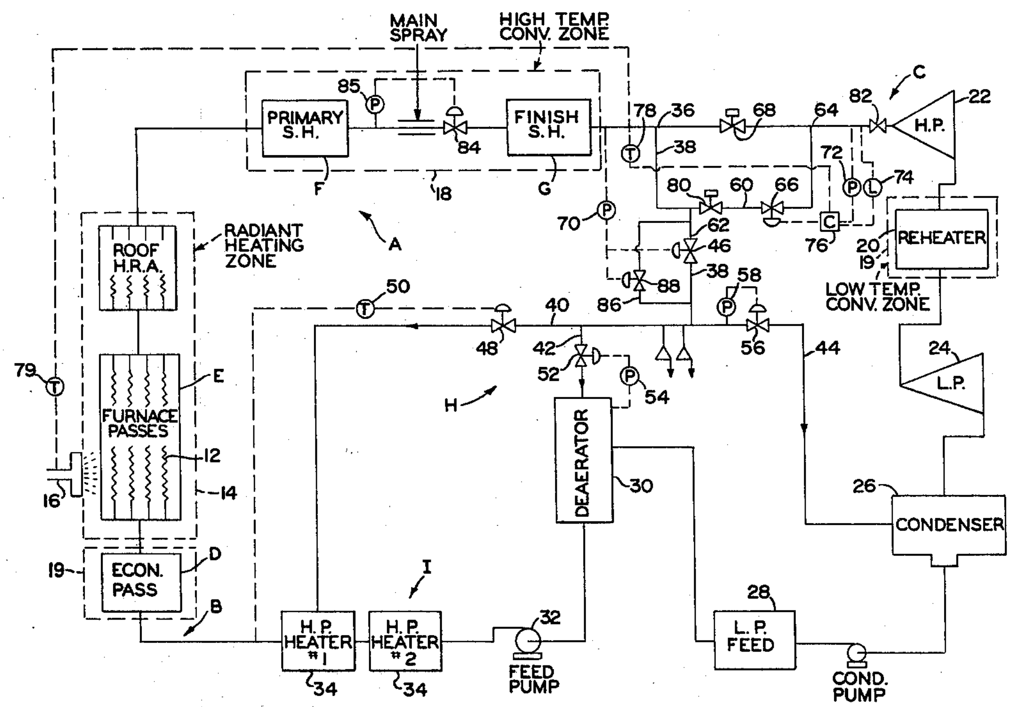
ABSTRACT: A once-through vapor generator which comprises a main flow path including heating surfaces, and a bypass system comprising a first conduit connected to the outlet end of said heating surfaces including a pressure-reducing means therein, and a second conduit leading from the inlet side of said pressure reducing means back to the main flow path connected to the latter at a point downstream of said first conduit. The second conduit also contains a pressure-reducing means, including control means which is responsive to the turbine inlet pressure and load once the flow at the heating surfaces outlet end reaches a preset temperature.



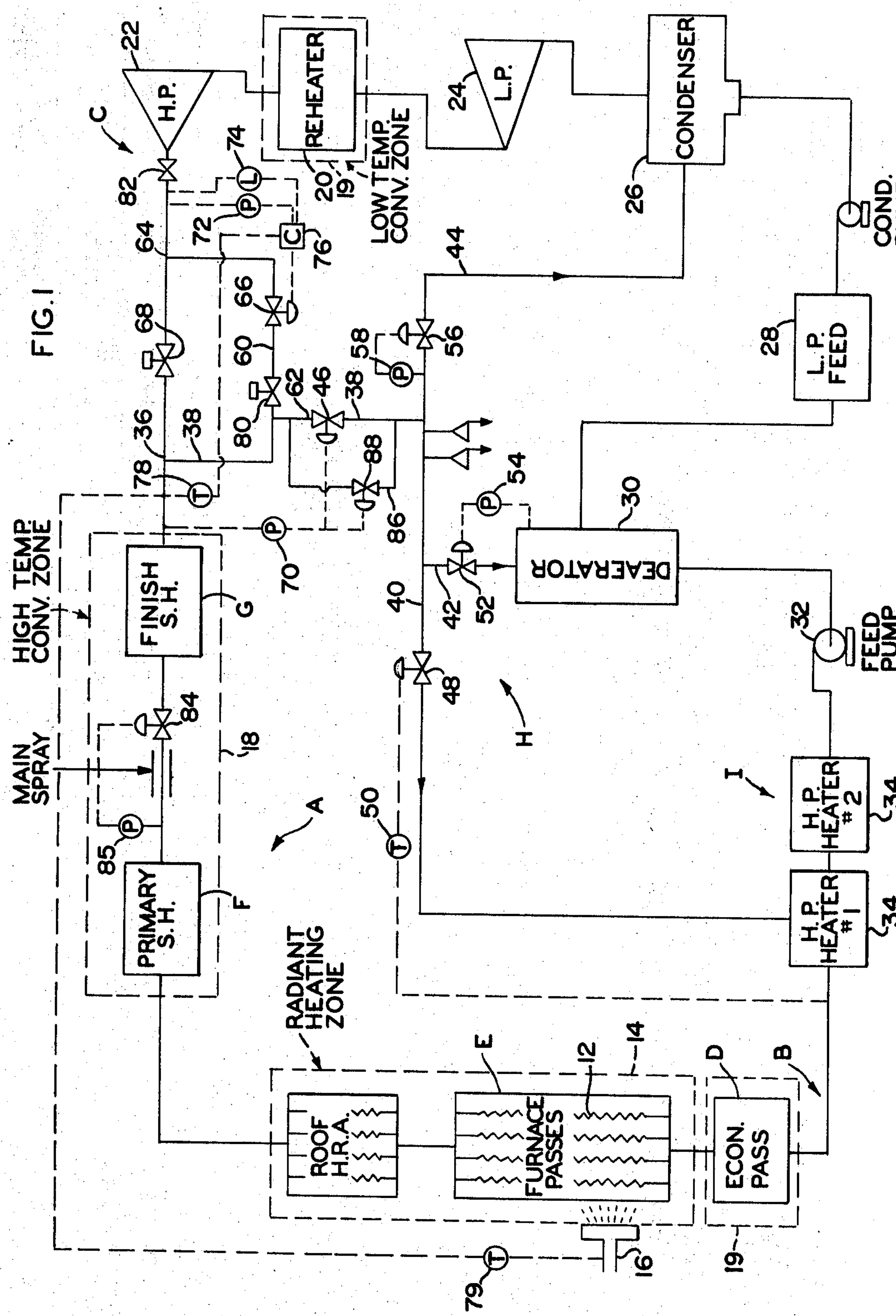

H.P.
REHEATER
L.P.
CONDENSER
LOW TEMP. CONV. ZONE
COND. PUMP
L.P. FEED
DEAERATOR
FEED PUMP
H.P. HEATER #2
H.P. HEATER #1
HIGH TEMP. CONV. ZONE
FINISH S.H.
MAIN SPRAY
PRIMARY S.H.
RADIANT HEATING ZONE
ROOF H.R.A.
FURNACE PASSES
ECON. PASS

FIG. 1

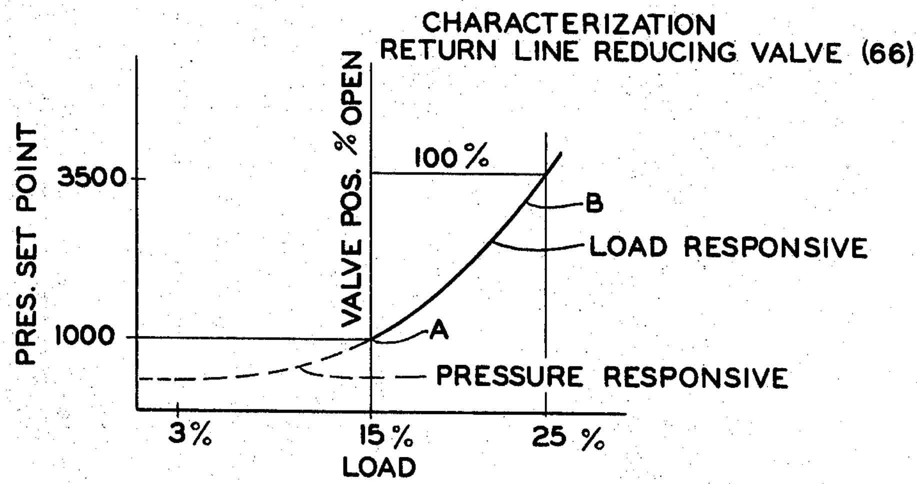


FIG. 2

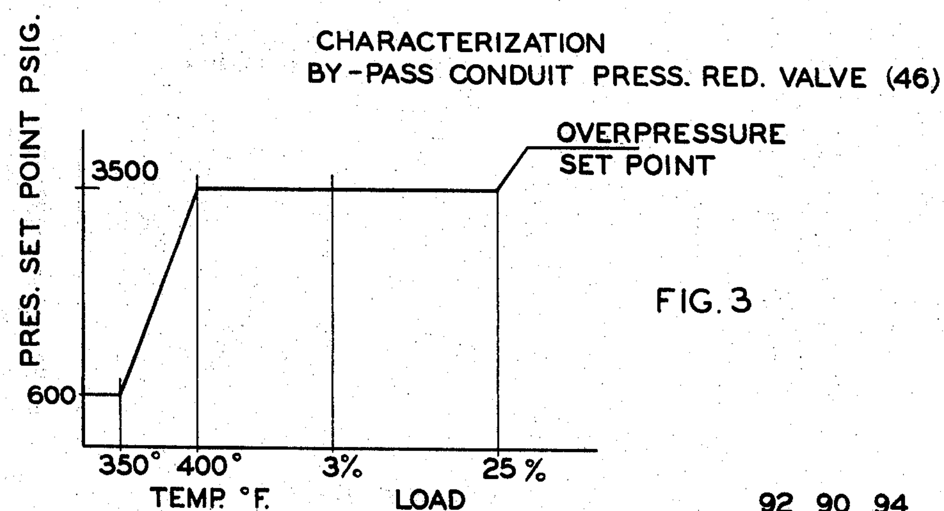


FIG. 3

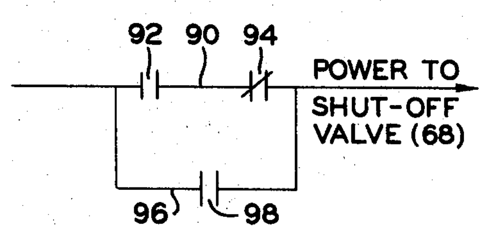


FIG. 5

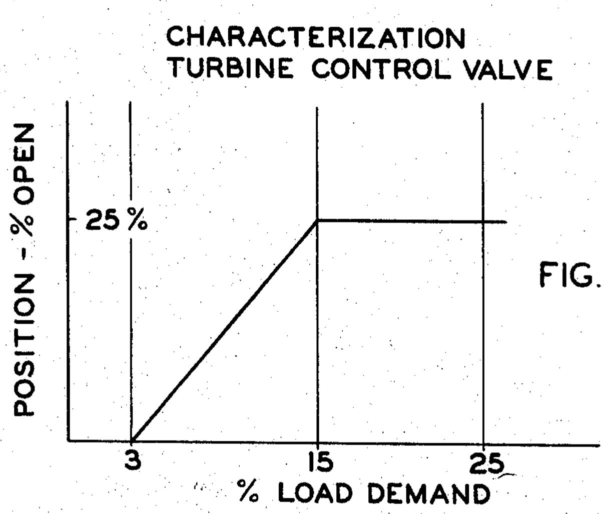


FIG. 4

VAPOR GENERATOR START-UP SYSTEM

The present invention relates to a once-through vapor generator, and in particular to a novel startup bypass system for such a generator.

The present invention is particularly applicable to a supercritical pressure once-through generator.

A typical once-through vapor generator, of the type to which the present invention pertains, will include an inlet end and an outlet end, with a plurality of heat transfer surfaces between said ends. As a general rule, these will include an economizer, furnace passes defining a high temperature radiant heat transfer portion of the generator, and primary and finishing superheating passes. The outlet end of the generator is connected to a suitable use, such as a high pressure turbine, exhaust flow from the turbine being transmitted through a reheater to a lower pressure turbine and from there to a condenser. After the condenser, the flow is through a deaerator, heat recovery surfaces, and to the inlet end of the generator.

During startup of the once-through vapor generator, the low enthalpy fluid cannot be handled by the high pressure turbine, and for this reason, the generator usually is provided with a bypass system to handle the flow until it is at a temperature level required by the turbine. It is known to transmit this flow to the heat recovery surfaces where it is passed in heat exchange with the feed flow to the vapor generator inlet end, thereby recovering the heat which is in the bypassed flow. It is also known to position a flash tank or separator in the bypass system designed to separate the flow entering the bypass system into a saturated vapor stream and a liquid stream and to transmit the vapor stream to various uses such as turbine gland sealing, and pegging the deaerator. Associated with the flash tank is a pressure reducing valve designed to maintain full pressure in the furnace passes and breakdown the pressure to one which the flash tank can handle.

Historically, the bypass systems have been positioned upstream of the finishing superheating surface. The reason for this is that early once-through generators were operated at subcritical pressures. The finishing superheater generally included pendant surface suspended in the generator, and the bypass system had to be upstream of the pendant surface to prevent liquid in the vapor-liquid subcritical mixture from settling in the surface, during the startup period. The primary reason for the flash tank or separation in the bypass system accordingly was to separate out liquid from the vapor-liquid mixture and avoid transmitting water to the finishing superheater. Otherwise slugs of water settling in the superheater would be forced in to the turbine during startup possibly damaging the turbine.

This location of the bypass system and use of a flash tank and pressure reducing station has carried over to the supercritical once-through generator for a variety of reasons.

One primary problem experienced with the startup system is that it produces a variable throughput in the finishing superheater during the startup period increasing as the enthalpy of the flow increases; i.e., as the quality of the flow increases and a larger vapor flow becomes available from the flash tank. Since the turbine requires a relatively constant temperature input, very complex control systems are required to control the firing rate, valve positions, pumping rate and other variables during the startup period.

An additional problem experienced with the conventional bypass systems is that as the once-through vapor generators become larger in size and capacity, the bypass systems of necessity must be designed to handle ever greater quantities of flow; that is, the conventional 25 to 30 percent minimum flow becomes increasingly greater. The flash tanks or separators which conventionally are positioned in the bypass system must be sized to handle the increased flows. Since they are heavy walled vessels designed to withstand high pressures and temperatures, it is apparent that they become major items in the capital cost of the generator, particularly in the cost of the bypass system.

A further disadvantage experienced with conventional once-through generators is the inordinantly long startup time required to heat the minimum 25 to 30 percent flow to that point at which it can be handled by the turbine and the turbine can be loaded. Efforts to reduce the startup period have been hampered by limitations on the firing rate created by the existence in the generator of uncooled reheater surface downstream of the high pressure turbine.

In addition to the above disadvantage, there is usually a vapor-liquid mixture in the main flow path upstream of the bypass system at the point in the startup period of switchover from flash tank vapor flow to main path flow. The downstream superheating surface which accordingly receives the lower temperature main path vapor-liquid mixture flow, instead of the higher temperature saturated vapor flash tank flow, undergoes or experiences a substantial temperature shock. Elaborate controls are employed conventionally to avoid this shock.

It is an object of the present invention to overcome the above problems, and in particular to provide a bypass system for a supercritical once-through vapor generator in which control of the generator during startup is substantially simplified.

It is a further object of the present invention to provide a startup bypass system for a once-through supercritical vapor generator in which the flash tank is eliminated, as well as the disadvantages usually associated therewith.

A further object of the present invention is to provide a startup bypass system for a supercritical once-through vapor generator which permits firing the generator at an increased firing rate.

In accordance with the present invention, there is provided a once-through vapor generator for use with a vapor turbine, which comprises a main flow path including a plurality of heating surfaces and an outlet end therefor. A startup bypass system includes a first conduit which leads from the main flow path from said heating surfaces outlet end, a pressure-reducing means in said conduit, and a second conduit connected adjacent the inlet end of the pressure-reducing means leading back to the main flow path, connected to the latter at a point downstream of the first conduit. The second conduit also contains a pressure-reducing means including control means therefor responsive to turbine inlet pressure and load once the flow at the heating surfaces outlet end reaches a predetermined temperature.

Preferably, in accordance with the invention, a shutoff valve is positioned in the main flow path between the points of connection of the first and second bypass conduits.

Also in a preferred embodiment, in accordance with the invention, the pressure-reducing means in the second conduit leading back to the main flow path, is first pressure responsive and then load responsive to conditions at the turbine inlet end during the startup period.

It will become apparent that among other advantages, the present invention, by connecting the bypass system to the outlet end of the heating surfaces, permits a constant throughput to be employed in the heating surfaces considerably simplifying the control of the startup period; control being limited primarily to adjustment of the firing rate in response to temperature demand at the outlet end of the heating surfaces.

In addition, by connecting the second bypass return line conduit on the inlet side of the pressure-reducing means of the first conduit, the need for a flash tank in the supercritical unit is avoided as well as the accompanying disadvantages of a flash tank; for instance, the temperature shock conventionally experienced by heating surface downstream of a bypass system.

As a further preferred embodiment in accordance with the invention, the generator is provided with radiant heating surfaces, followed by primary and finishing superheating surfaces in that order. A reheater follows the turbine positioned in a relatively low temperature convection zone of the generator, the primary and finishing superheating surfaces being in higher temperature gas zones of the generator. Since the full flow during startup is through the finishing superheater, as well as the other surfaces of the generator, the gas temperatures over the reheater are lowered permitting the generator to be fired at a faster rate.

The invention, embodiments, and advantages thereof will become more apparent upon further consideration of the following specification, with reference to the accompanying drawings, in which:

FIG. 1 is a schematic drawing of a vapor generator flow circuit and bypass system in accordance with the present invention;

FIGS. 2—4 are graphs illustrating characterization of control valves in accordance with the invention; and

FIG. 5 is further illustrative of control of the generator in accordance with the invention.

Referring to the drawings, wherein the showings are for the purpose of illustrating the preferred embodiment of the invention only and not for the purpose of limiting the same, FIG. 1 shows a once-through vapor generator flow circuit which comprises a main flow path A including an inlet end B and an outlet end C, between which are disposed heating surfaces including an economizer surface D, furnace passes E, primary superheating surface F and a finishing superheating surface G. A bypass system, designated by the letter H, extends from downstream of the finishing superheating surface to heat recovery surfaces I, the latter being disposed upstream of the inlet end B of the generator main flow path.

For the purpose of illustration, the furnace passes E are shown schematically as a plurality of parallel upright tubes **12** disposed in a radiantly heated furnace enclosure **14**, subjected to radiant heat from burners **16**. The tubes **12** receive an input flow from the economizer surface D, the heated flow from the tubes **12** passing to the primary superheating surface F and then to the finishing superheating surface G. The specific arrangement of surfaces or tubes is not part of this invention, although as a general rule, the generator will be divided into the radiantly heated enclosure area **14** and a convection heated enclosure area **18**, the latter containing at least in part the primary and finishing superheating surfaces.

Also, as a general rule, the primary and finishing superheating surfaces are considered high temperature surfaces located in relatively high temperature gas zones of the generator, lower temperature zones (**19**) being reserved for the economizer surface D and reheater surface **20**, to be described.

From the finishing superheater G, the flow is to the high pressure turbine **22**, the exhaust flow from the turbine being transmitted to the reheater **20**; and following reheating, to a lower pressure turbine **24**, and from there to a condenser **26**. From the condenser, the flow may pass through a low pressure heater **28**, a deaerator **30**, and from there to a feedwater pump **32**; where it is pressurized for passage through a plurality of high pressure heaters **34** and flow into the inlet end B of the generator generator and economizer D. As with the generator enclosure circuitry, this specific arrangement of components between the condenser and generator inlet end is subject to design criteria, and may be varied based on these criteria.

During startup of the generator, in order to insure a minimum safe velocity of the working fluid through the furnace passes and circuitry, it is necessary to have in these passes and circuitry a flow quantity during startup of at least 25 percent to 30 percent of maximum flow, towards safeguarding the surfaces (and circuitry) against burnout.

By the same token, this initial flow of working fluid cannot be handled by the high pressure turbine **22**, so that the bypass system H is connected to the main flow path upstream of the turbine, extending to the high pressure heaters **34**.

In accordance with the present invention, the bypass system is connected to the main flow path at a point **36** at or near the outlet end of the finishing superheater, so that all the heating surfaces, except the reheater **20**, receive the full flow during the startup period.

The bypass system comprises a first conduit **38** which leads to branch conduit **40**, connected to the high pressure heaters; to branch conduit **42** connected to the deaerator; and to branch conduit **44** connected to the condenser. The first conduit **38** is provided with a pressure reducing valve **46** designed to maintain generator full-operating pressure upstream of the valve, and a much reduced pressure in the heat recovery components including the high pressure heaters, deaerator, and condenser. The branch conduit **40** which leads to the high pressure heaters is also valved with a flow control and shutoff valve **48**, which is temperature controlled by control means **50**, responsive to temperature at the outlet of the heaters; the second branch conduit **42** to the deaerator being also valved controlled by a shutoff and flow control valve **52**, which is pressure controlled by control means **54**, responsive to the pressure in the deaerator. The third branch conduit **44** leading to the condenser also is valve controlled with shutoff and flow control valve **56**, controlled by pressure responsive control means **58**, responsive to the pressure upstream of this valve.

Also making up the bypass system is a second bypass conduit **60** connected to the first conduit **38** at a point adjacent to the inlet end **62** of the pressure-reducing valve **46**, the second conduit leading back to the main flow path connected to the latter at a point **64** downstream of the point of connection **36** of the first conduit **38**. The second bypass conduit **60** contains a pressure-reducing valve **66**; a shutoff valve **68** being positioned in the main flow path between the points of connection (**36, 64**) of the first and second bypass conduits.

In accordance with the present invention, the pressure-reducing valve **46** in the first bypass conduit **38** is controlled by pressure control means **70** responsive to the pressure at the outlet end of the finishing superheater; whereas the pressure-reducing valve **66** in the second bypass conduit **60** is responsive to conditions at the inlet end of the high pressure turbine **22**, through pressure and load control means **72, 74**, and master controller **76**. Providing an input into the latter is a temperature control signal means **78** responsive to the temperature at the outlet end of the superheater.

Also in accordance with the invention, a primary signal input to the burners **16** is through temperature controller **79** also responsive to temperatures at the outlet end of the finishing superheater.

In operation, during a cold start, the generator is pressurized by starting the feedwater pump **32**, the pressure-reducing valve **46** in the bypass system H maintaining the furnace and superheating circuitry that pressure required for safe operation and firing of the generator. The flow in total is passed through the valve **46** into the branch conduits **40, 42, 44**, through valves **48, 52**, and **56**. Initially during the startup period the pressure-reducing valve **46** may have a set point to maintain only a low pressure, for instance about 600 lbs per square inch, upstream of the valve; and at this point in the startup period, the valve **56** to the condenser may be fully closed and the valves **48** and **52** to the heaters and deaerator may be wide open.

The generator is kept at the low pressure until the temperature of the heated fluid at the finishing superheater outlet reaches about 350° F., at which time, the system pressure may be increased to the full pressure of about 3500 lbs per square inch at the finishing superheater outlet, and 3600 lbs per square inch in the furnace circuitry, by resetting reducing valve **46**. The breakdown in the pressure-reducing valve **46** may be to about 1000 lbs per square inch. Although pegging the deaerator through valve **52** may be delayed until the enthalpy at the outlet of the finishing superheater equals about 400 BTU's per pound, a maximum amount of the startup flow is passed through this valve and the valve **48** to the high pressure heater for optimum heat recovery during this stage of the startup period.

As the enthalpy of the fluid at the finishing superheater outlet further increases, from about 400 to about 500 BTU's per pound, the temperature at the finishing superheater outlet increasing to about 800° F., the regulation of the valves **48, 52** and **56** becomes automatic as follows: The deaerator valve **52** is pegged to maintain a pressure in the deaerator of about 50 lbs per square inch, and is opened dependent upon this pressure. The high pressure heater valve being temperature dependent maintains a maximum flow to the heaters which decreases as the temperatures in the system increases. The remainder of the flow is to the condenser through the valve 56, which is set to open and close so as to maintain the desired 1000 lbs per square inch upstream of the valve. This reduces the pressure drop across the pressure-reducing valve **46** and avoids excessive pressures in the portion of the generator between the low pressure turbine and the feedwater pump.

In the second bypass conduit **60**, upstream of the pressure reducing valve **66**, is shutoff valve **80**. The reason for this valve is that pressure-reducing valves as a general rule will leak, which in this case would undesirably permit water to settle against the turbine throttle valve, item **82**.

When the temperature at the outlet of the finishing superheater reaches about 850° to 900° F., which is well within the superheated vapor range of a temperature enthalpy diagram, the shutoff valve **80** is manually cracked to admit a flow of about 2 to 3 percent of full load flow to the turbine through the return line or second conduit pressure-reducing valve **66**, for warming and rolling the turbine.

Opening of the pressure-reducing valve is accomplished automatically, in accordance with the invention, by means of temperature controller **78** (responsive to the finishing superheater outlet temperature) which activates master controller **76** when the temperature at the finishing superheater outlet reaches a set value, permitting the latter to be responsive through pressure controller **72** to the pressure at the high pressure turbine inlet. The drop in pressure through the pressure-reducing valve is adiabatic, or at constant enthalpy, but because of the degree of superheat at the finishing superheater outlet, the flow at the turbine inlet is still in a vapor state.

The turbine throttle valve **82** at the turbine inlet is responsive to load demand on the turbine. When the turbine is up to temperature, and is ready to be synchronized and loaded, this valve is opened in response to the load demand to supply to the turbine a desired amount of vapor. At this stage of the startup period, the pressure-reducing valve **66** is still pressure responsive (to pressure upstream of the turbine throttle valve). As the turbine throttle valve opens, the pressure downstream of the reducing valve **66** drops causing the controller **72** to open the reducing valve and admit more vapor to the turbine. As an example, controller **72** may be set to maintain a turbine throttle pressure of about 1000 lbs per square inch. As the flow through reducing valve **66** increases, the pressure at the finishing superheater outlet drops causing the main pressure-reducing valve **46** to close to maintain at the finishing superheater outlet the desired 3500 lbs per square inch pressure. This causes the control valve **56** upstream of the condenser to close correspondingly, reducing the flow to the condenser and maintaining 1000 lbs per square inch pressure on the downstream side of valve **46**.

As shown in the graph FIG. **2**, the controller **72** is set at about 1000 lbs per square inch, and when this pressure is reached downstream of the turbine throttle valve, at about 15 percent load (point A) the reducing valve **66** is switched to load characterization through control means **74**, increasing the flow to the turbine in response to load demand; valves **46** and **56** continuing to react as above. Throughout this period, the flow through the finishing superheater is constant, and firing is controlled primarily to maintain a set temperature at the superheater outlet, by control **79**.

This sequence is followed until approximately 21 percent load is reached (point B, FIG. **2**) at which point the bypass valve **66** is about 90 percent open and begins to run out of capacity. At this point the main flow path valve **68** is opened, transfer of the flow from the startup bypass line to the main flow path occurring to the 25 percent load point. At this point, the valve **46** set point is ramped to an overpressure relief setting, further load increases beyond the 25 percent point being obtained in the usual way, by increasing pumping and firing rates. Characterization of the bypass valve **46** and the turbine throttle valve **82** is shown in FIGS. **3** and **4**.

The sequence for a hot restart is slightly different. Again, as with a cold start, there must be the minimum 25 percent circuit flow, with a distribution of the flow through the deaerator and high pressure heater valves **52** and **48**, as required to obtain a desired heat recovery; valve **56** to the condenser maintaining 1500 lbs per square inch on its upstream side. The pressure-reducing valve **46** is set to maintain about 2000 lbs per square inch at the finishing superheater outlet, the main flow path containing, between the primary and finishing superheaters, a third pressure-reducing valve **84** which maintains, in response to pressure controller **85**, the full 3500 lbs per square inch pressure on its upstream side in the primary superheater and furnace circuits.

The reason for the above arrangement is that in a hot restart, heating is not always commenced from the same generator temperature level; that is, the degree to which the generator has cooled will vary. By the same token, the turbine will be at a certain temperature, and a principle criteria will be to match the vapor temperature entering the turbine with the turbine temperature. This is more easily accomplished with the finishing superheater at a lower pressure; because the pressure breakdown at the turbine throttle valve is less; and because at the lower pressure, the heat pickup and outlet temperature in the finishing superheater are more easily controlled.

During the hot start, the firing rate is limited to a value which will not jeopardize the reheater metals, and is continued until an equilibrium temperature at the finishing superheater is reached, about 900° to 950°, at about 2000 lbs per square inch. The turbine is synchronized and loaded to approximately 19 percent load through the bypass valve **66** controlling throttle pressure at about 1000 lbs per square inch, the throttle pressure increasing with the increase in flow through the bypass valve until the capacity of the bypass valve is met. Further loading is achieved by opening valve **84** in the main flow line and increasing the pressure to full load pressure.

In the bypass system, in parallel with valve **46**, is a third conduit **86** containing pressure-reducing valve **88**. The reason for this conduit, and valve, is that since the flow through the finishing superheater is at a lower pressure, the driving force of the flow is less in effect reducing the capacity of the main valve **46**. Accordingly, the conduit **86** and valve **88** will handle this excess flow, valve **88** being pressure responsive as is valve **46**, through controller **70**.

The switching circuit of FIG. **5** illustrates control of the main flow path shutoff valve **68**, in a cold start and hot restart. The power to the shutoff valve **68** is through a first line **90** which has a normally open contact **92** followed by a normally closed contact **94**; or alternatively through a second line **96** in parallel with the first line, having a normally open contact **98**.

The first line **90** is for a hot restart, the normally closed contact **94** being in a normally closed position during a hot restart, but open during a cold start. In the hot start, then, the normally open contact **92** closes when the bypass valve **66** is about 90 percent open, thereby providing power to the main path valve **68** opening the same.

During a cold start, since contact **94** is open, normally open contact **98** in the second line **96** becomes the controlling contact. This contact is closed, with a time delay, when the pressure drop across the shutoff valve **68** is more than or equal to 500 lbs per square inch. The time delay corresponds with the increase in loading so that in a cold start at about 21 percent load, the valve **68** begins to open, and is completely open at 25 percent load.

Advantages of the invention should now be apparent, a principal advantage residing in the considerably simplified controls required in accordance with the present invention. Primarily, since the throughput in the finishing superheater is maintained at a constant level during the startup period, the adjustment of the firing rate need be primarily in response to the temperature demand at the outlet end of the finishing superheating surface, avoiding the complex controls heretofore required where both the flow rate and superheater outlet temperatures changed during the startup period. In the present invention, the flow is pegged at one value in the finishing superheater, and the operator need only wait until the flow at the finishing superheater is up to temperature to warm, roll and load the turbine; once up to temperature, and during loading, swings or excursions in the temperature do not occur.

As a second major advantage, since the flow is through the finishing superheater, during startup, as well as other major surfaces of the generator, the gas is cooled to a greater degree before it reaches the downstream (with respect to the gas flow) reheater surface. For this reason, the unit can be fired at a higher rate, reducing the startup period. Conventionally, the firing rate is less than desired limited by the temperature which the reheater surface can withstand.

As a further advantage, since the generator is at a supercritical pressure, and since switchover from the bypass system to the main flow path, by virtue of the design of the bypass system, need not be undertaken until the enthalpy of the fluid has reached a high value, no flash tank is required; eliminating the costs and other disadvantages associated with a flash tank. A larger header only distributes the flow through the pressure reducing valve into the heat recovery surfaces, deaerator and condenser.

Although the invention has been described with reference to specific embodiments, variations within the scope of the following claims will be apparent to those skilled in the art.

I claim:

1. A once-through vapor generator comprising:
- a main flow path including a plurality of heating surfaces, a point of use, and an outlet end of said heating surfaces connected to said point of use;
- a startup bypass system which includes;
- a first conduit leading from the main flow path from said heating surfaces outlet end;
- a pressure-reducing means in said conduit;
- a second conduit connected adjacent the inlet end of the pressure-reducing means leading back to said main flow path, connected to the latter at a point downstream of the first conduit in communication with said point of use;
- the second conduit also containing a pressure-reducing means including control means comprising a first input means responsive to vapor temperature at the heating surfaces outlet end, and a second input means responsive to vapor conditions at said point of use, said second input means being responsive when said heating surfaces outlet end reaches a predetermined temperature.

2. The generator of claim 1 further including a shutoff valve positioned in the main flow path between the points of connection of the first and second conduits.

3. The generator of claim 2 including a turbine at said point of use, wherein said second input means comprises a first pressure control means responsive to the pressure upstream of the turbine inlet end and a second load control means responsive to the load demand on the turbine; said first input means sensitizing said pressure and load control means when the temperature reaches a predetermined value at said heating surfaces outlet end.

4. The generator of claim 3 wherein said pressure-reducing means in said first conduit includes control means therefor responsive to the pressure at the outlet end of the generator-heating surfaces.

5. The generator of claim 4 further including burner means, and control means therefor responsive to the temperature at the outlet end of said heating surfaces.

6. The generator of claim 5, wherein said heating surfaces include primary and finishing superheating surfaces, said generator further including; pressure-reducing means upstream of said finishing superheating surface arranged to reduce the pressure in the finishing superheater and reduce the pressure breakdown in the pressure-reducing means in said second conduit during a hot restart.

7. A once-through vapor generator for use with a vapor turbine which comprises a main flow path including in series flow relationship radiantly heated surfaces and primary and finishing superheating surfaces, an outlet end for said finishing superheating surface, said primary and finishing superheating surfaces being positioned in high temperature convection zones of said generator;
- a reheating surface positioned in a lower temperature convection zone of said generator;
- a startup bypass system including a first conduit which leads from said main flow path from said finishing superheating surface outlet end;
- pressure reducing means in said conduit;
- a second conduit connected adjacent to the inlet end of said pressure-reducing means leading back to the main flow path, connected to the latter to a point downstream of said first conduit;
- the second conduit containing a pressure-reducing means including control means therefor responsive to turbine inlet pressure and load once the flow at the finishing superheating surface outlet end reaches a predetermined temperature;
- shutoff valve means positioned in the main flow path between the points of connection of the first and second conduits;
- said generator further including between said vapor turbine and radiantly heated surfaces a condenser means, a deaerator and high pressure heat recovery means, in series flow relationship;
- said bypass system including first, second and third branch conduit means extending from the outlet end of the first conduit pressure-reducing means to said high pressure heat recovery means, deaerating means and condenser means, respectively;
- valve means in said branch conduit means, the valve means in said third branch conduit means to said condenser means being responsive to the pressure upstream thereof to maintain a set pressure on the downstream side of said first conduit pressure-reducing means.

8. The generator of claim 7 wherein the pressure-reducing means in said first conduit includes control means responsive to the pressure at said finishing superheating surface outlet end.

9. The generator of claim 8 wherein the control means for said second conduit pressure-reducing means comprises a first input means responsive to vapor temperature at said finishing superheating surface outlet end, and a second input means responsive to the turbine inlet pressure and load once the flow at the finishing superheating surface outlet end reaches a predetermined temperature.

10. A method of starting up a once-through vapor generator which includes heating surfaces, an outlet end therefor, and a point of use connected to said outlet end by a main flow path; comprising the steps of
- passing a startup flow at a constant flow rate through the heating surfaces to said outlet end;
- bypassing the full startup flow at said outlet end from said point of use;
- firing said generator at a rate responsive to temperature demand at said heating surfaces outlet end;
- returning a portion of the bypassed flow to the main flow path when the temperature at the heating surfaces outlet end reaches a predetermined value; and
- increasing the amount of flow returned to said main flow path in response to demand at said point of use.

11. The method of claim 10 wherein said bypassed flow is reduced in pressure and used in the reduced pressure state for the recovery of heat therein.

12. The method of claim 11 wherein the portion of the bypassed flow returned to the main flow path is also reduced in pressure to a set pressure, the amount returned to the main flow path during part of the startup period being that required to maintain said set pressure.

13. The method of claim 10, wherein said generator includes primary and finishing superheating surfaces further in-

cluding the step of reducing the pressure upstream of said finishing superheating surface to a pressure intermediate the pressure upstream of the finishing superheating surface and the reduced pressure of the flow returned to said main flow path.