

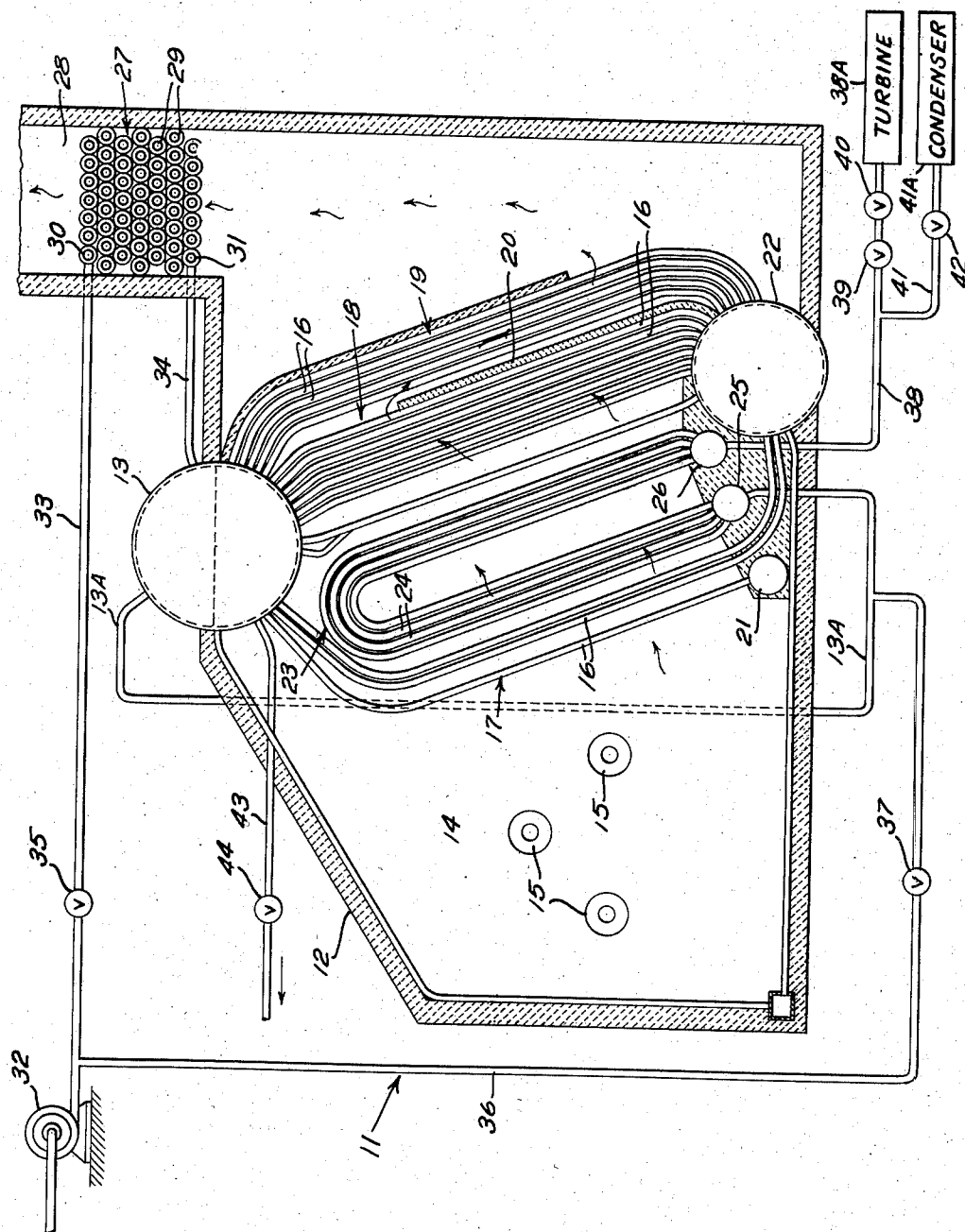
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METHOD FOR GENERATING VAPOR

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METHOD FOR GENERATING VAPOR

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This invention relates to vapor generators and more particularly to a method for generating vapor under rapid start-up conditions.

In some instances it is desirable to provide for rapid start-ups of a vapor generator from a "shut-down" or "cold" condition but such start-ups have adverse effects on the vapor generator. For example, numerous start-ups and shut-downs cause failure of the pressure parts, such as superheater tubes and boiler tubes, which failure is due to overheating of the parts and consequent fatigue and loss of rupture strength in the tubes.

It is an object of the present invention to provide a novel method for generating vapor under rapid start-up conditions and for firing a vapor generator at high rates immediately after light-off and throughout the whole start-up period.

The present invention, therefore, contemplates a novel method wherein a liquid, under pressure, is provided in the vapor generating tubes and superheater tubes during light-off of the vapor generator and throughout the whole start-up period.

The above and other objects and advantages of the present invention will appear more fully hereinafter from a detailed description which follows, taken together with the accompanying drawing wherein the single figure thereof illustrates a diagrammatic transverse section of an embodiment of the invention.

Referring to the drawing, the apparatus of the present invention is disclosed as embodying a vapor generator 11 which comprises a setting 12 having a vapor and liquid vessel 13 disposed in the upper portion thereof, and a furnace or combustion chamber 14 fired by a plurality of burners 15. A plurality of boiler or vapor generating tubes 16 are arranged in setting 12 in three spaced banks 17, 18 and 19; banks 18 and 19 having a baffle 20 therebetween. The upper ends of the vapor generating tubes of each bank are connected to vapor and liquid vessel 13 while the lower ends of the tubes of bank 17 are connected to a liquid header 21 and a liquid drum 22, and those of banks 18 and 19 are connected to drum 22.

A superheater 23, comprising substantially U-shaped superheater tubes 24, is disposed between banks 17 and 18 and is provided with a superheater inlet header 25 and a superheater outlet header 26. A vapor conduit 13A is connected at one end to the upper portion of vessel 13 and at the other end to inlet header 25 to provide the latter with vapor during normal operation of the vapor generator. An economizer 27 is disposed in a substantially vertical gas passage 28 which discharges combustion gases from the setting. Economizer 27 comprises a tubular coil 29 which has an inlet 30 and an outlet 31. A feed pump 32 is connected to a source of liquid (not shown), as for example water, and at its discharge side is connected to inlet 30 of economizer 27 by a conduit 33. Outlet 31 of economizer 27 is connected to vessel 13 by a conduit 34 to provide the vessel with water. A valve 35 is provided in conduit 33 to control the flow of water to economizer 27. A bypass conduit 36 is connected at

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one end to conduit 33 upstream of valve 35 and is connected at its other end to conduit 13A. A valve 37 is connected in line 36 to control flow of water to inlet header 25. A superheater outlet conduit 38 is connected to outlet header 26 of superheater 23 and communicates the latter with a turbine 38A. A turbine shut-off valve 39 and a throttling valve 40 are connected in outlet conduit 38 for controlling the flow and the pressure, respectively, of the superheated steam to the turbine. A bypass conduit 41 is connected to conduit 38 and at its other end to the condenser 41A. A valve 42 is arranged in line 41 and serves as a pressure controller during start-up of the vapor generator, as will be presently set forth herein-after. A blow down conduit 43 is connected to the lower portion of vessel 13 and the line is provided with a valve 44 to control the flow of liquid therethrough.

In operation, when the vapor generator is to be started up from a "cold" or "shut-down" condition, turbine shut-off valve 39 and throttling valve 40 in conduit 38 are closed to prevent flow to the turbine. Valve 44 in line 43 is also closed and valve 35 in conduit 33 is opened to provide flow of feed water from feed pump 32 to economizer 27. Water from economizer 27 flows into vessel 13 thence downwardly into vapor generating tubes 16 of banks 17, 18 and 19, and header 21 and liquid drum 22, respectively. When economizer 27, vessel 13 and vapor generating tubes 16 are completely filled with water, valve 35 is closed to thereby effect a completely sealed circuit from which the water cannot flow. Valve 37, in conduit 36, is opened to provide flow of feed water through the following circuit: Feed pump 32, conduit 33, conduit 36, valve 37, conduit 13A, superheater inlet header 25, tubes 24 of superheater 26, superheater outlet header 26, conduit 38 and line 41. Valve 42, in line 41, is opened sufficiently to cause a desired pressure at the superheater outlet. Burners 15 are then ignited at a high firing rate. The resulting combustion gases formed in chamber 14 flow over tubes 16 of bank 17, then in heat exchange relationship with superheater tubes 24 and tubes 16 of banks 18 and 19 whence the gases pass upwardly through gas passage 28 and in heat exchange relationship with tubular coil 29 of economizer 27.

Shortly after light-off, the water in tubes 16 reaches a temperature slightly above the boiling point at the metal-wall interface. The water boils locally and the main body of water in the tubes is heated by condensation of some or all the bubbles formed at the metal-wall interface. Since the system is completely filled with water and is closed, the pressure of the water causes the latter to be subsaturated that is, the pressure of the liquid is in excess of the pressure at which vapor and liquid are in a state of thermo-dynamic equilibrium, so that the steam bubbles formed are not large enough to cause the tubes to become steam bound and thereby prevent circulation. Steam formed in the tubes 16 and which is not condensed therein flows to vessel 13 in admixture with the subsaturated water in the latter where the steam (bubbles) is condensed to heat the water. Consequently, steam-free water flows from the drum into the downcomer tubes 16 away from the furnace, and enters the heated or riser tubes 16, closer to the furnace, to provide for ready circulation in the system. In this manner overheating of the boiler parts is prevented. The superheater is also protected from overheating because of flow of fluid therethrough. The system pressure is utilized to cause a flow of fluid through the superheater regulated in amount by valve 42 to keep the superheater metal parts sufficiently cool at the high initial firing rate.

When the temperature of the water in the vapor generating elements reaches the desired or rated temperature value, valve 37 in line 36 and valve 42 in line 41 are closed, and valve 44 in blow down line 43 is opened to

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decrease the level of the water in drum 13 to the normal operating level. Valve 35 in conduit 33 is then opened to again provide flow of water to economizer 27 and turbine shut-off valve 39 and throttling valve 40 are also opened to permit flow of steam through line 38 and to the turbine 38A.

If some steaming should occur in economizer 27, valve 35 may be opened slightly to provide water to the economizer, or a bypass conduit may be provided to bypass the valve 35 to deliver a small flow of water to economizer during start-up. In the present description, the feed water pump is disclosed as pressurizing the water in the boiler but it is to be understood that any auxiliary pump, or other means may be employed for such pressurizing purpose.

It will now be apparent that the present invention provides a novel method for generating vapor under rapid start-up conditions to greatly reduce the time necessary for starting vapor generators as compared with conventional arrangements. The positive pressurizing of the boiler parts of the vapor generator causes the bulk of the water therein to be subsaturated under rapid start-up conditions, whereby circulation through the tubes is enhanced by virtue of minimum volume occupied by steam at the pressure maintained on the system. Consequently, overheating of the boiler parts of the vapor generator is prevented. By providing a constant flow of water through the superheater during the start-up period overheating of the super-heater also is prevented.

Inasmuch as various changes may be made in the particular form, location, and arrangement of parts of the apparatus disclosed and in the steps of the method and other sequences disclosed without departing from the principles of the invention, it will be understood that the invention should not be limited excepting by the scope of the appended claims.

What is claimed is:

1. A method for rapid start-up of a vapor generator to raise liquid therein to a temperature and pressure for the production of vapor, said vapor generator including a circuit containing a vapor and liquid vessel and vapor generating tubes in communication with each other, said circuit having an inlet and an outlet both in communication with a source of liquid under pressure, the circuit inlet receiving liquid from said source and the circuit outlet being subjected to the pressure of said source and adapted to discharge vapors from said circuit, the steps comprising, conducting liquid from the liquid source to the circuit inlet to fill the vapor and liquid vessel and vapor generating tubes completely with liquid, closing off communication between the source of liquid and the circuit inlet but maintaining communication between the liquid source and the circuit outlet to prevent flow of liquid from said circuit and to cause the pressure of said liquid source to be impressed upon the liquid in the circuit to thereby cause subsaturation of the liquid during start-up firing of the vapor generator, firing the vapor generator during start-up at a rapid rate until the liquid in the vapor generating tubes is raised to the desired temperature and pressure to produce vapor, withdrawing a portion of the liquid from the vapor and liquid vessel to reduce the liquid in said vessel to a normal operating level, cutting off communication between the source of liquid and the circuit outlet to permit discharge of vapors from the circuit, and re-opening communication between the source of liquid and the circuit inlet to permit flow of liquid to the latter.

2. A method of rapid start-up of a vapor generator to raise liquid therein to a desired temperature and pressure to provide vapor, said vapor generator including a circuit containing a vapor and liquid vessel and vapor generating tubes in communication with each other, said circuit having an inlet and an outlet both in communication with a source of liquid under pressure, the circuit

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inlet receiving liquid from said source and the circuit outlet being subjected to the pressure of said source and adapted to discharge vapors from said circuit, and a superheater having an inlet in communication with the circuit outlet and with the source of liquid and having an outlet in communication with a vapor operated turbine, said superheater outlet also being in communication with a condenser, the steps comprising, conducting liquid from the liquid source to the circuit inlet to fill the vapor and liquid vessel and the vapor generating tubes completely with liquid, closing off communication between the source of liquid and the circuit inlet but maintaining communication between the source and the circuit outlet and superheater inlet to prevent flow of fluid from said circuit and to cause the pressure of the source of liquid to be impressed upon the liquid in the circuit to thereby cause subsaturation of the liquid during start-up firing of the vapor generator, cutting off communication between the superheater outlet and the vapor operated turbine but maintaining communication between the superheater outlet and condenser to provide a flow of liquid through the superheater and into the condenser during start-up, firing the vapor generator during start-up at a rapid rate until the liquid in the vapor generating tubes is raised to the desired temperature and pressure to produce vapor, withdrawing a portion of the liquid from the vapor and liquid vessel to reduce the liquid therein to a normal operating level, cutting off communication between the source of liquid and the circuit outlet to permit discharge of vapors from the circuit, closing off communication between the superheater outlet and the condenser, reopening communication between the superheater outlet and the vapor operated turbine, and reopening communication between the source of liquid and the circuit inlet to permit flow of liquid to the latter.

3. A method for rapid start-up of a vapor generator to bring liquid in the latter to a desired temperature and pressure for the production of vapor, said vapor generator including an economizer in communication with a feed liquid pump, a circuit containing vapor generating tubes and a vapor and liquid vessel in communication with each other, said circuit having an inlet in communication with the feed liquid pump, the circuit inlet receiving liquid from said economizer and the circuit outlet being subjected to the pressure of said feed liquid pump and adapted to discharge vapors from said circuit, and a superheater having an inlet in communication with the circuit outlet and with the feed liquid pump and having an outlet in communication with a vapor operated turbine, said superheater outlet also being in communication with a condenser, the steps comprising, delivering liquid from the feed liquid pump to the economizer, passing the liquid from the economizer to the circuit inlet until the vapor and liquid vessel and the vapor generating tubes are completely filled with liquid, closing off communication between the feed liquid pump and the economizer but maintaining communication between the feed liquid pump and the circuit outlet and the superheater inlet to prevent flow of fluid from the circuit and to cause the pressure of the feed liquid pump to be impressed upon the liquid in the circuit to thereby cause subsaturation of the liquid during start-up firing of the vapor generator, cutting off communication between the superheater outlet and the vapor operated turbine but maintaining communication between the superheater outlet and condenser to provide a flow of liquid through the superheater and into the condenser during start-up, firing the vapor generator during start-up at a rapid rate until the liquid in the vapor generating tubes is raised to the desired temperature and pressure to produce vapor, withdrawing a portion of the liquid from the vapor and liquid vessel to reduce the liquid therein to a normal operating level, closing off communication

between the feed liquid pump and the circuit outlet and superheater inlet to permit flow of vapors from the circuit outlet to the superheater inlet, cutting off communication between the superheater outlet and the condenser and reopening communication between the superheater outlet and the vapor operated turbine, and reopening communication between the feed liquid pump and the economizer to permit flow of liquid through the economizer and the circuit.

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