Oct. 31, 1950

M. FRISCH

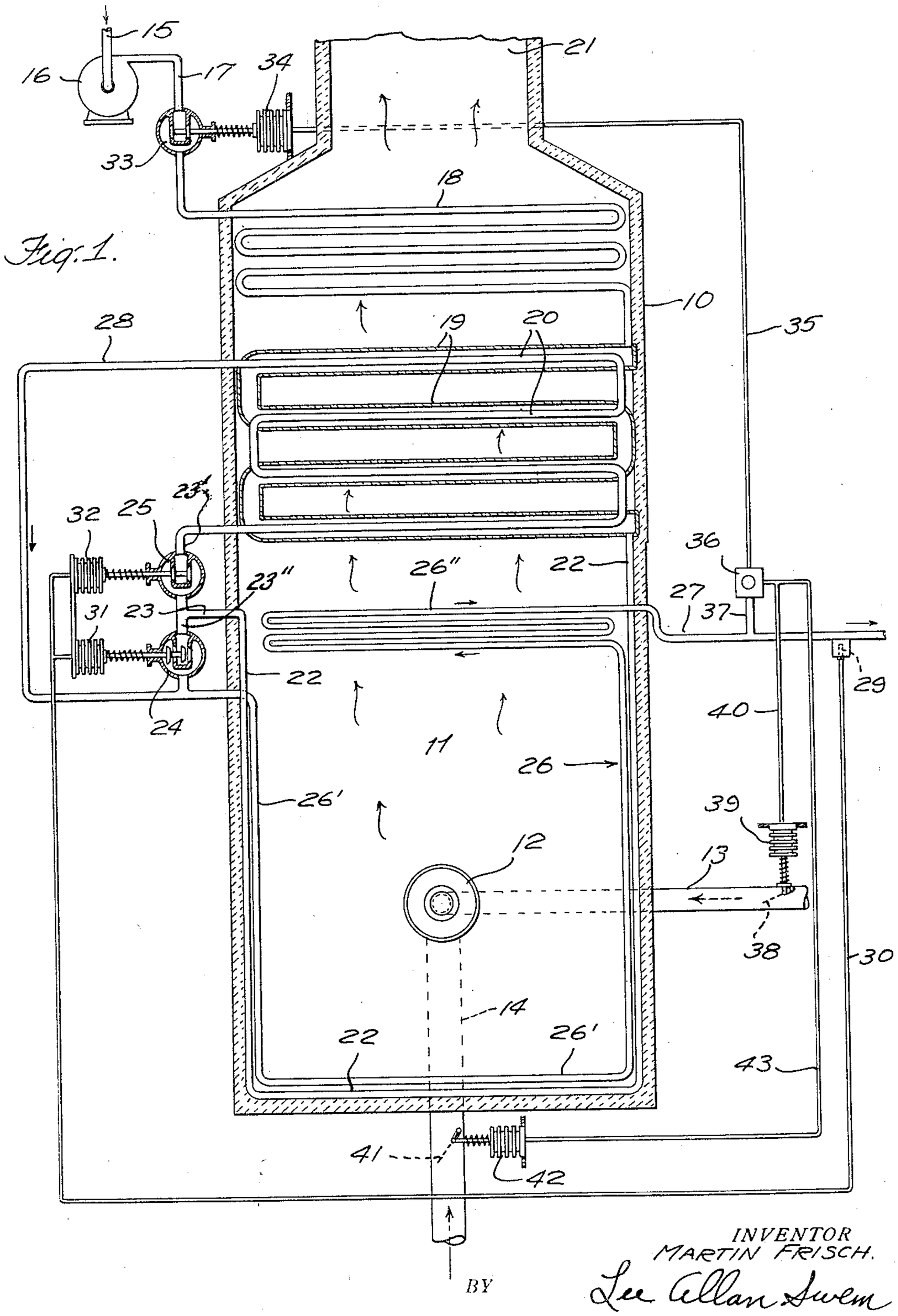
2,527,539

VAPOR GENERATING APPARATUS WITH AUTOMATIC FUEL CONTROL

Filed Sept. 21, 1944

2 Sheets-Sheet 1

Fig. 1.



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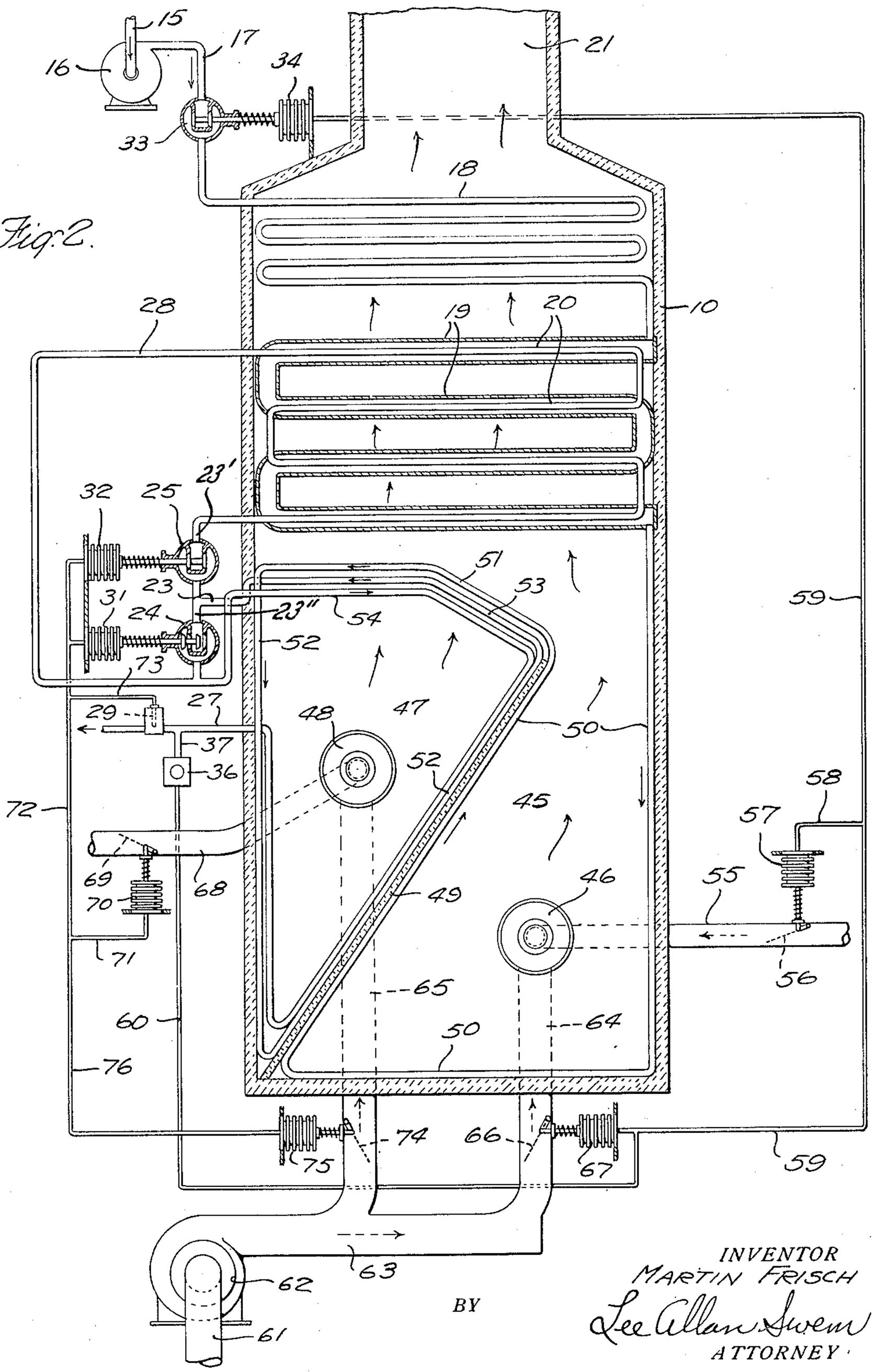
2 Sheets-Sheet 2

Fig. 2.



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VAPOR GENERATING APPARATUS WITH AUTOMATIC FUEL CONTROL

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Application September 21, 1944, Serial No. 555,121

29 Claims. (Cl. 122—448)

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This invention relates to vapor generators, and more particularly pertains to vapor generators of the forced circulation, once-through type, and to controls therefor.

The invention provides a once-through vapor generator and superheater which is regulated automatically to deliver superheated vapor at the desired temperature and pressure and in the required quantity, with little or no lag in the response to changes in conditions requiring regulation.

The invention will be understood from the following description considered in connection with the acompanying drawings forming a part thereof, and in which:

Fig. 1 is a more or less diagrammatic vertical sectional view of a steam generator and superheater embodying the invention, and

Fig. 2 is a similar view of another form of the invention.

Like characters of reference refer to the same or to similar parts throughout the several views.

Referring to Fig. 1 of the drawings, reference character 10 designates the setting of a once-through, forced circulation steam generator and superheater. The setting has a furnace 11 in the lower portion thereof which is fired by firing means, a fuel burner 12, to which fuel is supplied through line 13 and air is supplied through line 14. Feed water is conducted to a vapor generating portion of a combined vapor generating and vapor desuperheating section through means for supplying fluid thereto which means comprises line 15 through which the water is conducted to a feed pump 16 which pump forces it through line 17 into a water heating or an economizer section 18 in the upper part of the setting. Heated water, or a mixture of heated water and steam, is conducted from the economizer section 18 to a steam generating section 19 located in the intermediate part of the setting 10. This steam generating section is of the double tube type, and the water, or water and steam mixture, from the economizer flows through the outer tubes in the space between the outer tubes 19 and the inner tubes 20. Both the economizer section 18 and the steam generating section 19 are disposed in the path of the gases produced in furnace 11, and which flow in a generally vertically upward direction to the flue 21. The steam generating section 19 is connected to a first superheater in the setting which comprises a radiant generating and superheating section 22. Section 22, in the form shown, comprises a plurality of tubes lining the side walls and bottom of the furnace chamber 11.

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In the first part of the section 22, the evaporation of the water is completed and in the last part thereof the steam is superheated to a temperature intermediate the saturation temperature and the final desired temperature. The steam flowing from section 22 enters means connecting the first superheater with a second superheater 26 in the setting which means comprises a line 23 having other conducting means or a first connection, branch line 23', and further conducting means or a second connection, branch line 23''. Branch lines 23' and 23'' have means therein controlled by the temperature of the superheated steam flowing from a second superheater 26 in the setting which means is for controlling the flow of steam from said first superheater to said second superheater and to tubes 20 of a desuperheating section and comprises a second valve 24 in branch 23'' on one side of the outlet of section 22, and also a first valve 25 in branch 23' on the other side of the outlet of section 22. Valve 24 controls the direct flow of steam into a superheater 26 which in the form shown, has a radiant superheating section 26' lining the side walls and bottom of the furnace 11 and a convection superheating section 26'' disposed in the furnace 11 in the path of gases flowing therefrom into the flue 21. Superheated steam is conducted from the generator through line 27. The tubes of radiant superheater section 26' may be disposed adjacent the walls of the furnace with the tubes of the section 22 in any desired manner, for example by alternating the tubes 26' with the tubes 22. For clarity of illustration, the tubes 26' are shown in Fig. 1 as disposed inwardly of the tubes 22, although it will be understood that they may be disposed in alignment with the tubes 22 along the wall of the furnace.

Part of the steam flowing from the section 22 may be passed through the desuperheating section comprising tubes 20 which are disposed mainly within the tubes of the generating section 19. Valve 25 controls the quantity of steam flowing to the desuperheating section 20. Desuperheated steam flows through other conducting means or a third connection line 28 into the superheater 26 where it mixes with steam from the section 22 which has passed through valve 24. Valves 24 and 25 are actuated in response to the temperature of the superheated steam flowing from the generator through line 27. To this end, a thermostat 29 is disposed in line 27 and this thermostat is connected through a line 30 with bellows 31 and 32 which actuate valves 24 and 25 respectively. The arrangement is such

that as the temperature of the superheated steam flowing through line 27 increases, valve 24 will be moved toward closed position and valve 25 will be moved toward opened position, and as the temperature of the superheated steam decreases, valve 24 will be moved toward opened position and valve 25 will be moved toward closed position. With this arrangement, as the temperature of the superheated steam flowing through line 27 increases, a proportionately greater quantity of the steam leaving the section 22 will flow through the desuperheater 20 before flowing into the radiant superheater 26' and convection superheater 26'', and contrariwise as the temperature of the superheated steam diminishes, a smaller portion of the steam flowing from section 22 will flow through the desuperheater 20. When steam flows through the desuperheater 20, additional heat is transmitted to the water flowing through the evaporating section 19 and additional evaporation in this section results, which increases the resistance to the flow of the water, or the water and steam mixture, through the evaporating section, and this resistance to flow in the evaporating section 19 immediately results in a reduction of the pressure at the boiler outlet, or in the line 27.

Feed line 17 is provided with means for controlling the supply of fluid to the vapor generating section in response to the pressure of steam flowing from the second superheater in the setting and comprises a control valve 33 which is actuated by a bellows 34, which in turn is operated in response to variations in pressure of the steam flowing through line 27, to which the bellows is connected through line 35, pressure regulator control box 36 and line 37. Means for controlling the firing of the furnace in response to the pressure of the superheated steam flowing from the second superheater 26 is also provided. The quantity of fuel supplied to the burner 12 is controlled, in the form shown, by a valve 38 in fuel supply means comprising line 13, which is actuated by a bellows 39 which also operates in response to variations in pressure in line 27 to which it is connected through line 40, control box 36 and line 37. The quantity of air supplied to the burner 12 is controlled by a valve 41 in the air supply means comprising a line 14, which is actuated by a bellows 42 which also operates in response to pressure variations in line 27, to which it is connected through line 43, control box 36 and line 37. The arrangement is such, that upon an increase in pressure of the superheated steam flowing through line 27, valve 33 will be moved toward closed position to decrease the quantity of water supplied to the economizer section 18, and valves 38 and 41 will be moved toward closed position to decrease the quantity of fuel and air supplied to the burner 12. Upon a reduction in pressure of the superheated steam flowing from the boiler through line 27, valve 33 will be moved toward open position to permit a greater quantity of water to be supplied to the economizer section 18 and to the evaporating section 19, and valves 38 and 41 will be moved toward open position to increase the quantity of fuel and air supplied to the burner 12.

In operation, feed water is supplied to the boiler by feed pump 16, and after flowing through the economizer section 18, it flows into and through the evaporating section 19 and through the radiant evaporating and superheating section 22. The steam flowing from section 22 flows into line 23, and depending upon the positions of the

valves 24 and 25, part or all of the steam will flow through the desuperheating section 20 and thence into the superheater 26, or part or all of the steam will by-pass the desuperheating section and will flow into the superheater 26. The steam, after flowing through the radiant superheating section 26' of the superheater 26 passes into the convection superheating section 26''. The superheated steam at the desired temperature will flow from the boiler through line 27. If the temperature of the steam flowing through line 27 rises, it may be anticipated that such rise in temperature is the result of a reduced demand for steam and that such reduced demand will cause an increase in pressure of the steam flowing through line 27. The increase in temperature will cause valve 24 to be moved toward closed position and valve 25 to be moved toward open position, which will permit steam flowing from section 22 to flow through the desuperheating section 20 or will increase the flow of steam through the desuperheating section. Such flow or increase of flow, will cause additional evaporation in the evaporating section 19 which will increase the resistance to flow of water, or steam and water, through the evaporating section 19 momentarily before the pressure regulator will act through the valve 33 to decrease the flow of feed water into the boiler. In this manner, the effect of diverting steam to the desuperheater upon an increase in temperature of the superheated steam flowing through line 27 in order to adjust the temperature in line 27, has the effect of anticipating the pressure regulation and thereby eliminating or decreasing the lag which normally would be present if reliance were had solely upon the pressure regulation. The increased pressure, in addition to moving valve 33 toward closed position will also move valves 38 and 41 toward closed positions and will diminish the flow of fuel and air to the burner 12, thereby effecting a reduction in the pressure of the steam flowing through line 27. Upon a drop in temperature of the superheated steam flowing through line 27, it may be anticipated that this is due to the fact that the demand for superheated steam has increased and steam is taken out of the boiler at a greater rate, resulting in a drop in pressure at the boiler outlet. The temperature regulator will operate to diminish or stop the flow of steam through the desuperheater 20, which will reduce the evaporation in section 19 and will momentarily increase the flow of water, or steam and water, through the evaporating section for a given setting of the feed water control valve 33. This momentary increase in flow through the evaporating section, will anticipate the pressure control of the valve 33 and as previously described, will reduce or eliminate the lag which normally would occur in the response to the new conditions requiring pressure regulation.

In the form of the invention shown in Fig. 2, the control system is employed with a multi-furnace steam generator of the forced circulation, once-through type. The steam generator has a boiler furnace 45 fired by a fuel burner 46, and a superheater furnace 47 fired by a fuel burner 48. A vertically inclined baffle 49 separates the furnaces 45 and 47. Water or steam, or both, flowing from the evaporating section 19 is conducted into and through conducting means comprising a radiant section 50, constituting an evaporating or superheating zone, or both, having tubes which line the side walls and bottom of the boiler furnace 45, and tubes 51 extending across

the upper end of the superheater furnace 47. From tubes 51 the steam, or steam and water mixture, flows into and through a first superheater in the superheater furnace, consisting of radiant superheating tubes 52 extending along the side walls of the superheater furnace 47. From radiant superheater 52, the steam flows through tubes 53 which also extend across the upper end of superheater furnace 47, and into the tube 23 from which the steam flows through valve 24 or valve 25, or through both of these valves, depending upon their settings. Steam flowing through valve 25 flows through the desuperheating section 20 and then through line 28 into a second superheater in the superheater furnace, consisting of radiant superheating section 54. Superheated steam at the desired temperature flows from the boiler through line 27. Steam flowing from the section 52 and through tubes 53 and valve 24, flows directly into the superheating section 54.

Means for controlling the firing of both furnaces in response to the pressure of the superheated steam flowing from superheater 54, the second superheater in the superheater furnace, is also provided. Fuel is conducted to burner 46 of the boiler furnace 45 through a fuel line 55 which is controlled by a valve 56 actuated by a bellows 57 which is operated in response to the pressure of the steam flowing through line 27 to which it is connected through lines 58, 59 and 60, control box 36, and line 37. Air is supplied to both burners 46 and 48 through duct 61 through which it is drawn by fan 62 and is forced thereby through duct 63 and into air ducts 64 and 65 which conduct air to the burners 46 and 48 respectively. The quantity of air supplied to burner 46 is controlled by valve 66 controlled by bellows 67 which is actuated in response to the pressure of the superheated steam in line 27, being connected therewith through line 60, control box 36 and line 37. The quantity of fuel and air delivered to superheater burner 48 is controlled in response to temperature variations of the superheated steam flowing through line 27. Fuel is supplied through line 68 and the quantity thereof is controlled by valve 69 actuated by bellows 70 and connected to thermostat 29 in line 27 through lines 71, 72 and 73. The quantity of air supplied to burner 48 through duct 65 is controlled by valve 74 actuated by bellows 75 which is connected to thermostat 29 through lines 76, 72 and 73. As in the form shown in Fig. 1, the valves 24 and 25 are actuated in response to variations in temperature of the superheated steam flowing through line 27. Valve 33 which controls the feed to the boiler, is actuated in response to variations in pressure of the steam flowing through line 27.

The operation is essentially the same as the operation of the boiler illustrated in Fig. 1, excepting that for greater sensitivity of control, the superheater furnace firing is controlled from the temperature of the superheated steam while the boiler furnace firing is controlled from the pressure of the superheated steam. The action of the desuperheater section 20 is the same as in the form shown in Fig. 1, with the result that the operation of the desuperheating section anticipates the changes required by temperature variations of the superheated steam and acts before the other temperature and pressure controls act, thereby reducing or eliminating the lag which would be present otherwise in the response to meet the changed conditions.

With apparatus embodying and employing the

invention, complete automatic regulation of once-through forced circulation boilers is provided to produce superheated steam at a substantially constant temperature at all loads on the boiler, and in which fluctuations in pressure and temperature are minimized. Moreover, it will be observed that with systems embodying the invention, there is always the full allotted flow through the radiant heating sections, such as section 22 of Fig. 1, and sections 50 and 52 of Fig. 2.

The term "steam" as used in the specification and the term "vapor" as used in the claims shall means vapor generated from water or from any other liquid.

Changes may be made in the form, location and relative arrangement of the several parts of the apparatus disclosed without departing from the principles of the invention. For example, in lieu of employing a feed water control valve such as valve 33, the pressure control may be arranged to vary the speed of feed pump 16 to obtain the same result. Additionally, instead of employing valves in the fuel lines and air ducts to the burners, the temperature and pressure regulators may be arranged to control the speed of the fuel oil pump or the speed of the fan supplying air to the burners. In view thereof, it will be understood that the invention is not to be limited excepting by the scope of the appended claims.

What is claimed is:

1. Vapor generating apparatus comprising a setting, a furnace in the setting, means for firing the furnace, a combined vapor generating and vapor desuperheating section in the setting disposed in heat exchange relationship with the gases produced in the furnace, means for supplying fluid to said section, a first superheater in the setting, a second superheater in the setting, means connecting the first superheater with the second superheater and the desuperheating section, the section being arranged so that the fluid and superheated vapor flow in indirect heat exchange relationship with each other, means controlled by the temperature of the superheated vapor flowing from the second superheater for controlling the flow of vapor from the first superheater to the second superheater and to the desuperheating section, and means for controlling the supply of fluid to the vapor generating section in response to the pressure of the superheated vapor flowing from the second superheater.

2. Vapor generating apparatus comprising a setting, a furnace in the setting, means for firing the furnace, a combined vapor generating and vapor desuperheating section in the setting disposed in heat exchange relationship with the gases produced in the furnace, means for supplying fluid to said section, a first superheater in the setting, a second superheater in the setting, means connecting the first superheater with the second superheater and the desuperheating section, the section being arranged so that the fluid and superheated vapor flow in indirect heat exchange relationship with each other, means controlled by the temperature of the superheated vapor flowing from the second superheater for controlling the flow of vapor from the first superheater to the second superheater and to the desuperheating section, means for controlling the supply of fluid to the vapor generating section in response to the pressure of the superheated vapor flowing from the second superheater, and means for controlling the means for firing the furnace in response to the pressure of the super-

heated vapor flowing from the second superheater.

3. Vapor generating apparatus comprising a setting, a furnace in the setting, at least one fuel burner for firing the furnace, a combined vapor generating and vapor desuperheating section in the setting disposed in heat exchange relationship with the gases produced in the furnace, means for supplying fluid to said section, a first superheater in the setting, a second superheater in the setting, means connecting the first superheater with the second superheater and the desuperheating section, the section being arranged so that the fluid and superheated vapor flow in indirect heat exchange relationship with each other, means controlled by the temperature of the superheated steam flowing from the second superheater for controlling the flow of vapor from the first superheater to the second superheater and to the desuperheating section, means for controlling the supply of fluid to the vapor generating section in response to the pressure of the superheated vapor flowing from the second superheater, means for supplying fuel to said burner, means for supplying air to said burner, and means for controlling the quantity of fuel and air supplied to said burner in response to the pressure of the superheated vapor flowing from the second superheater.

4. Vapor generating apparatus comprising a setting, a furnace in the setting, at least one fuel burner for firing the furnace, a combined vapor generating and vapor desuperheating section in the setting, both the vapor generating portion and the desuperheating portion of said section being disposed in the path of flow of the gases produced in the furnace, the portions being arranged so that fluid and superheated vapor flow in indirect heat exchange relationship with each other, means for supplying fluid to the generating portion of said section, a first radiant superheater in the furnace, a first connection between said superheater and the desuperheating portion of said section, a first valve in said connection, a second superheater in said furnace, a second connection between said first and second superheaters, a third connection between the outlet of the desuperheating portion of said section and the second superheater, a second valve in said second connection, and means for operating said valves in response to the temperature of the superheated vapor flowing from said second superheater, said valve operating means being arranged to move the first valve toward open position and the second valve toward closed position upon an increase in temperature and to move the first valve toward closed position and the second valve toward open position upon a decrease in temperature.

5. Vapor generating apparatus of the character defined in claim 4, in which the quantity of fluid supplied to said section is controlled in response to the pressure of the superheated vapor flowing from the second superheater.

6. Vapor generating apparatus of the character defined in claim 4, in which the intensity of firing of the at least one fuel burner is controlled in response to the pressure of the superheated vapor flowing from the second superheater.

7. Vapor generating apparatus of the character defined in claim 4, in which the quantity of fluid supplied to said section and the intensity of firing of the at least one fuel burner is controlled in response to the pressure of the superheated vapor flowing from the second superheater.

8. Vapor generating apparatus comprising a setting, a furnace in the setting, at least one fuel burner for firing the furnace, a combined vapor generating and vapor desuperheating section in the setting, both the vapor generating portion and the desuperheating portion of said section being disposed in the path of flow of the gases produced in the furnace, the portions being arranged so that fluid and superheated vapor flow in indirect heat exchange relationship with each other, means for supplying fluid to the generating portion of said section, a first radiant superheater in the furnace, a first connection between said superheater and the desuperheating portion of said section, a first valve in said connection, a second superheater having a radiant superheating section and a convection superheating section disposed in said furnace, a second connection between said first and second superheaters, a third connection between the outlet of the desuperheating portion of said section and the second superheater, a second valve in said second connection, and means for operating said valves in response to the temperature of the superheated vapor flowing from said second superheater, said valve operating means being arranged to move the first valve toward open position and the second valve toward closed position upon an increase in temperature and to move the first valve toward closed position and the second valve toward open position upon a decrease in temperature.

9. Vapor generating apparatus comprising a setting, a furnace in the setting, at least one fuel burner for firing the furnace, a combined vapor generating and vapor desuperheating section in the setting disposed in the path of flow of the gases produced in the furnace, means for supplying fluid to the generating portion of said section, a superheater furnace in the setting, at least one fuel burner for firing the superheater furnace, a first superheater in the superheater furnace, conducting means for conducting vapor from the vapor generating portion of said section to the first superheater, a second superheater in the superheater furnace, other conducting means for conducting vapor from the first superheater to the desuperheating portion of said section and from said portion to the second superheater, further conducting means for conducting vapor directly from the first to the second superheater, means responsive to the temperature of the vapor flowing from the second superheater for controlling the quantity of vapor flowing from the first superheater to the desuperheating portion of said section, and means for controlling the quantity of fluid delivered to the generating portion of said section in response to the pressure of the superheated vapor flowing from the second superheater.

10. Vapor generating apparatus comprising a setting, a furnace in the setting, at least one fuel burner for firing the furnace, a combined vapor generating and vapor desuperheating section in the setting disposed in the path of flow of the gases produced in the furnace, means for supplying fluid to the generating portion of said section, a superheater furnace in the setting, at least one fuel burner for firing the superheater furnace, a first superheater in the superheater furnace, conducting means for conducting vapor from the vapor generating portion of said section to the first superheater, a second superheater in

the superheater furnace, other conducting means for conducting vapor from the first superheater to the desuperheating portion of said section and from said portion to the second superheater, further conducting means for conducting vapor directly from the first to the second superheater, means responsive to the temperature of the vapor flowing from the second superheater for controlling the quantity of vapor flowing from the first superheater to the desuperheating portion of said section, means for controlling the quantity of fluid delivered to the generating portion of said section in response to the pressure of the superheated vapor flowing from the second superheater, means for controlling the intensity of firing of the at least one burner in said furnace in response to the pressure of the superheated vapor flowing from the second superheater, and means for controlling the intensity of firing of the at least one burner for the superheater furnace in response to the temperature of the superheated vapor flowing from the second superheater.

11. Vapor generating apparatus comprising a setting, a furnace in the setting, at least one fuel burner for firing the furnace, a combined vapor generating and vapor desuperheating section in the setting disposed in the path of flow of the gases produced in the furnace, means for supplying fluid to the generating portion of said section, a radiant heating section in said furnace connected with the generating portion of the first mentioned section, a superheater furnace in the section separated from said furnace, at least one fuel burner for firing the superheater furnace, a first superheating section in the superheater furnace connected with the radiant heating section in said furnace, a second superheater in the superheater furnace, a first connection between the first superheater and the desuperheating portion of said first mentioned section, a second connection from the first to the second superheater, a third connection from the outlet of the desuperheating portion of said first mentioned section to the second superheater, a first valve in said first connection, a second valve in said second connection, means for operating said valves substantially simultaneously in response to the temperature of the vapor flowing from the second superheater section so that upon a rise in temperature of the vapor flowing from the second superheater section, the valve in said first connection will be moved toward open position and the valve in the second connection will be moved toward closed position and upon a fall in temperature of said vapor, the valve in the first connection will be moved toward closed position and the valve in the second connection will be moved toward open position, means for controlling the flow of fluid to the generating portion of said first mentioned section in response to the pressure of the vapor flowing from the second superheater so that an increase in said pressure will cause more fluid to flow to said combined vapor generating and vapor desuperheating section and a decrease in pressure will cause less fluid to flow to said combined section, means for delivering fuel and air to the at least one burner for said furnace, means for controlling the quantity of fuel and air delivered to said burner in response to the pressure of the vapor flowing from the second superheater so that an increase in pressure will result in less fuel and air being delivered to said burner and a decrease in pressure will result in more fuel and air being delivered to said burner, means for

delivered fuel and air to the superheater burner, and means for controlling the quantity of fuel and air delivered to said burner in response to the temperature of the vapor flowing from the second superheater so that upon an increase in temperature less fuel and air will be delivered to said burner and upon a decrease in said temperature more fuel will be delivered to said burner.

12. The method of generating and superheating vapor which comprises delivering fluid to a vapor generating zone, producing a stream of products of combustion for flow in heat exchange relationship with said zone, flowing the vapor from said zone through a first superheating zone wherein the vapor is superheated to a point below its final desired temperature, flowing vapor from the first superheating zone through a second superheating zone wherein the vapor is heated to the final desired temperature, upon an increase in final temperature of the vapor, causing vapor from the first superheating zone to flow through a desuperheating zone disposed in heat exchange relationship with the fluid flowing through said vapor generating zone prior to flowing to the second superheating zone, and controlling the quantity of fluid delivered to said vapor generating zone in response to the pressure of the superheated vapor flowing from the second superheating zone.

13. The method of generating and superheating vapor which comprises delivering fluid to a vapor generating zone, producing a stream of products of combustion for flow in heat exchange relationship with said zone, flowing the vapor from said zone through a first superheating zone wherein the vapor is superheated to a point below its final desired temperature, flowing vapor from the first superheating zone through a second superheating zone wherein the vapor is heated to the final desired temperature, flowing vapor from the first superheating zone through a desuperheating zone disposed in heat exchange relationship with the fluid flowing through said vapor generating zone prior to flowing to the second superheating zone, controlling the quantity of vapor flowing to the desuperheating zone and to the second superheating zone in response to the temperature of the vapor flowing from the second superheating zone, controlling the quantity of fluid delivered to said vapor generating zone in response to the pressure of the vapor flowing from the second superheating zone, and controlling the volume of said stream of products of combustion in response to the pressure of the vapor flowing from the second superheating zone.

14. The method of generating and superheating vapor which comprises delivering fluid to a vapor generating zone, producing separate streams of products of combustion for flow in heat exchange relationship with said zone, flowing the vapor and liquid from said zone through a heating zone in radiant heat exchange relationship with one of the streams of products of combustion, flowing vapor from said heating zone through a first superheating zone in radiant heat exchange relationship with another stream of products of combustion wherein the vapor is superheated to a point below its final desired temperature, flowing vapor from the first superheating zone through a second superheating zone disposed in radiant heat exchange relationship with said other stream of products of combustion wherein the vapor is heated to the final desired temperature, flowing vapor from the first superheating zone through a desuperheating zone disposed in heat exchange relationship with the fluid flowing through said

vapor generating zone prior to flowing to said heating zone, controlling the quantity of vapor flowing to the desuperheating zone and to the second superheating zone in response to the temperature of the vapor flowing from the second superheating zone in such manner that a rise in said temperature will cause an increase in the flow of vapor through the desuperheating zone and a decrease in temperature will cause a reduction in the flow of vapor through the desuperheating zone, controlling the quantity of fluid delivered to the vapor generating zone in response to the pressure of the vapor flowing from the second superheating zone, controlling the volume of said one stream of products of combustion in response to the pressure of the vapor flowing from the second superheating zone, and controlling the volume of said other stream of products of combustion in response to the temperature of the vapor flowing from the second superheating zone.

15. Vapor generating apparatus comprising a setting, a furnace in the setting, at least one fuel burner for firing the furnace, a combined vapor generating and vapor desuperheating section in the setting disposed in the path of flow of the gases produced in the furnace, means for supplying fluid to the generating portion of said section, a first radiant superheater in the furnace, a first connection between said superheater and the desuperheating portion of said section, a first valve in said connection, a second superheater having a radiant superheating section and a convection superheating section disposed in said furnace, a second connection between said first and second superheaters, a third connection between the outlet of the desuperheating portion of said section and the second superheater, a second valve in said second connection, means for operating said valves in response to the temperature of the superheated vapor flowing from said second superheater, said valve operating means being arranged to move the first valve toward open position and the second valve toward closed position upon an increase in temperature and to move the first valve toward closed position and the second valve toward open position upon a decrease in temperature, and means for controlling the supply of fluid to the vapor generating section in response to the pressure of the superheated vapor flowing from the second superheater.

16. Vapor generating apparatus comprising a setting, a furnace in the setting, means for firing the furnace, a combined vapor generating and vapor desuperheating section in the setting disposed in heat exchange relationship with the gases produced in the furnace, said vapor generating section comprising a first tubular member and said desuperheating section comprising another tubular member within a portion of the first tubular member and providing a space between the tubular members, means for supplying fluid to the space between the tubular members, a superheater in the furnace having a superheated vapor outlet, means connecting the superheater and said other tubular member at a point in the superheater prior to said outlet, means controlled by the final temperature of the superheated vapor from the superheater for controlling the flow of vapor from the superheater to said other tubular member and to said outlet, and means for controlling the supply of fluid to the vapor generating section in response to the pressure of the superheated vapor flowing from the superheater.

17. Vapor generating apparatus comprising a setting, a furnace in the setting, at least one fuel burner for firing the furnace, a combined vapor generating and vapor desuperheating section in the setting disposed in heat exchange relationship with the gases produced in the furnace, means for supplying fluid to the vapor generating portion of said section, a superheater furnace in the setting, at least one fuel burner for firing the superheater furnace, a first superheater in the superheater furnace, conducting means for conducting vapor from the vapor generating portion of said section to the first superheater, a second superheater in the superheater furnace, other conducting means for conducting vapor from the first superheater to the desuperheating portion of said section and from said portion to the second superheater, further conducting means for conducting vapor directly from the first to the second superheater, means responsive to the temperature of the vapor flowing from the second superheater for controlling the quantity of vapor flowing from the first superheater to the desuperheating portion of said section, means for controlling the supply of fluid to the vapor generating section in response to the pressure of the superheated vapor flowing from the second superheater, and means for controlling the means for firing said furnace and said superheater furnace in response to the pressure of the superheated vapor flowing from the second superheater.

18. Vapor generating apparatus comprising a setting, a furnace in the setting, at least one fuel burner for firing the furnace, a combined vapor generating and vapor desuperheating section in the setting disposed in heat exchange relationship with the gases produced in the furnace, means for supplying fluid to the generating portion of said section, a superheater furnace in the setting, at least one fuel burner for firing the superheater furnace, a superheater in the first-mentioned furnace, said superheater being in communication with the vapor generating portion of said section so that vapor passes from the vapor generating portion of said section to the superheater, a first superheater in the superheater furnace, the superheater and first superheater being in communication with one another so that vapor passes from the superheater to said first superheater, a second superheater in the superheater furnace, other conducting means for conducting vapor from the first superheater to the desuperheating portion of said section and from said portion to the second superheater, further conducting means for conducting vapor directly from the first to the second superheater, means responsive to the temperature of the vapor flowing from the second superheater for controlling the quantity of vapor flowing from the first superheater to the desuperheating portion of said section, and means for controlling the quantity of fluid delivered to the generating portion of said section in response to the pressure of the superheated vapor flowing from the second superheater.

19. Vapor generating apparatus comprising a setting, a furnace in the setting, means for firing the furnace, a combined vapor generating and vapor desuperheating section in the setting disposed in heat exchange relationship with the gases produced in the furnace, means for supplying fluid to said section, a first superheater in the setting, a second superheater in the setting, a first connection between the first superheater and said desuperheating section, a second connection from the first to the second superheater, a third connection from the outlet of the de-

superheating portion of said first mentioned section to the second superheater, a first valve in said first connection, a second valve in said second connection, means for operating said valves substantially simultaneously in response to the temperature of the vapor flowing from the second superheater so that upon a rise in temperature of the vapor flowing from the second superheater, the valve in said first connection will be moved toward open position and the valve in the second connection will be moved toward closed position and upon a fall in temperature of said vapor, the valve in the first connection will be moved toward closed position and the valve in the second connection will be moved toward open position, means for controlling the flow of fluid to the generating section in response to the pressure of the vapor flowing from the second superheater so that an increase in said pressure will cause more fluid to flow to said vapor generating section and a decrease in pressure will cause less fluid to flow to said vapor generating section, means for delivering fuel and air to said firing means, and means for controlling the quantity of fuel and air delivered to said firing means in response to the pressure of the vapor flowing from the second superheater so that an increase in pressure will result in less fuel and air being delivered to said firing means and a decrease in pressure will result in more fuel and air being delivered to said firing means.

20. The method of generating and superheating vapor which comprises delivering fluid to a vapor generating zone, producing a stream of products of combustion for flow in heat exchange relationship with said zone, flowing the vapor from said zone through a first superheating zone wherein the vapor is superheated to a point below its final desired temperature, flowing vapor from the first superheating zone through a second superheating zone wherein the vapor is heated to the final desired temperature, flowing vapor from the first superheating zone through a desuperheating zone disposed in heat exchange relationship with the fluid flowing through said vapor generating zone prior to flowing to the second superheating zone, controlling the quantity of vapor flowing to the desuperheating zone and to the second superheating zone in response to the temperature of the vapor flowing from the second superheating zone, and controlling the quantity of fluid delivered to said vapor generating zone in response to the pressure of the vapor flowing from the second superheating zone.

21. Vapor generating apparatus comprising a setting, a furnace in the setting, at least one fuel burner for firing the furnace, a combined vapor generating and vapor desuperheating section in the setting disposed in heat exchange relationship with the gases produced in the furnace, means for supplying fluid to the vapor generating portion of said section, a superheater furnace in the setting, at least one fuel burner for firing the superheater furnace, a first superheater in the superheater furnace, conducting means for conducting vapor from the vapor generating portion of said section to the first superheater, a second superheater in the superheater furnace, other conducting means for conducting vapor from the first superheater to the desuperheating portion of said section and from said portion to the second superheater, further conducting means for conducting vapor directly from the first to the second superheater, means responsive to the temperature of the vapor flowing from the second superheater for controlling the quantity of vapor flowing from the first superheater to the desuperheating portion of said section, and means for controlling the supply of fluid to the vapor generating section in response to the pressure of the superheated vapor flowing from the second superheater.

22. In a forced circulation vapor generator comprising a setting having a furnace chamber therein, means for firing the furnace, a fluid flow path in the setting having an economizer section, an evaporating section and a superheating section, means for supplying fluid under pressure to the economizer for said flow path, a desuperheater within the fluid flow path in said evaporating section and in indirect heat exchange relationship with the vapor and liquid flowing through said evaporating section, and means for supplying a portion of the superheated vapor from the superheater to the desuperheater.

23. In a forced circulation vapor generator comprising a setting having a furnace chamber therein, means for firing the furnace, a fluid flow path in the setting having an economizer section, an evaporating section and a superheating section, said sections being so arranged in the chamber that gases of combustion flow in heat exchange relationship consecutively with the superheating, the evaporating and the economizer sections, means for supplying fluid for the flow path to said economizer section under pressure, a desuperheater positioned in said evaporating section in the path of flow of vapor and liquid passing therethrough and in indirect heat exchange relationship with said vapor and liquid, and means for supplying a portion of the superheated vapor from the superheater to the desuperheater.

24. In a forced circulation vapor generator comprising a setting having a furnace chamber therein, means for firing the furnace, a fluid flow path in the setting having an economizer section, an evaporating section and a superheating section, means for supplying fluid under pressure to the economizer for said flow path, a desuperheater within the fluid flow path in said evaporating section and in indirect heat exchange relationship with the vapor and liquid flowing through said evaporating section, means for supplying a portion of the superheated vapor from the superheater to the desuperheater, and means for controlling the supply of fluid under pressure to said flow path in response to the temperature of superheated vapor flowing from the superheater section.

25. In a forced circulation vapor generator comprising a setting having a furnace chamber therein, means for firing the furnace, a fluid flow path in the setting having an economizer section, an evaporating section, a superheating section and a second superheating section, means for supplying fluid under pressure to the economizer for said flow path, a desuperheater within the fluid flow in said evaporating section and in indirect heat exchange relationship with the vapor and liquid flowing through said evaporating section, means connecting the first-mentioned superheater section and the second superheating section and the desuperheater, and means controlled by a condition of the superheated vapor flowing from the second superheating section for controlling the flow of vapor from the first superheating section to said second superheating section and to the desuperheater.

26. In a forced circulation vapor generator comprising a setting having a furnace chamber

therein, means for firing the furnace, a fluid flow path in the setting having an economizer section, an evaporating section, a superheating section and a second superheating section, means for supplying fluid under pressure to the economizer for said flow path, a desuperheater within the fluid flow path in said evaporating section and in indirect heat exchange relationship with the vapor and liquid flowing through said evaporating section, means connecting the first-mentioned superheater section and the second superheating section and the desuperheater, and means controlled by the temperature of the superheated vapor flowing from the second superheating section for controlling the flow of vapor from the first superheating section to said second superheating section and to the desuperheater.

27. In a forced circulation vapor generator comprising a setting having a furnace chamber therein, means for firing the furnace, a tubular fluid flow path in the setting having an economizer section, an evaporating section and a superheating section, means for supplying fluid under pressure to the economizer for said flow path, a tubular desuperheater having a portion at least disposed within the tubular flow path in the evaporating section thereof and providing a space between said tubular desuperheater and the tubular flow path to permit the passage of vapor and liquid through the evaporating section and in indirect heat exchange relationships with the desuperheater, and means for supplying a portion of the superheated vapor from the superheater to the desuperheater.

28. In a forced circulation vapor generator comprising a setting having a furnace chamber therein, means for firing the furnace, a fluid flow path in the setting having an economizer section and an evaporating section, means for supplying fluid under pressure to the economizer for said flow path, a desuperheater within the fluid flow path in said evaporating section and in indirect heat exchange relationship with the vapor and liquid flowing through said evaporating section, a superheater furnace in the setting, at least one fuel burner for firing the superheater furnace, a first superheater in the superheater furnace, conducting means for conducting vapor from the evaporating secton of said flow path to the first superheater, a second superheater in the superheater furnace, other conducting means for conducting vapor from the first superheater to the desuperheater and from said desuperheater to the second superheater, further conducting means for conducting vapor directly from the first to the second superheater, and means responsive to the temperature of the vapor flowing from the second superheater for controlling the quantity of vapor flowing from the first superheater to the desuperheater.

29. The method of generating and superheating vapor which comprises delivering fluid under pressure to a liquid heating zone, passing heated liquid from the heating zone to an evaporating zone, flowing vapor from the evaporating zone to a first superheating zone wherein the vapor is superheated to a point below its final desired temperature, flowing vapor from the first superheating zone through a second superheating zone wherein the vapor is heated to the final desired temperature, producing a stream of products of combustion for flow in heat exchange relationship with the vapor heating, the evaporating and the first and second superheating zones, and upon an increase in the final temperature of the vapor, causing vapor from the first superheating zone to flow through a desuperheating zone within the evaporating zone and in indirect heat exchange relationship with the path of flow of vapor passing therethrough prior to flowing to the second superheating zone.

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