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2,987,053

BALANCED FEED WATER SYSTEM FOR STEAM GENERATORS

Filed May 27, 1954

2 Sheets-Sheet 1

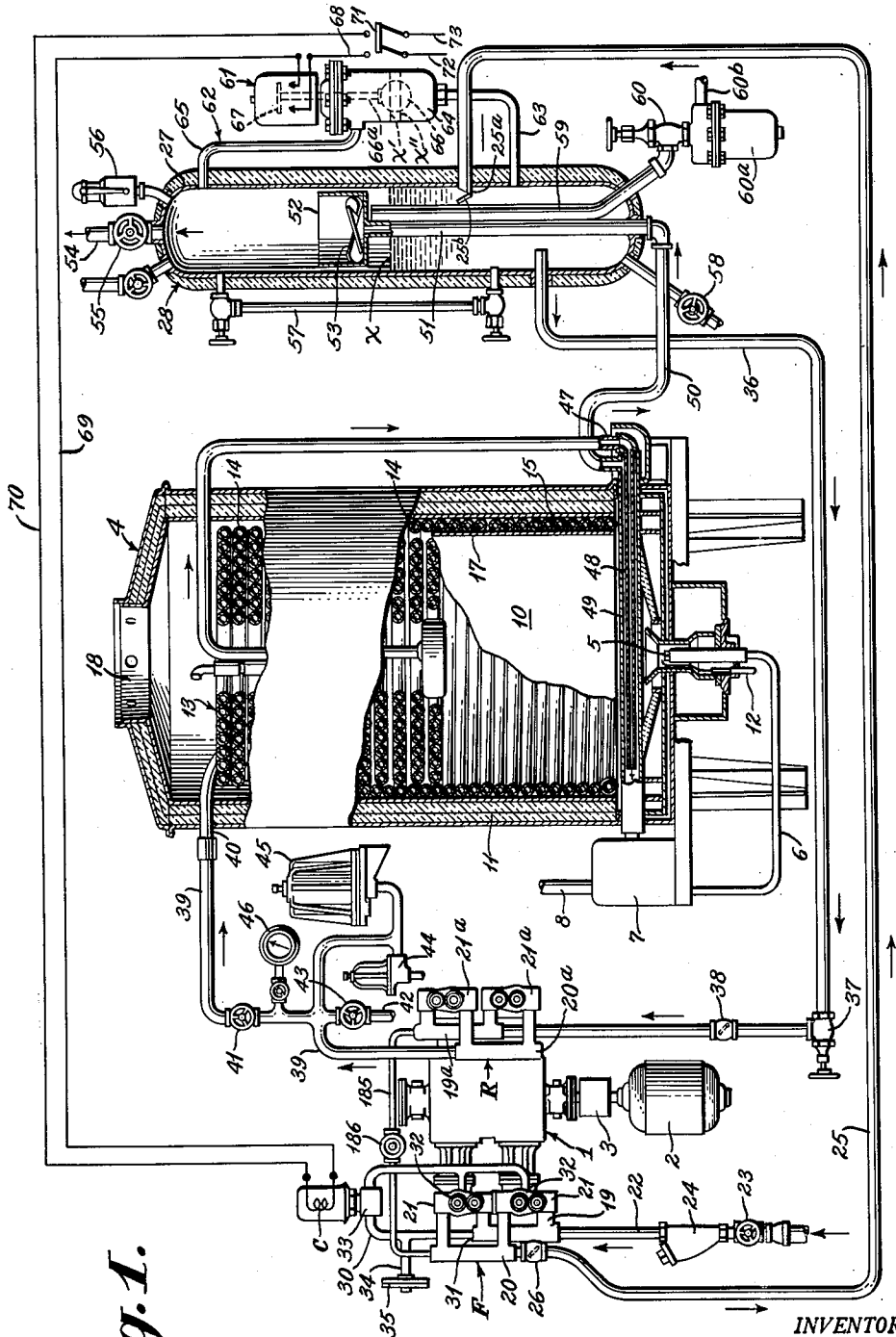


Fig. 1.

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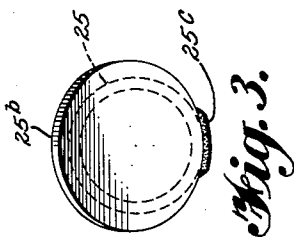
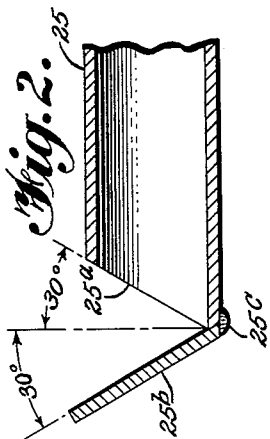
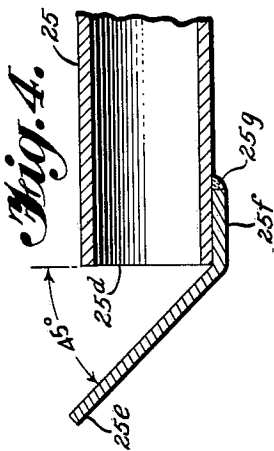
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BALANCED FEED WATER SYSTEM FOR STEAM GENERATORS

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4 Claims. (Cl. 122-451)

The present invention relates to steam generating apparatus and, more particularly, to steam generating systems including a heating coil or boiler, a steam separator, and automatic means for controlling the amount of feed water introduced into the system in accordance with variations in the level of the liquid in the steam separator from a given desired maximum level.

More specifically, the invention relates to feed water control systems for steam generating apparatus wherein the volume of water in the system is always maintained in excess of the steam demand, and the feed water added to the system is maintained in balance with the amount of water withdrawn from the system in the form of steam to meet a given load demand, so that a substantially constant volume of excess liquid is always present in the system. This excess of liquid is provided by a continuously running feed water pump having by-pass valve means associated therewith and controlled to automatically add feed water when the liquid level in the steam separator drops below a given height. The by-pass valve means is preferably normally closed and is actuated to open position to cause bypassing of feed water discharged from the feed pump so that it is not forced into the system. However, the by-pass valve means may be normally open and the control means therefor correspondingly modified to effect the same result.

Another feature of the invention is that the excess liquid in the various systems disclosed herein is continuously circulated (by a continuously running circulating pump) from the steam separator where it collects, through the heating coil, and back to the steam separator, even at times when no additional feed water is being added to the system. The heating coil is positively maintained full of fluid at all times. Thus, with a continuously running circulating pump, the interior surface of the heating coil is constantly kept wet by the liquid content of the fluid so that numerous undesirable conditions in the heating coil are avoided, which would otherwise occur if the heating coil were intermittently wet and dry. For example, any scale forming impurities deposited from the liquid that has passed through the coil become hard caked scale during any interval that the coil is dry and exposed to fire. Again, any injurious chemical condition, such as over caustic or over acid in the liquid circulated through the heating coil, becomes aggravated during the dry interval and results in an attack on the metal in the heating coil. In addition, when the heating coil is subjected to intermittently wet and dry conditions, especially through firing or heated intervals, the expansion and contraction of the heating tube metal tends to fatigue such metal at a faster rate than when the coil is maintained full of fluid and at a substantially uniform temperature.

As stated above, the present system embodies means for varying the amount of feed water that is permitted to enter the system, in accordance with the changes in level of the liquid in the steam separator. This result can be accomplished in numerous ways. For example, the amount of feed water supplied to the system can be varied by employing a feed water by-pass valve to by-pass feed water around the feed water pump, and

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which by-pass valve is automatically controlled by means responsive to changes in the liquid level in the steam separator. This by-pass valve may be a solenoid-operated valve controlled by either a float-operated switch, or a thermally responsive switch. In either event, the switch is actuated in accordance with the liquid level condition in the separator. In this connection, a supplemental control may be employed with the thermally responsive switch, if desired, the supplemental control under such conditions comprising a normally open thermally responsive switch associated with a generally similar but normally closed switch for controlling the operation of the solenoid-operated by-pass valve.

Another feature of the invention resides in the fact that the make-up or feed water for the system is introduced directly into the steam separator, instead of into the inlet of the heating coil, as is customary. This departure from prior practice affords numerous operating advantages. For example, it is well known that calcium and magnesium, normally present in the feed water, are caused to precipitate when the water is heated to a temperature of about 150-160 degrees F. In the present systems, under normal operation, the temperature of the water in the steam separator is well above the precipitating temperatures of these impurities so that they are automatically caused to precipitate and settle out in the steam separator, rather than be introduced into the heating coil where they would otherwise precipitate and form scale on the inside of the coil. In this connection, the circulating conduit is connected with the steam separator at a point well above the bottom of the steam separator in order not to interfere with the collection of precipitated matter or sludge in the bottom of the steam separator.

Still another important feature of the invention resides in the manner in which the make-up or feed water is introduced into the steam separator, it being essential that the water be introduced in such a way as to substantially avoid turbulence in the liquid already collected in the steam separator, inasmuch as a violently turbulent condition will defeat the desired precipitation of the impurities in the feed water. Actually, the make-up water is introduced into the steam separator in such a manner as to produce stratification, or layers of liquid which are at different temperatures. In this connection, the discharge end of a feed water pipe is provided with means for gently diffusing the feed water into the liquid contained in the steam separator, and is located at a level such that the temperature is high enough to precipitate the impurities contained in the feed water. Moreover, the circulation pipe or conduit, which is connected to the circulation pump, has its inlet end connected with the steam separator at a level below the discharge end of the feed water pipe, but substantially above the bottom of the steam separator, so that the precipitated impurities are settled out in the steam separator rather than picked up and introduced into the heating coil by the circulating pump.

A still further feature resides in a novel nozzle construction through which the heated fluid from the heating coil is discharged into the steam separator, also with a substantially uniform centrifugal pattern, thus assuring good separation and the delivery of substantially dry steam from the separator.

A still further feature of the invention comprises the provision of automatic means for priming the circulating pump when the pressure developed by the feed water pump exceeds a predetermined value.

Accordingly, the principal object of the invention is to provide feed water control means for steam generating systems and the like that will maintain the volume

of feed water added to the system in balance with the amount of water withdrawn from the system in the form of steam, so that a substantially constant volume of liquid is maintained in the system.

Another object is to provide steam generating apparatus wherein the volume of liquid in the system is always in excess of the maximum load demand, and the excess liquid is continuously circulated through the system.

Another object of the invention is to provide feed water control means for steam generating apparatus and the like that will prevent the pumping of water into the system during standby periods, that is, when the steam demand has dropped off and the burner is shut off, or at a time when the burner has been modulated or shut off manually, or by safety controls or other limit controls.

Still another object is to provide a feed water control system for steam generators that is automatically responsive to variations in the liquid level in the steam separator from a predetermined desired liquid level and which will function to restore and normally maintain such liquid level.

A further object is to provide an automatic feed water control system for steam generating apparatus wherein the feed water is introduced directly into the steam separator, rather than into the inlet end of the heating coil.

A still further object is to provide steam generating apparatus wherein the discharge of feed water into the steam separator is controlled so that stratification of the feed water occurs, and the feed water is subjected to such temperatures that the impurities in the feed water, such as calcium and magnesium, are precipitated and settle out in the steam separator, rather than be introduced into the heating coil where they would be likely to form scale.

Other objects, features and advantages of the invention will be apparent from the following description taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a diagrammatic view of a steam generating system embodying the principles of the present invention and including a normally open solenoid-operated feed water by-pass valve controlled by a float operated switch in response to variations in the liquid level in the steam separator;

FIG. 2 is an enlarged sectional view through the discharge end of the feed water delivery pipe;

FIG. 3 is a left side elevational view of the pipe end shown in FIG. 2; and

FIG. 4 is a view similar to FIG. 2, but illustrating a modified form of feed water pipe discharge end.

Referring now, more particularly, to FIG. 1 of the drawings, the numeral 1 generally identifies a multiple pump means including a feed water supply pump F and a circulating pump R. The pump means 1 is driven by an electric motor 2 connected with said pump means by a conventional shaft coupling 3. A steam generating unit, generally identified by the numeral 4, comprises a suitable burner nozzle 5, to which fuel is supplied through a conduit 6 under the control of a conventional thermostat actuated valve 7, fuel being supplied to said valve through a conduit 8. Fuel from the nozzle 5 is sprayed into a combustion chamber 10 contained within a housing 11, the fuel being ignited by suitable electrode means 12. The housing 11 contains a heating coil or steam generating boiler 13, including a number of conventional pancake coils or sections 14 at the upper end thereof and a helical water-wall section 15 at the lower end thereof. A suitable sheet metal lining 17 is disposed within the water-wall section 15 below the pancake coils 14. A flue 18 is provided at the upper end of the housing 11 for the escape of the products of combustion.

The feed pump F is a multiple head pump and includes an intake feed manifold 19 and an outlet or discharge manifold 20 interconnected by identical standpipe or pump head housings 21, each containing suitable check valves (not shown) for aiding in effecting the pumping of feed

water in a known manner. The feed pump F is not new per se and further details thereof are disclosed, for example, in my Patents 2,574,368 and 2,657,640, which are hereby incorporated by reference, although the means shown in said patents for preventing vapor locking of the pump is unnecessary in the systems disclosed herein. The feed water is supplied to the intake manifold 19 through a pipe 22 connected with a hot well (not shown). A manually operable shut-off valve 23 is connected in the pipe 22 and a strainer 24 is connected in said pipe between the valve 23 and the intake manifold 19. A feed water delivery pipe 25 has one end thereof connected with the discharge manifold 20, a conventional check valve 26 being interposed between one end of said pipe and said discharge manifold 20 for the purpose of preventing reverse flow through said pipe, i.e., flow in a direction toward the manifold 20. The opposite end of the feed water pipe is connected to the casing 27 of a steam separator generally identified by the numeral 28. The pipe 25 is connected to the casing 27 at a predetermined height above the bottom thereof for reasons which will be explained later.

The feed water pipe 25 has a discharge end 25a which projects slightly into the separator casing 27 and has an end face inclined on an angle of about 30 degrees from the vertical, as is best shown in Fig. 2. A disc 25b, slightly larger in diameter than the outside diameter of the pipe 25 is welded to the end of said pipe, as indicated at 25c. The disc 25b is inclined on an angle of about 30 degrees on the opposite side of the vertical, so that the included angle between the disc 25b and the adjacent end face of the pipe 25 is about 60 degrees. The disc 25b serves as a baffle to diffuse the incoming feed water (60° F.) into the relatively much hotter liquid already collected in the steam separator 28 in such a manner as to cause it to spread or fan out and avoid the creation of any substantial turbulence within the separator casing 27. Actually, stratification occurs in the liquid in the casing 27, the hottest strata being uppermost and deriving its heat from the steam contained in the upper portion of the casing 27. In any event, the temperature of the strata at the level of the discharge end 25a of the feed water pipe is substantially in excess of 160 degrees, so that the usual impurities in the feed water are precipitated and settle out onto the bottom of the casing 27.

FIG. 4 illustrates a modified form of discharge end for the feed water pipe 25, wherein the end of the pipe is perpendicular to the axis thereof as indicated at 25d, and a baffle 25e having a projecting tongue 25f is welded to the lower portion of the pipe as indicated at 25g. The baffle 25e is preferably inclined upon an angle of 45 degrees to the vertical as illustrated in FIG. 4, in order to effect the desired diffusion of the feed water in the steam separator casing 27.

It will be noted from FIGS. 2 and 4 that the baffles 25b and 25e are mounted upon the pipe 25 in such a way that the pipe can drain or be flushed out so that sludge and other matter are prevented from collecting at the discharge end of the pipe.

A by-pass conduit 30 for by-passing feed water around the feed pump F has one end thereof connected with the inlet manifold 19, as indicated at 31, and the opposite end thereof is connected with the discharge valve chambers of the respective pump heads 21, as indicated at 32. A conventional solenoid-operated valve 33 is connected in the by-pass conduit 30 and is normally maintained open when de-energized. It will be apparent, however, that when the valve 33 is energized and closed, water cannot be by-passed from the discharge chamber of the pump heads 21 to the inlet manifold 19, but must be forced out of the pump heads 21 into the discharge manifold 20, past the check valve 26 and into the feed water pipe 25. Hence, when the by-pass valve 33 is open, the feed pump F is prevented from, or rendered ineffective for, pumping any water into the feed water pipe 25 for

delivery to the steam separator 28. On the other hand, when the valve 33 is closed, by-passing of feed water will be interrupted and the pump F will deliver feed water to the separator 28.

The by-pass conduit 30 has a branch conduit 34 connected thereto and a conventional intake surge chamber 35 is connected with the branch conduit 34 for eliminating surging action in the intake manifold 19.

The circulating pump R is also a multiple head pump and includes an intake circulating manifold 19a and an outlet or discharge circulating manifold 20a. These manifolds are generally similar to the manifolds 19 and 20 of the feed water pump F. The manifolds 19a and 20a are connected to standpipes and pump heads 21a similar to the heads 21 previously described.

The inlet circulating manifold 19a is connected by a circulating pipe 36 with the casing 27 of the steam separator 28 at a point spaced a substantial distance above the lower end of said housing. A manually operable shut-off valve 37 is connected in the pipe 36 and a conventional check valve 38 is connected in said pipe between the valve 37 and the intake of the circulating manifold 19a. The purpose of the check valve 38 is to prevent flow through the pipe 36 in a direction from the circulating pump R toward the steam separator 28.

The outlet circulating manifold 20a is connected by a pipe 39 with the inlet end 40 of the uppermost pancake coil 14, whereby fluid discharged through the pipe 39 from the circulating pump R is directly introduced into the inlet of the heating coil 13. A manually operable shut-off valve 41 is connected in the pipe 39 for shutting off the back flow of fluid from the coil 13 during maintenance operations. A branch pipe 42 is connected with the pipe 39 and a coil drain valve 43 is connected in said branch pipe. A pump pressure relief valve 44, and a pump discharge snubber 45 are also connected with the pipe 39 and are of conventional construction. A pressure gauge 46 is connected with the pipe 39 for indicating the pressure at the inlet end of the heating coil 13.

The heating coil 13 has a discharge end 47 that communicates with a tube 48 of a conventional thermostat device for controlling the operation of the fuel valve. The tube 48 is enclosed in a tube 49 of larger diameter, which, in turn, discharges into a pipe 50 that is connected to the lower end of the separator casing 27. The pipe 50 delivers the mixture of heated water and vapor from the heating coil 13 to a discharge pipe 51 disposed centrally within the separator casing 27. A discharge nozzle constructed and functioning as described in my copending application Serial No. 272,059, filed February 18, 1952, now Patent No. 2,800,196, issued July 23, 1957, is mounted upon the upper end of the pipe 51. For present purposes it is sufficient to state that the nozzle comprises a cup-like member 52 welded to the upper end of the pipe 51. This cup contains vanes or baffles 53 shaped to cause the fluid discharging into the cup from the pipe 51 to flow tangentially within the cup and then spill radially outwardly over the rim of the cup, whereby any fluid not flashed into vapor within the steam separator 28 is caused to impinge against the inner wall of the separator casing 27 and to flow downwardly by gravity as a film on said wall to be collected in the lower part of the separator as excess liquid. In this way, the centrifugal force of the fluid while it is travelling within the cup 52 causes moisture particles to strike against the inner wall of the casing 27 and to adhere thereto and flow downwardly, rather than be carried out of the separator by the steam as it leaves the upper end of the separator. In this connection, at least one pipe 54 is connected with the upper end of the separator casing 27 for delivering steam to a point of use, a shut-off valve 55 being connected in the pipe 54 to control the flow of steam from the separator 28. A conventional safety valve 56 is also connected with the separator casing 27 to prevent an ex-

cessive pressure condition from being developed within said separator.

A conventional gauge glass 57 is connected with the separator casing 27 to indicate the water level within the separator 28. A conventional blow-down valve 58 is connected with the bottom of the separator casing 27 for effecting removal of precipitated matter, sludge or any other foreign matter that may have accumulated in the bottom of said casing. An over-flow pipe 59 extends into the bottom of the casing 27 and upwardly along the pipe 51 to a point slightly below the bottom of the cup 52. The pipe 59 is open at its upper end and has a shut-off valve 60 connected to its lower end, exteriorly of the casing 27, a conventional steam trap 60a being connected with the valve 60 for the purpose of removing any excess liquid that may accumulate within the separator and rise above the upper end of the pipe 59, the desired maximum liquid level being lower and indicated by the level X. Any liquid trapped out through the steam trap 60a is discharged through a pipe 60b connected with a hot well or sump (not shown) for the feed water. However, the system normally operates without requiring any water to be trapped out and this avoids undesirable steaming in the hot well (not shown).

A conventional float-operated switch mechanism 61 is connected in a water leg 62 associated with the steam separator 28. The water leg 62 comprises a lower conduit 63 connected at one end with the casing 27 at a point well below the level X and connected at its other end to a hollow housing 64 providing a float chamber. A second conduit 65 has its lower end connected with the upper portion of the housing 64 and its upper end connected with the casing 27 at a point well above the level X. A float 66 is disposed in the housing 64 and is arranged to actuate a conventional switch 67 through a float arm 66a which establishes an operative connection between the float 66 and the switch 67. It will be understood that the float 66 effects opening and closing of the switch 67 depending upon the level of the liquid in the housing 64. This level will always correspond to the liquid in the separator 28. Thus, as shown, the liquid level in the casing 64, indicated at X' coincides with level X in the steam separator 28. The switch 67 is purposely made so that it will respond to a slight differential in liquid level in the housing 64. Thus, should the liquid level in the casing 64 drop from the level X' to that indicated by X'', the float 66 will be lowered sufficiently to actuate the switch 67 to its closed position. In actual practice, the difference in level between that indicated at X' and X'' is only about a half inch, so that the switch 67 exercises a very sensitive control over the feed water introduced into the system, as will be explained more fully hereinafter.

The switch 67 has one end of a conductor 68 connected to one contact thereof and a second conductor 69 is connected to the other contact of said switch and also to a coil C of the solenoid-operated valve 33. Another conductor 70 has one end connected with the coil C and its other end connected with a contact of the main switch 71. The conductor 68 also has one end thereof connected with a contact of the switch 71. Main conductors 72 and 73 conduct current to the switch 71.

The float-operated switch 67 remains open so long as the liquid level in the steam separator 28 is approximately at the level X. Hence, at this time, the by-pass valve 33 is open and by-passes feed water around the pump F to prevent introduction thereof into the system. The advantage of employing a normally open by-pass valve 33 is that it avoids the possibility of feed water being introduced into the system, should the switch 67 fail to function, or the circuit fail in any other manner. However, when the liquid level in the steam separator 28 drops to approximately the level X'', the float 66 will descend and the switch 67 will be actuated thereby to complete the circuit to the solenoid-operated by-pass

valve 33, to energize said valve and thereby cause the same to close. The closing of the valve 33 will prevent by-passing of the feed water around the pump F and cause the same to be forced into the feed water pipe 25 for ultimate discharge into the casing 27 of the steam separator 28. When the liquid level in the separator 28 again rises to a point where it actuates the switch 67 to its open position, the by-pass valve 33 will be de-energized and, although the feed pump F continues to operate, it cannot deliver any additional feed water to the system. In this way, a substantially constant volume of liquid is maintained in the system at all times, and since an excess quantity of liquid is maintained in the steam separator 28 and circulated by the continuously operating circulating pump R, all danger of the heating coil 13 running dry is precluded. The circulating pump R, of course, pumps the water from the lower part of the steam separator through the pipe 36, and discharges it into the pipe 39 for introduction into the inlet end 40 of the heating coil. It will be observed that the discharge end of the feed water pipe 25 is at a height approximately midway between the level X and the inlet end of the circulation pipe 36. Incidentally, the inlet end of the pipe 36 is at a level at which the temperature of the liquid in the separator is high enough to precipitate the impurities in the feed water.

It is to be understood that the details of construction and arrangement of the system disclosed may be varied without departing from the principles of the invention or the scope of the annexed claims.

I claim:

1. Steam generating apparatus, comprising: a heating coil having an inlet and an outlet; a steam separator; means connecting the outlet of said heating coil with said steam separator; a feed water pump having an inlet and a discharge; means connecting said discharge of said feed water pump with the lower portion of said steam separator for introducing feed water directly into said steam separator; a circulating pump having an inlet and a discharge; means connecting the inlet of said circulating pump with the lower portion of said steam separator; means connecting the discharge of said circulating pump with the inlet of said heating coil; and conduit means connecting the discharge of said feed water pump with the inlet of said circulating pump for priming said circulating pump.
2. Steam generating apparatus, comprising: a heating coil having an inlet and an outlet; a steam separator; means connecting the outlet of said heating coil with said steam separator; a feed water pump having an inlet and a discharge; means connecting said discharge of said feed water pump with the lower portion of said steam separator for introducing feed water directly into said steam separator; a circulating pump having an inlet and a discharge; means connecting the inlet of said circulating pump with the lower portion of said steam separator; means connecting the discharge of said circulating pump with the inlet of said heating coil; and conduit means

including a fluid pressure operable valve connecting the discharge of said feed water pump with the inlet of said circulating pump for priming said circulating pump, said fluid pressure operable valve being arranged to open only when the pressure at the inlet of said circulating pump is less than a predetermined value.

3. Steam generating apparatus, comprising: a heating coil having an inlet and an outlet; a steam separator; means connecting the outlet of said heating coil with said steam separator for effecting the discharge of heated fluid from said heating coil into the upper portion of said steam separator; a feed water pump; means responsive to the liquid level in said steam separator controlling the amount of feed water delivered to said steam separator by said feed water pump to maintain a desired liquid level in said steam separator; a feed water pipe connected with said feed water pump and having a discharge and extending horizontally into the lower portion of said steam separator at a level normally below the desired liquid level in said steam separator; means on said discharge end of said feed water pipe for diffusing the feed water into the liquid in said steam separator, whereby to prevent the creation of turbulence in the liquid in said steam separator while the feed water is being introduced into said steam separator to thereby aid in precipitation and separation of solids from the feed water; a circulating pump having an inlet and an outlet; means connecting the inlet of said circulating pump with said steam separator at a region below the discharge end of said feed water pipe, but substantially above the lower end of said steam separator; and means connecting the outlet of said circulating pump with the inlet of said heating coil.

4. Steam generating apparatus as defined in claim 3, in which the discharge end of the feed water pipe is located in a plane approximately midway between the desired liquid level and the means connecting the steam separator with the inlet of the circulating pump.

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