Sept. 3, 1968 P. ARANT 3,399,655

FORCED CIRCULATION STEAM GENERATOR WITH THERMAL-MECHANICAL PRE-REMOVAL OF CORROSIVE GASES FROM THE LIQUID SUPPLIED TO THE HEATING COIL

Filed April 24, 1967 3 Sheets-Sheet 1

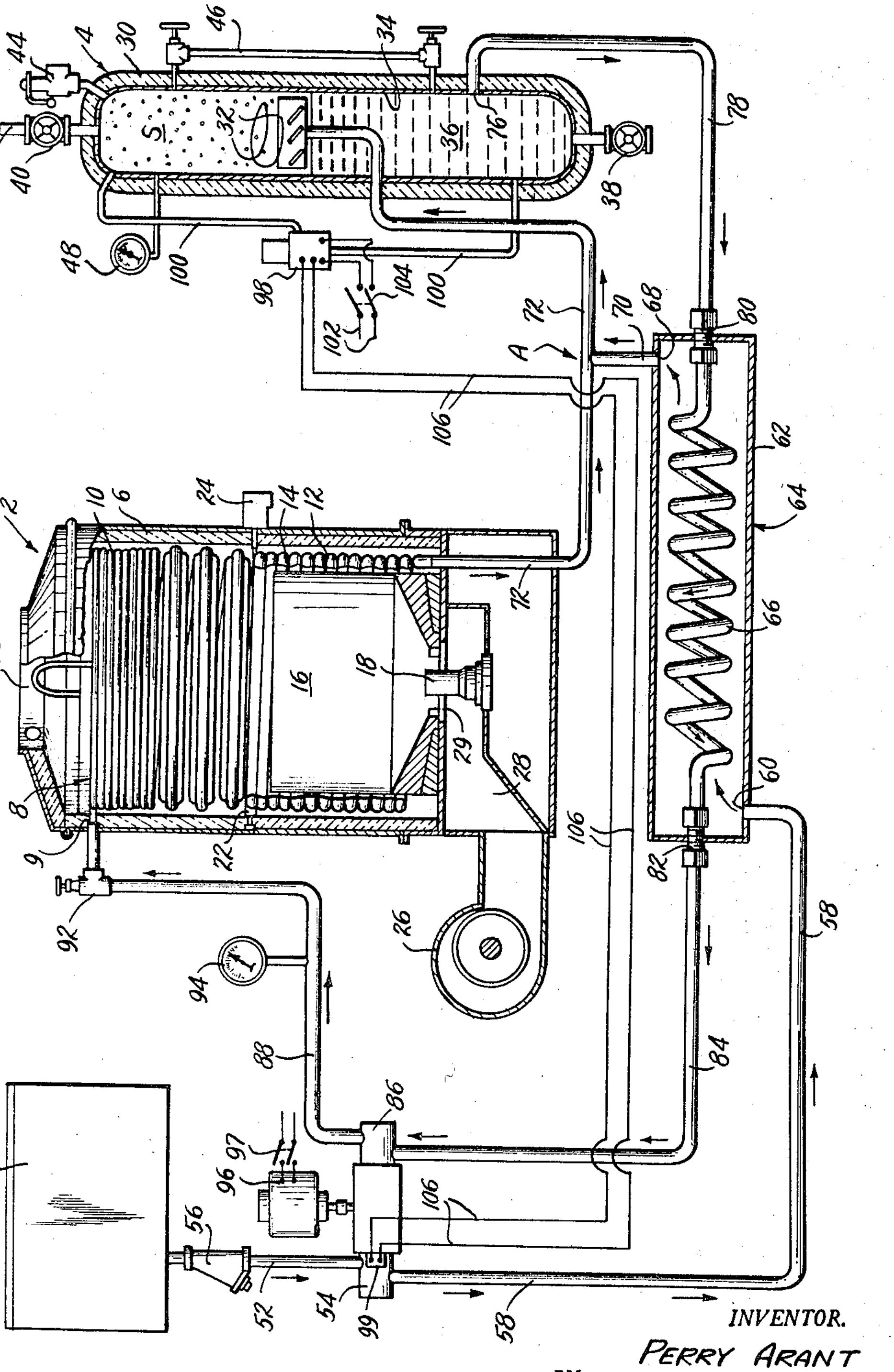


Fig. 1.

INVENTOR.
PERRY ARANT
BY
Bacon & Thomas
ATTORNEYS

Sept. 3, 1968 P. ARANT 3,399,655

FORCED CIRCULATION STEAM GENERATOR WITH THERMAL-MECHANICAL PRE-REMOVAL OF CORROSIVE GASES FROM THE LIQUID SUPPLIED TO THE HEATING COIL

Filed April 24, 1967

3 Sheets-Sheet 2

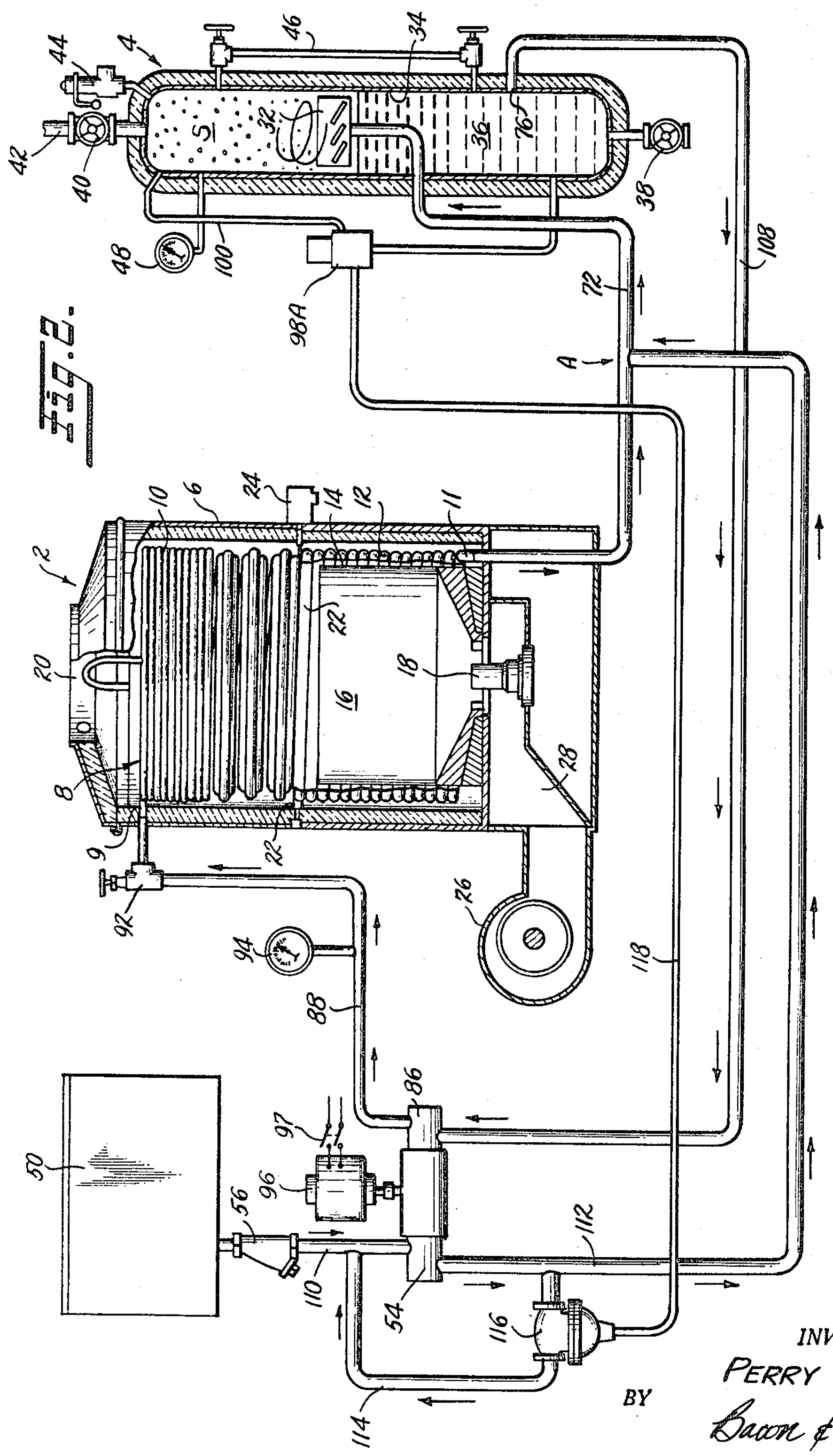


FIG. 2.

INVENTOR.

PERRY ARANT

BY

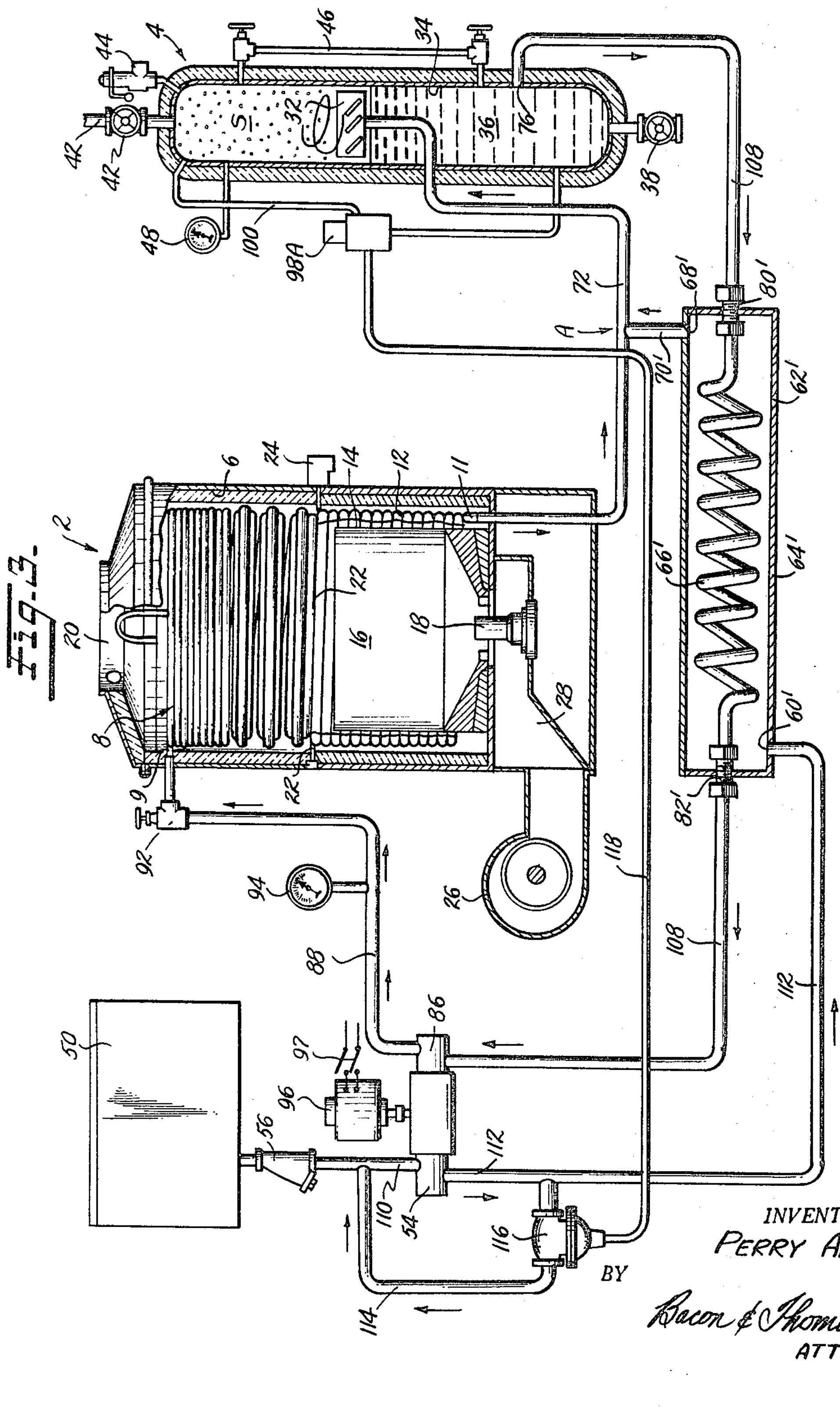
Bacon & Thomas

ATTORNEYS

Sept. 3, 1968 P. ARANT 3,399,655

FORCED CIRCULATION STEAM GENERATOR WITH THERMAL-MECHANICAL PRE-REMOVAL OF CORROSIVE GASES FROM THE LIQUID SUPPLIED TO THE HEATING COIL

Filed April 24, 1967 3 Sheets-Sheet 3



INVENTOR.
PERRY ARANT

BY

Bacon & Thomas
ATTORNEYS

United States Patent Office

3,399,655

Patented Sept. 3, 1968

3,399,655

FORCED CIRCULATION STEAM GENERATOR WITH THERMAL-MECHANICAL PRE-REMOVAL OF CORROSIVE GASES FROM THE LIQUID SUPPLIED TO THE HEATING COIL

Perry Arant, Newport Beach, Calif., assignor to Clayton Manufacturing Company, Los Angeles, Calif., a corporation of California

Filed Apr. 24, 1967, Ser. No. 633,195

14 Claims. (Cl. 122—406)

ABSTRACT OF THE DISCLOSURE

Steam generating apparatus with forced circulation including a heating coil and a steam separator, and wherein raw feedwater, preferably preheated, is introduced into the system as make-up water at a juncture point between the heating coil and the steam separator and there blended with a stream of steam-containing liquid from the heating coil. The blended mixture is flashed in the steam separator, forming more steam and releasing corrosive gases contained in the feedwater and making available gas-free liquid which is then circulated from the separator through the heating coil by a circulating pump to be heated and cyclically blended with raw feedwater and flashed in the separator, thus continually removing and preventing corrosive gases from entering the heating coil.

BACKGROUND OF THE INVENTION

(1) *Field of the invention*

This invention relates generally to steam generating apparatus of the forced circulation type (see my prior Patent 2,987,053), normally including a heating coil or boiler, and a steam separator to which feedwater is supplied and from which stored circulating liquid is withdrawn and pumped to the heating coil, and more particularly to improvements comprising means for supplying feedwater, preferably preheated or at a modulated flow rate or both, to the system in such manner that dissolved corrosive gases in the raw feedwater are removed in the steam separator through thermal-mechanical action before the feedwater is added to the circulating liquid storage for subsequent pumping to the heating coil or boiler.

(2) *Description of the prior art*

In a conventional steam boiler the design of the drum and other heating surfaces usually is such that any corrosive dissolved gases in the raw feedwater are liberated before severe corrosive action can occur. This is not true of forced circulation steam generating apparatus wherein the water is forced through a continuous coiled heating element, and any gases dissolved therein are trapped in the steam moving through the coil so that they cannot freely escape. The high evaporative rates inherent in this type of apparatus make for somewhat active corrosion, oxygen corrosion in particular.

The common presence of corrosive gases, such as oxygen and carbon dioxide, in the raw feedwater supplied directly to a separator, or to the heating coil of a forced circulation steam generator can cause deterioration and shorten the life of the heating coil to the point of failure, and it is, therefore, highly desirable to remove such dissolved gases from the raw feedwater.

In the past, apparatus such as deaerators per se, and chemical scavengers, both with and without deaeration,

have been associated with steam generators to remove entrained and/or dissolved gases from feedwater, but because of cost and other operational problems involved, the need has existed for a more effective, simple and economical solution, and particularly one which eliminates, rather than creates, new problems. The present invention not only overcomes the prior problems but affords the additional advantages of:

(a) Adding feedwater to the system without objectionable temperature drop in the saturated steam delivered to the steam separator;

(b) The delivery of feedwater to the steam separator at the same temperature as the saturated steam and circulation liquid stored in the steam separator; and

(c) The elimination of stratified layers of circulation liquid at different temperatures in the steam separator.

SUMMARY OF THE INVENTION

The present invention relates to steam generating apparatus having forced circulation and including a heating coil and a steam separator, wherein raw feedwater (usually containing corrosive gases, for example, oxygen and carbon dioxide) is pumped by a feedwater pump to a juncture point between the heating coil and the steam separator and blended with a stream of steam-containing liquid from the heating coil. The fluids thus blended are delivered to a centrifugal separator nozzle located inside the steam separator casing where the steam and corrosive gases are separated from the liquid, as the major portion of the liquid flashes into steam and releases the corrosive gases. A circulating pump withdraws the gas-free liquid from the separator storage reservoir and circulates it through the heating coil, thereby preventing entry of corrosive gases into the heating coil. A feedwater heat exchanger is connected in series in the circulation path of the gas-free circulating liquid, between the separator and the circulating pump, and utilizes some of the heat of the gas-free circulating liquid to heat the feedwater before it reaches the blending juncture point. The feedwater pump and the circulating pump is a combination assembly driven by a continuously operating, single motor. The feedwater pump includes a by-pass that is controlled by a solenoid in response to a switch that opens and closes with changes in level of the circulating liquid in the separator, so that the level does not drop below a given minimum level nor exceed a given maximum level.

Additionally, and/or as an alternative, a modulating type feedwater flow rate control valve can be installed in a by-pass pipe around the feedwater pump to control the rate at which feedwater is blended with the heated stream from the heating coil to minimize the temperature change at the blending point along with relative pressure changes. The modulating type valve in such embodiment is controlled by a liquid level responsive control unit, which may be electrical, hydraulic or pneumatic depending upon the kind of modulating valve that is used. A single motor for driving both the feedwater pump and circulating pump is independently controlled and runs continuously.

It is the principal object of this invention to provide forced circulation steam generating apparatus designed to remove through thermal-mechanical action any corrosive gases dissolved in the raw feedwater supplied to the system, so that circulation liquid supplied to the heating coil or boiler is free of such corrosion-causing agents.

Another object is to provide forced circulation steam generating apparatus employing a heating coil, or boiler, and a steam separator, wherein the centrifugal separating nozzle of the steam separator is utilized to remove dissolved gases from raw feedwater before it is supplied to the heating coil as make-up water.

Still another object is to provide forced circulation steam generating apparatus wherein raw feedwater is blended with the saturated discharge flowing from the heating coil, the blend then being delivered to a steam separator wherein, in the process of separating steam from liquid, gases dissolved in the raw feedwater are released for discharge from the separator with the steam.

A further object is to provide improved forced circulation steam generating apparatus designed to minimize any adverse thermal effects of blending raw feedwater with the saturated discharge from the heating coil or boiler and to increase the thermal efficiency of the apparatus by controlling the rate at which the raw feedwater is added.

Other objects and many of the attendant advantages of the invention will become readily apparent from the following detailed description, when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic view of a first embodiment of the steam generating apparatus, showing a heat exchanger through which the raw feedwater is passed before being blended with the saturated discharge from the heating coil, for entry therewith into the steam separator;

FIG. 2 is a diagrammatic view of a second embodiment of the invention, wherein the heat exchanger is eliminated and a by-pass modulating valve is utilized to control the blending of raw feedwater with the heating coil discharge; and

FIG. 3 is a view similar to FIG. 2, but includes the heat exchanger of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. 1, a forced circulation steam generating apparatus is shown including a steam generating unit **2** and a steam separator **4**. The generating unit **2** includes a housing **6** within which is disposed a heating coil or boiler **8**, comprising a conventional pancake coil upper section **10**, and a helical lower water wall section **12** containing a sheet metal combustion chamber liner **14**. The coil **8** is continuous and has an inlet **9** at the upper pancake end thereof, and an outlet **11** at the lower end of the water wall section **12**.

The lower end of the housing **6** contains a combustion chamber **16**, into which projects an oil burner nozzle **18** for injecting fuel into the combustion chamber **16**, where the fuel is burned. The upper end of the housing **6** has a flue **20** for the escape of combustion gases, the burning fuel functioning to heat the liquid in the coil **8**. A ring thermostat tube **22** is disposed at the base of the pancake coil **10** and is connected with a conventional thermostat control **24** that controls the supply of fuel to the burner nozzle **18**, whereby control is maintained over the temperature of the water in the coil **8**. A blower **26** supplies air to the combustion chamber **12** through a duct **28** and an opening **29** at the lower end of said chamber.

The steam separator **4** includes an insulation-jacketed casing **30** within which is mounted a centrifugal separating nozzle **32** positioned about midway of the height of the casing. The centrifugal nozzle **32** functions to separate steam from a saturated mixture of steam and liquid supplied to the separator **4** from the outlet **11** of the steam generator unit **2**, the separated liquid falling by gravity into a reservoir portion **34** below the nozzle **32** where it forms a supply of circulating liquid **36**. Any solid matters contained within the liquid **36** in the reservoir **34** will precipitate out and accumulate in the lower end of the reservoir, the bottom of the casing **30** having a blow-down valve **38** connected thereto for periodically cleaning the reservoir.

The upper end of the casing **30** has a conventional shut-off valve **40** thereon, which is connected with a conduit **42** for conducting steam away from the separator **4**. The upper end of the casing **30** is also fitted with a safety valve **44**, which can be of any suitable type for relieving any excess pressure that may occur in the separator **4**. A conventional gauge glass **46** is mounted at one side of the casing **30**, and a pressure gauge **48** is connected with the steam accumulation chamber S in the upper portion of the casing **30** to provide a reading of the steam pressure.

Raw feedwater for the steam generating apparatus is withdrawn from a storage tank **50**, or other source of supply, through a conduit **52** by a feedwater pump **54**, the conduit **52** having a strainer **56** connected therein for screening out solid impurities. The discharge or outlet side of the feedwater pump **54** is connected by a conduit **58** to the inlet **60** of a water jacket or casing **62** of the heat exchanger **64**, the water jacket **62** having a heat exchange coil **66** extending therethrough. An outlet **68** of the water jacket **62** is connected by a conduit **70** with a conduit **72** at a juncture A. The conduit **72** connects the outlet **11** of the heating coil **8** with the centrifugal separating nozzle **32** in the steam separator **4**. Thus, raw feedwater supplied by the feedwater pump **54** is blended with the hot saturated discharge from the heating coil **8** at the junction A, i.e., in advance of the steam separator **4**, and the resultant blend flows to the nozzle **32** for discharge into the steam chamber S. The addition of feedwater is controlled so that no objectionable temperature drop occurs in the saturated stream.

The separator casing **30** has an outlet **76** for the circulating liquid **36** positioned substantially above the bottom of the reservoir portion **34** to minimize the possibility of withdrawing accumulated solid contaminates that have been precipitated from the liquid **36**. A conduit **78** is connected to the outlet **76** and leads to an inlet **80** of the heat exchange coil **66**. An outlet **82** of the heat exchange coil **66** is connected by a conduit **84** with the inlet of a circulating pump **86**. The discharge or outlet side of the circulating pump **86** is connected by a conduit **88** to the inlet **9** of the heating coil **8**. The conduit **88** has a shut-off valve **92** connected therein and a pressure gauge **94** is mounted in said conduit between the valve **92** and the circulating pump **86** to indicate coil inlet pressure.

The feedwater pump **54** and the circulating pump **86** are combined and driven by a single electric motor **96** controlled by a manual switch **97**. The feedwater pump **54** has a solenoid-operated by-pass control **99** connected thereto so that the circulating pump **86** operates continuously, while the feedwater pump **54** is rendered ineffective to pump feedwater to the junction point A when the solenoid by-pass control **99** is energized. The operation of the feedwater pump through the solenoid by-pass **99** is controlled through a conventional float or other type of switch **98**, which is responsive to changes in the level of the circulating liquid **36** within the steam separator reservoir portion **34**. The switch **98** is connected in a water leg **100** in the conventional manner, so that it is operable by and responsive to variations in the level of the circulating liquid. The switch **98** is supplied with electricity by leads **102** through a switch **104**, and is connected to the terminals of the feedwater by-pass solenoid **99** by conductors **106**.

The switch **98** is designed to open and close in response to a given change in the level of the circulating liquid **36**. When the level of the liquid **36** rises to its top limit, the switch **98** closes to cause operation of the by-pass solenoid **99** to interrupt pumping of feedwater by the feedwater pump **54**. When the liquid level in the reservoir **34** falls to a lower limit, the switch **98** opens to deenergize the by-pass solenoid **99** and render the feedwater pump **54** effective to resume pumping of feedwater to the junction point A and thence to the reservoir **34**. Thus, a relatively constant supply of circulating liquid **36** is maintained available in the reservoir **34**.

In operation, the circulating pump **86** withdraws circulating liquid **36** from the steam separator reservoir section **34** through the conduit **78**, heat exchange coil **66** and conduit **84** and supplies it to the inlet **9** of the heating coil **8** through the conduit **88**. The liquid is then pumped through the heating coil **8**, wherein it is heated to form a mixture of steam and water under a desired pressure, for example, 150 p.s.i. This mixture then passes through the conduit **72** to the centrifugal separating nozzle **32** where a pressure drop occurs and the mixture nearly completely flashes into steam. The feedwater pump **54** supplies raw feedwater, which usually contains dissolved corrosive gases, to the conduit **58**, from whence it passes through the heat exchanger **64** into the conduit **70** and to the junction A, where it is blended with the saturated heating coil discharge in the conduit **72** prior to entry into the steam separator.

The resultant blend of coil discharge fluid and raw feedwater passes to the centrifugal separator nozzle **32**, which functions to separate both steam and dissolved gases from the liquid. The portion of the liquid not flashed into steam drops, or flows down the inner wall of the separator casing **30**, into the reservoir **34** to accumulate as the circulating liquid **36**. Dissolved gases originally contained within the raw feedwater, such as oxygen and carbon dioxide, are thus freed by a thermal-mechanical action and thereafter pass out of the casing **30** through the conduit **42**, together with the steam. Thus, the circulating liquid **36** contained within the reservoir **34** is free of such corrosive gases, and the heating coil corrosion problem associated with such gases is eliminated.

The raw feedwater could be supplied directly to the junction A in FIG. 1 without passing through the heat exchanger casing **62**, if desired, and the centrifugal nozzle **32** would still function to release the dissolved gases. However, if the raw feedwater is fed directly to the junction A for blending with the heated fluid from the heating coil **8**, each time that feedwater is fed into the system it would cause a rapid consumption of latent heat in the fluid in the conduit **72**, which in turn would result in a wide fluctuation of steam pressure within the steam accumulation space S of the steam separator **4**. For example, considering a 175 horsepower steam generator unit operating at 150 p.s.i. with 60° F. feedwater, a pressure drop of 40–50 p.s.i. in the steam accumulator space S can occur each time that a charge of the raw feedwater is rapidly fed directly to the junction A, and which pressure drop is objectionable.

The use of the heat exchanger **64** greatly alleviates the problem of undesirable steam pressure fluctuation in the steam separator **4**. Thus, the relatively hot circulating liquid **36** in passing through the heating coil **66** in counterflow to the raw feedwater substantially raises the temperature of the feedwater before it is blended with the fluid from the heating coil **8** at the junction A. By thus preheating the feedwater before blending, say to within 50° F., or less, of the temperature of the saturated coil discharge fluids, steam pressure fluctuations in the steam accumulation space S can be held to within a few p.s.i. The closer the temperature of the raw feedwater to the temperature of the coil discharge fluids at the time the two are blended at junction A, the less will be the steam pressure fluctuation in the steam separator **4**.

Fluctuation in the steam pressure can also be alleviated by gradually and carefully modulating the flow of feedwater into the conduit **72**, as described later. Normally, in FIG. 1, when the switch **98** closes, raw feedwater will be pumped rapidly through the heat exchanger **64** into the conduit **72**, and it is this rapid combining of large quantities of relatively cooler raw feedwater with the hotter heating coil discharge fluids that would cause the principal loss of latent heat and consequent objectionable pressure drop in the absence of feedwater preheating.

Another embodiment of the invention is shown in FIG. 2, wherein the flow of feedwater is modulated in such a way that blending of the raw feedwater with the heating coil discharge can be achieved very gradually without using a heat exchanger, and without causing severe fluctuations in steam pressure.

Referring to FIG. 2, wherein the elements which are identical to those of FIG. 1 bear the same reference numerals as in FIG. 1, the outlet **76** of the steam separator **4** is connected directly to the inlet of the circulating pump **86** by a conduit **108**. The inlet of the feedwater pump **54** is connected to the storage tank **50** by a conduit **110** having a strainer **56** therein, and the outlet side of the feedwater pump **54** is connected by a conduit **112** to a junction A with the conduit **72** leading from the heating coil to the centrifugal separating nozzle **32**. A by-pass pipe **114** is connected around the feedwater pump **54** between the conduits **110** and **112**, and has a diaphragm type flow modulating valve **116** of conventional construction connected therein. The valve **116** is connected by a fluid pressure transmitting and release tube **118** to a liquid level responsive control **98A**, which may be in the form of a conventional pilot valve. The motor **96** runs continuously when the device is in use to continuously operate the feedwater pump **54** and the circulating pump **86**.

The pressure in the tube **118** will be relieved and the modulating by-pass valve **116** will be substantially fully open when the pilot control **98A** senses a maximum level condition in the reservoir **34**, whereby raw feedwater will then be circulated through the by-pass pipe **114** by the pump **54** and will not be supplied to the junction A. When the level of the circulating liquid **36** falls sufficiently to actuate the pilot control **98A** to supply pressure (air or hydraulic) through the tube **118**, the modulating diaphragm valve **116** will gradually close to thereby discontinue by-passing of the feedwater and gradually blend raw feedwater with the discharge fluids flowing through the conduit **72**. The pilot control **98A** is responsive to very slight changes in liquid level in the separator **4** and causes the valve **116** to modulate in its opening and closing to vary the rate of flow therethrough in accordance with the liquid level variations in the reservoir **34**. By maintaining changes in the feedwater flow rate at a very gradual level, that is, slightly in excess of the existing steam demand so that little by-passing occurs, a nearly constant level liquid will be maintained in the reservoir **34**, and steam pressure fluctuation within the accumulator S can be held to a minimum.

The embodiments of FIGS. 1 and 2 both function to effectively remove soluble corrosive gases from raw feedwater before make-up from the separator is supplied to the heating coil or boiler **8**. Thus, the problem of coil corrosion due to corrosive gases being dissolved in the liquid supplied to the heating coil **8** is eliminated. With the elimination of such gases, coil life is greatly prolonged, and because the danger of coil rupture is greatly reduced, the safety of operation of the forced circulation type steam generator is greatly enhanced.

A further embodiment of the invention is shown in FIG. 3, wherein a heat exchanger **64′** is connected in the conduit **108**. The inlet **60′** of the heat exchange jacket **62′** is connected with the conduit **112**. The outlet **68′** of the jacket **62′** is connected by a conduit **70′** to the conduit **72** at the junction A. A heat exchange coil **66′** has its inlet **80′** and its outlet **82′** connected with spaced portions of the conduit **108**. The heat exchanger **64′** functions in the same manner as the heat exchanger **64** previously described. The modulating valve **116** functions in the same manner previously described in controlling the gradual rate of flow of raw feedwater to the juncture point A. Thus, the embodiment of FIG. 3 combines the advantages of preheating the feedwater, as in FIG. 1, and the gradual flow rate of feedwater, as in FIG. 2, for the utmost efficiency in operation, in addition to effecting removal of corrosive gases from the raw feedwater.

While the feedwater flow rate modulating valve **116** has been described as pressure-operated in response to variations in circulating liquid level sensed by the pilot valve **98A**, it will be understood that the modulating valve may be of an electrical type and that it may be controlled by an electrical liquid level sensing device that signals changes in level to the modulating valve to control flow therethrough to maintain the desired liquid level in the separator **4**.

Obviously, many modifications and variations of the present invention are possible in the light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically shown and described.

I claim:

1. In a steam generating apparatus having a heating coil with an inlet and an outlet, a feedwater pump having an inlet and an outlet, a steam separator containing a steam separator nozzle, means connecting the outlet of said heating coil with said steam separator nozzle, a circulating pump having an inlet and an outlet, means connecting said separator with the inlet of the circulating pump and connecting the outlet of said circulating pump with said heating coil for supplying hot liquid from said separator to said heating coil, the improvement comprising: means connected with the outlet of the feedwater pump arranged to introduce feedwater into the means connecting the outlet of the heating coil with the separator, whereby to blend feedwater with the fluid from the heating coil prior to entry thereof into the steam separator.

2. The improvement as recited in claim **1**, including means for preheating the feedwater prior to blending thereof with the fluid from the heating coil.

3. The improvement as recited in claim **2**, wherein the means for preheating said feedwater comprises a heat exchanger arranged to utilize the hot liquid flowing through the means connecting the separator to the inlet of the circulating pump, as a heating medium for the feedwater.

4. The improvement as recited in claim **3**, wherein the heat exchanger comprises a casing having an inlet connected with the outlet of the feedwater pump and an outlet connected with the means connecting the outlet of the heating coil with the steam separator nozzle, and wherein the heat exchanger casing contains a heat transfer element comprising a part of the means connecting the inlet of the heating coil with the separator, said heat transfer element being located between the separator and the inlet of the circulating pump, whereby circulating liquid from the separator serves as the heating medium for the feedwater.

5. The improvement as recited in claim **1**, including means actuated in response to changes in the level of liquid within said separator to control the flow of feedwater from the feedwater pump to be blended with the fluid from the heating coil.

6. The improvement as recited in claim **5**, wherein the means for controlling the flow of feedwater comprises a by-pass solenoid on the feedwater pump, and wherein the means responsive to changes in liquid level in the separator is a switch connected with said bypass solenoid.

7. The improvement as recited in claim **5**, wherein the means for controlling the flow of feedwater comprises a fluid pressure responsive modulating valve connected in a by-pass pipe around the feedwater pump, and wherein the means responsive to changes in liquid level in the separator is a pilot valve connected with said modulating valve.

8. In a steam generating apparatus having a heating coil with an inlet and an outlet, a feedwater pump having an inlet and an outlet, a steam separator having an upper steam accumulator space and a lower reservoir for collecting circulating liquid, a first conduit connecting the outlet of said heating coil with said separator, a circulating pump having an inlet and an outlet, a second conduit connecting the inlet of said circulating pump with the circulating liquid reservoir of said separator, and a third conduit connecting the outlet of said circulating pump with the inlet of said heating coil to supply hot liquid from said reservoir to said heating coil, the improvement, comprising: a heat exchanger including a heat exchange element connected in series in said second conduit, and a casing enclosing said heat exchange element, said heat exchanger casing having an inlet and an outlet; a feedwater supply conduit connecting the outlet of said feedwater pump with the inlet of said heat exchanger casing and connecting the outlet of said heat exchange casing with said first conduit at a point between said heating coil outlet and said separator, whereby to utilize the circulating liquid to preheat the feedwater and to provide a junction point at which the preheated feedwater is blended with the fluid from the heating coil before entering the separator; and means responsive to variations in the level of the circulating liquid in said separator reservoir controlling the supply of feedwater from the feedwater pump to the separator.

9. Steam generating apparatus as recited in claim **8**, wherein the feedwater flow control means, comprises: a by-pass conduit interconnecting the discharge and the inlet of the feedwater pump, a modulating valve connected in said by-pass conduit arranged to be opened or closed in response to variations in the level of liquid within said steam separator, and means responsive to variations in said liquid level controlling said modulating valve.

10. In a steam generating apparatus having a heating coil with an inlet and an outlet, a feedwater pump having an inlet and an outlet, a steam separator having an upper steam accumulator space and a lower reservoir for collecting circulating liquid, a first conduit connecting the outlet of said heating coil with said separator, a circulating pump having an inlet and an outlet, a second conduit connecting the inlet of said circulating pump with the circulating liquid reservoir of said separator, a third conduit connecting the outlet of said circulating pump with the inlet of said heating coil to supply hot liquid to said heating coil, and means for driving said pumps, the improvement, comprising: a feedwater supply conduit connecting the outlet of said feedwater pump with said first conduit at a point between said heating coil outlet and said separator, whereby to provide a junction point at which the feedwater is blended with the fluid from the heating coil before entering the separator; means for controlling the rate of flow of feedwater to said junction point comprising a by-pass pipe interconnecting the outlet and inlet of said feedwater pump and a flow rate modulating valve connected in said by-pass pipe; and means responsive to variations in the liquid level of the circulating liquid in said separator reservoir arranged to control the opening and closing of said feedwater flow rate modulating valve as required to maintain not less than a desired minimum liquid level in said steam separator.

11. The improvement as recited in claim **10**, wherein the feedwater flow rate modulating valve is a fluid pressure operated valve, and wherein the means responsive to variations in the circulating liquid level in the separator reservoir is a pilot valve.

12. The improvement as recited in claim **10**, wherein a heat exchanger is connected in the feedwater supply conduit between the feedwater pump and the blending junction point.

13. The improvement as recited in claim **12**, wherein the hot circulating liquid from the separator reservoir is passed through the heat exchanger to preheat the feedwater.

14. The improvement as recited in claim **10**, wherein the feedwater flow rate modulating valve is a fluid pressure operated valve; and wherein the means responsive to variations in the circulating liquid level in the separator reservoir is a liquid level responsive pilot valve, and wherein a heat exchanger is connected in the feedwater supply conduit between the feedwater pump and the blending junction point; and wherein the hot circulating liquid from the separator reservoir is passed through the heat exchanger to preheat the feedwater.

References Cited

UNITED STATES PATENTS

1,898,196	2/1933	Lucke	122—235
2,800,117	7/1957	Arant	122—448 XR
3,261,331	7/1966	Egart	122—448

KENNETH W. SPRAGUE, *Primary Examiner.*