

[54] **HEAT RECOVERY STEAM GENERATOR EMPLOYING MEANS FOR PREVENTING ECONOMIZER STEAMING**

[75] **Inventor:** Paul A. Berman, Plymouth Meeting, Pa.

[73] **Assignee:** Westinghouse Electric Corporation, Pittsburgh, Pa.

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[58] **Field of Search**..... 60/106, 107; 122/406 R

[56] **References Cited**

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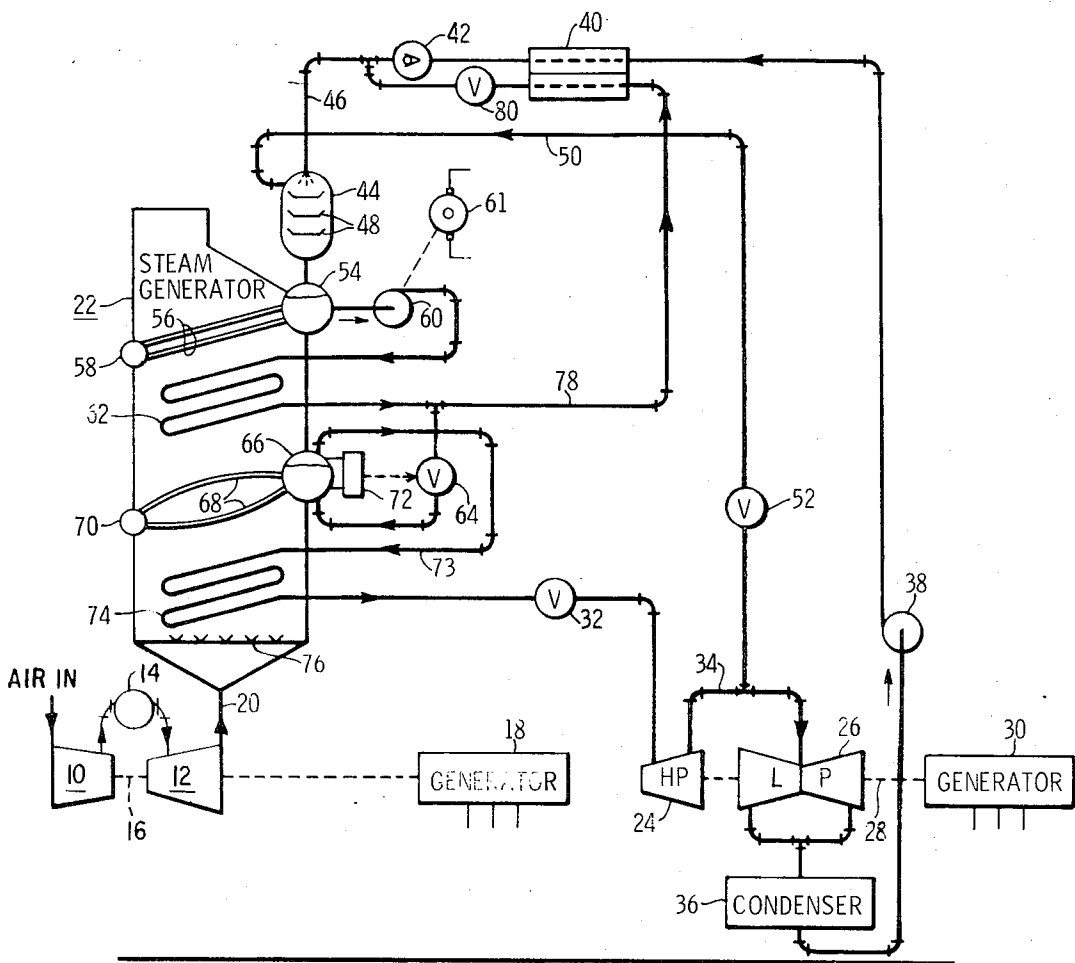
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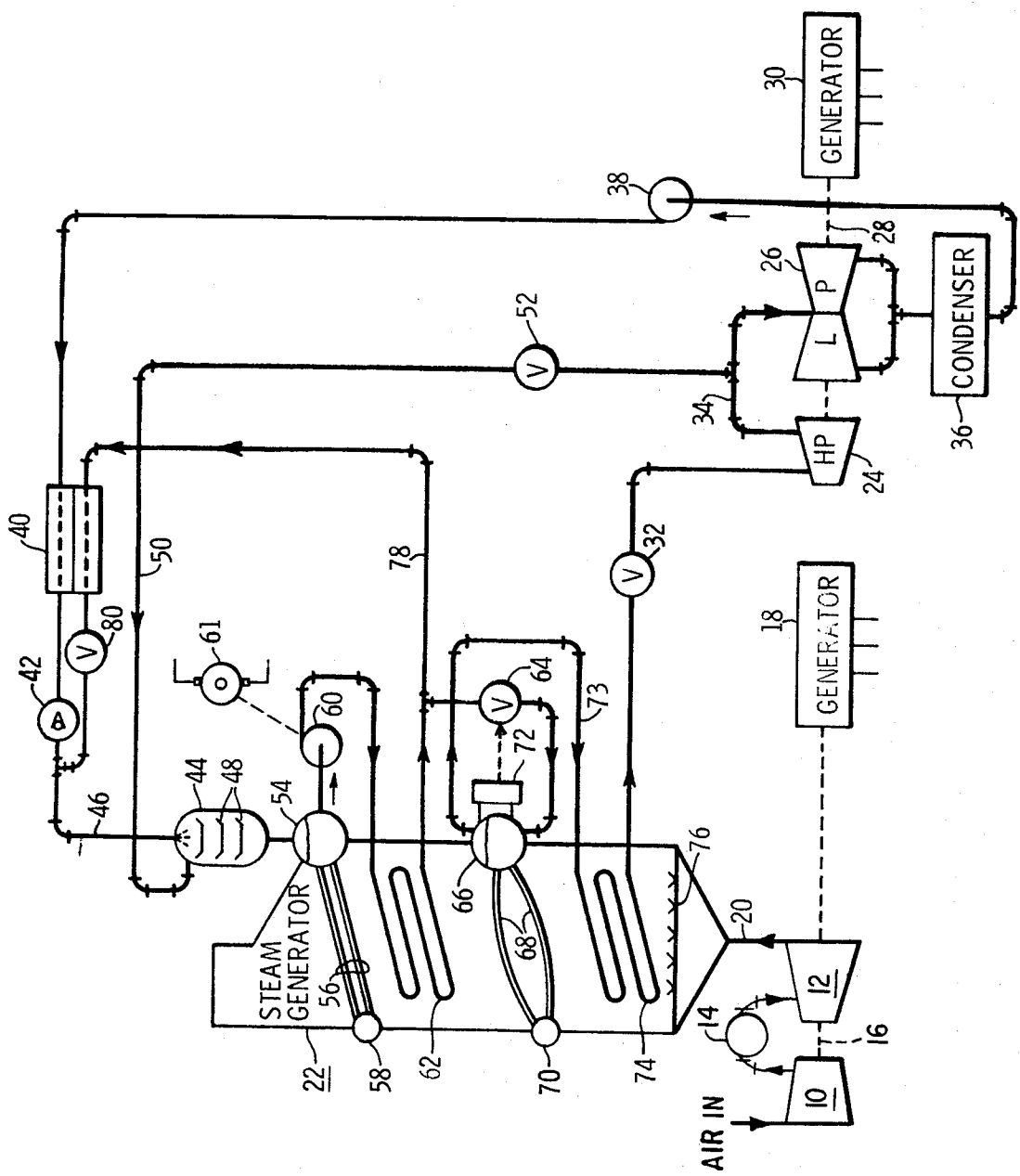
Primary Examiner—Martin P. Schwadron
Assistant Examiner—Allen M. Ostrager
Attorney—A. T. Stratton et al.

[57] **ABSTRACT**

A system for preventing the formation of steam in an economizer coil disposed within a heat recovery steam generator used in a combined gas turbine and steam turbine power plant. This is accomplished by recycling a portion of the water at the output of the economizer back into the condensate conduit feeding the steam generator such that a constant water flow will be maintained through the economizer under all operating conditions, preventing a more or less stagnant water condition in the economizer and insuring against the formation of steam therein. The recirculated water, prior to entering the condensate conduit, is preferably passed through a heat exchanger where the heat of the water from the economizer is transferred to the incoming condensate to prevent flashing as the water from the economizer enters the condensate conduit through a valve.

9 Claims, 1 Drawing Figure





HEAT RECOVERY STEAM GENERATOR EMPLOYING MEANS FOR PREVENTING ECONOMIZER STEAMING

BACKGROUND OF THE INVENTION

Combined power plant systems are known in which a gas turbine unit is used to provide power, the expended hot exhaust gases from the turbine being directed through an exhaust duct to a waste heat recovery steam generator where the heat is extracted for generating steam for a steam turbine before the gases are dumped into the atmosphere. In such installations, the hot exhaust gases pass upwardly in the stack containing the steam generator through super-heating coils, a high pressure steam boiler, economizer coils and thence through a low pressure steam boiler. Condensate from the turbine is passed through a deaerator, and then through the low pressure steam boiler from where it is pumped by a boiler feed pump through the economizer coils to the high pressure boiler and finally to the superheater before being fed back to the inlet of the turbine.

In a system of this type, there is a strong tendency at part load for steam to form in the economizer. During full load conditions, heat from auxiliary fuel burners is supplied to the generator in addition to the heat from the exhaust gases. While these auxiliary fuel burners can be turned off at part load, the heat supplied to the economizer coils from the hot exhaust gases remains essentially constant at all times. Furthermore, at part load, less water is required in the boiler with the result that in prior art systems, the water flow through the economizer slows down. Since this water is exposed to the essentially constant heat content of the exhaust gases, steam may form in the economizer coils under part load conditions. Steam formation in the economizer requires special design features; and if this is not done properly or if excessive steaming occurs, damage can result to the steam generation equipment.

SUMMARY OF THE INVENTION

In accordance with the present invention, a steam generation system of the type described is provided in which steaming in the economizer is prevented under any and all load conditions. This is accomplished by operating the boiler feed pump at the input to the economizer at a constant flow rate, even though the water level control valve for the main boiler is closed. Excess water at the output of the economizer, as will occur under part load conditions when the main boiler drum is full, is recycled to the condensate conduit feeding the steam generation system. However, since the recycled water will be at a higher temperature and pressure than that in the condensate line, the recycled water is preferably passed through a heat exchanger where heat is transferred to the incoming condensate prior to being introduced into the condensate conduit through a pressure regulating valve. In this manner, flashing and formation of steam in the condensate conduit is prevented.

DESCRIPTION OF PREFERRED EMBODIMENT

The above and other objects and features of the invention will become apparent from the following detailed description taken in connection with the accompanying single FIGURE drawing which schematically illustrates one embodiment of the invention.

With reference now to the drawing, a combined power plant system is shown of the type in which a gas turbine unit is employed to provide power, while the expended exhaust gases from the gas turbine are directed to a steam generator where the heat of the exhaust gases is recovered to heat liquid which is subsequently converted into steam for motivating a steam turbine. In the drawing, only the essential components are shown relative to the present invention for purposes of simplicity.

The power plant includes an internal combustion turbine comprising a compressor portion 10, a gas turbine portion 12 and a fuel combustion chamber 14 interposed between the compressor 10 and the turbine 12. The compressor 10 and turbine 12 are provided with rotor structures, not shown, connected to each other by a shaft 16. Liquid or gaseous fuel is injected into the combustion chamber 14. In the operation of the turbine, air enters the compressor 10, is compressed, and is then fed to the combustion chamber 14 where it is mixed with the fuel, either gaseous or liquid, and ignited to form hot motive gaseous products. The hot gases are then directed against the blades of the rotor structure in the turbine 12, causing the shaft 16 to turn. The shaft 16 is connected as shown to an alternating current, three-phase generator 18.

The hot products of combustion at the outlet of the turbine 12 are directed via duct 20 to the bottom of a steam generator assembly, generally indicated by the reference numeral 22 in the drawing. In the steam generator, which consists essentially of a vertical duct containing steam and water pipes, the hot products of combustion are used to assist in generating steam for a steam turbine which, as shown, includes a high pressure turbine 24 and a low pressure turbine 26 both of which are coaxial and connected through shaft 28 to a second three-phase alternating current generator 30. In the operation of the steam turbine, steam from the steam generator 22 is admitted through a main steam control valve 32 to the high pressure turbine 24. Low pressure steam at the output of the high pressure turbine 24 then passes through conduits 34 to the low pressure turbine 26. The steam, after passing through the low pressure turbine 26, is then directed to a condenser 36 where it is condensed back into water.

From the condenser 36, the condensed water is pumped by pump 38 through heat exchanger 40 and check valve 42 back to a deaerator, generally indicated by the reference numeral 44. The purpose of the deaerator is to remove oxygen and other gases from the condensate, thereby minimizing the possibility of corrosion to the boiler parts. In addition, the deaerator initially preheats the condensate prior to its being converted back into steam. The condensate in conduit 46 is sprayed into the deaerator via a nozzle assembly where it passes downwardly through perforated plates or trays 48 and collects at the bottom. At the same time, steam from a low pressure steam line 50 is fed into the deaerator 44 along with the condensate in conduit 46 to initially preheat the same. The low pressure steam can be derived, for example, from the output of the high pressure turbine 24 via an extraction line non-return valve 52.

The condensate from the deaerator 44 flows into a low pressure boiler which includes an upper drum 54 connected through inclined tubes 56 to a lower drum 58 in accordance with well-known techniques. The

steam produced in drum 54 may be used to supplement the low pressure steam brought from the steam turbine by steam line 50. The heated water in the drum 54 is then pumped by a boiler feed pump 60 to an economizer coil 62 disposed within the steam generator 22. Pump 60 is driven by motor 61 which operates at constant speed. From the economizer coil 62, the water flows through a feed water valve 64 to the drum 66 of a high pressure boiler which includes tubes 68 extending through the interior of the steam generator 22 and connected at their lower ends to a header 70. The level of the water within the high pressure drum 66 is sensed by a suitable level sensor 72. The level sensor 72, in turn, controls the feed water valve 64 so as to maintain a constant liquid level within the drum 66.

As the condensate passes downwardly through the low pressure boiler, the economizer 62 and the high pressure boiler, it is converted to steam. This steam, above the surface of the liquid in the high pressure drum 66, is conducted via conduit 73 to superheating coils 74 and thence through the main steam control valve 32 back to the high pressure turbine 24, thereby completing the cycle.

The water and/or steam passing through the low pressure boiler, the economizer coil, the high pressure boiler and the superheater is heated by the hot products of combustion passing upwardly through the interior of the steam generator from the turbine 12. Additionally, heat is supplied to the interior of the steam generator under full load conditions by independent fuel burners, schematically illustrated in the drawing and identified by the reference numeral 76. As was mentioned above, the purpose of the economizer coil 62 is to preheat the condensate prior to its being pumped into the high pressure drum 66; however it is undesirable for steam to form in the economizer coils. Due to the fact that the hot products of combustion from the turbine 12 are continually flowing upwardly through the steam generator 22, there will be a certain minimum temperature in the zone occupied by the economizer coil 62. Furthermore, at part load, it has been common practice to reduce the flow of water through the low pressure boiler and economizer 62. When this happens, there is a tendency to form steam within the economizer 62.

In accordance with the present invention, the formation of steam within the economizer 62 is prevented by causing the boiler feed pump 60 to operate at a constant flow rate under all load conditions and to recycle a portion of the flow back into the input condensate line 46. Thus, the output of the economizer coil 62, in addition to being connected to the inlet port of valve 64, is also connected through conduit 78 and through heat exchanger 40 to a pump discharge pressure regulator valve 80. The other side of the valve, in turn, is connected to the condensate return line 46.

It will be appreciated that under part load conditions, less steam is required from the high pressure drum 66, with the result that the water input to the drum 66 must be reduced to maintain a given level. As a result, valve 64 closes as steam requirements are decreased; and since the pump 60 is operating at a continual, constant flow rate, pressure will begin to build up in conduit 78. The pump discharge pressure regulator valve 80, however, will permit the high pressure water within conduit 78 to flow back into the condensate return line 46.

The heat exchanger 40 is required since the water temperature at the output of the economizer, although below the boiling point at the economizer pressure which is in the range of about 300 to 1,200 psia, is nevertheless above the boiling point at the pressure within the return conduit 46. Typically, this may be on the order of about 10 to 100 psia. The temperature at the output of the economizer, for example, may be 415° F at a pressure of 450 psia; while the temperature of the return condensate may be about 108° F at a pressure of 100 psia. If, therefore, an attempt is made to mix the hotter, high pressure water from conduit 78 with the cooler, low pressure condensate in conduit 46, flashing and steam generation could occur. The heat exchanger 40, however, acts to transfer heat from the water to conduit 78 to that in conduit 46 such that when the two are mixed at the output of check valve 42, they are of substantially the same temperature. The check valve 42, of course, prevents the higher pressure recycle flow from the economizer from flowing backwardly through the heat exchanger 40.

This present invention thus provides a system for preventing economizer steaming in which a boiler feed pump, operating at a constant flow rate over its load range, is utilized in combination with a heat exchanger to extract heat from the heated water to prevent economizer steaming while permitting mixing of the excess water that is passed through the economizer with water that is cooler and at a lower pressure without damage to the power plant equipment. At the same time, heat is recovered from the recycled water to assist in heating the incoming feed water.

Although the invention has been shown in connection with a certain specific embodiment, it will be readily apparent to those skilled in the art that various changes in form and arrangement of parts can be made to suit requirements without departing from the spirit and scope of the invention.

I claim as my invention:

1. In a steam generator for a steam turbine of the type in which steam from a high pressure boiler in the generator is fed into the turbine to drive it while condensate from a condenser connected to the turbine flows through a condensate return conduit to a low pressure boiler in the generator and is then pumped through an economizer to said high pressure boiler through a level control valve for the high pressure boiler; the combination of means for preventing steaming in said economizer regardless of the rate at which steam is delivered to said turbine comprising:

a boiler feed pump interposed between said low pressure boiler and said economizer for pumping heated water through the economizer and thence to said high pressure boiler through said level control valve,

means for driving said boiler feed pump to maintain an essentially constant flow rate through the economizer regardless of the condition of said level control valve,

conduit means connecting the output of said economizer back to said condensate return conduit, a pressure regulating valve in said conduit connecting means for permitting the escape of water which does not pass through said level control valve back into said condensate conduit, and

a heat exchanger for transferring heat from water in said conduit means to condensate in said conden-

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sate return conduit, said heat exchanger being located at a point on said condensate return conduit ahead of the point at which said conduit connecting means is connected to the condensate return conduit.

2. The combination of claim 1 wherein said pressure regulating valve is disposed in the conduit connecting means between said heat exchanger and the connection of the conduit connecting means to said condensate return conduit.

3. The combination of claim 1 including a deaerator interposed between the condensate return conduit and said low pressure boiler.

4. The combination of claim 1 wherein the steam generator comprises a duct through which the gaseous products of combustion from a gas turbine pass, and including additional supplementary fired fuel burners in said duct for supplying additional heat.

5. In a steam generator having a boiler for producing motive steam for a steam turbine in which the motive steam drives the turbine and is condensed in a condenser connected to the turbine and the condensate returns to the steam generator via a condensate return conduit and is then passed through an economizer and then to said boiler through a level control valve which controls the level of the liquid maintained in said boiler; the combination of means for preventing steaming in said economizer regardless of the rate at which motive steam is delivered to said turbine, said means for preventing steaming comprising

a boiler feed pump interposed between said condensate return conduit and said economizer,

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means for driving said boiler feed pump to maintain essentially a constant flow through the economizer regardless of the position of said level control valve, conduit means connecting the output of said economizer to said condensate return conduit,

pressure regulating means disposed in said conduit collecting means for permitting the escape of water which does not pass through said level control valve back into said condensate return conduit, and

a heat exchanger for transferring heat from liquid in the conduit connecting means to condensate in the condensate return conduit.

6. The combination of claim 5 wherein the pressure regulating means is disposed in the conduit connecting means between the heat exchanger and the condensate return conduit.

7. The combination of claim 6 including a deaerating heater disposed in the condensate return conduit downstream of the connection with the conduit connecting means.

8. The combination of claim 5, wherein the steam generator comprises a duct through which the gaseous products of combustion from a gas turbine pass, and supplemental fuel burners disposed in said duct for supplying additional heat to produce steam of the desired pressure and temperature.

9. The combination as set forth in claim 5 including a deaerating heater disposed in the condensate return conduit and forming a portion thereof.

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