

[54] STEAM AIR PREHEATER FOR A STEAM BOILER SYSTEM
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[58] Field of Search 60/105, 106, 107, 65, 70, 60/73, 67

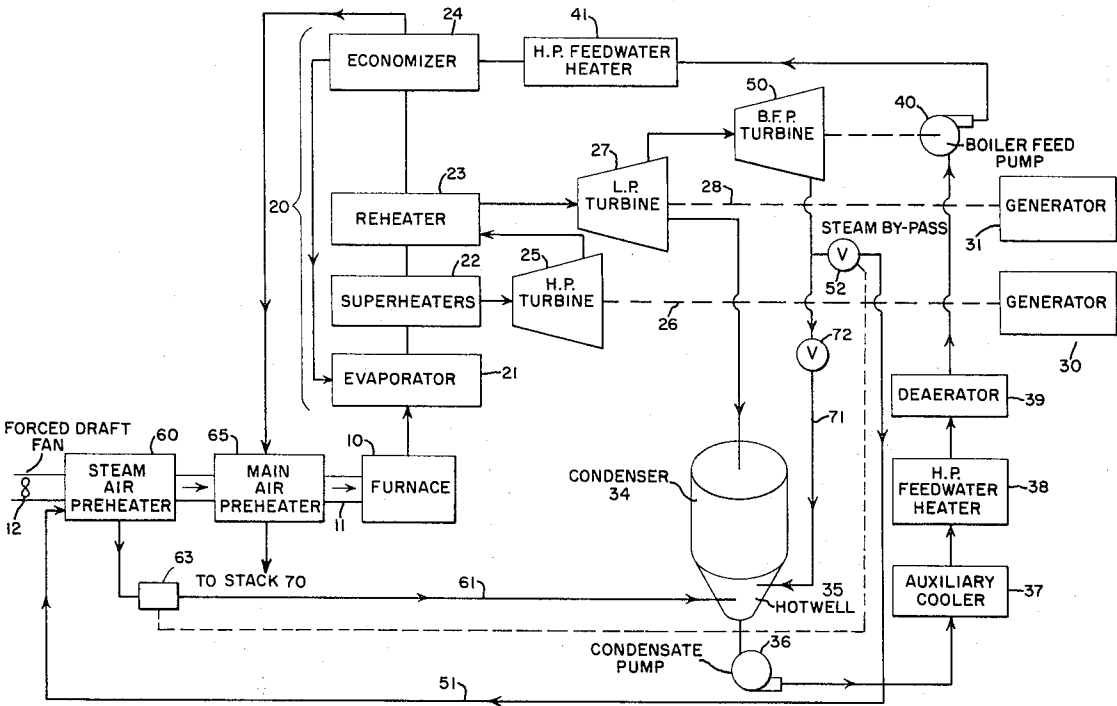
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[57] **ABSTRACT**
A steam boiler system includes a steam air preheater disposed in inlet ducting for preheating intake air. A boiler feed pump provides high-pressure water to a boiler which in turn produces steam to drive a main turbine. Exhaust flow from the turbine is routed directly to a main condenser, with the exception of a small extraction flow which is used to drive a boiler feed pump turbine. Prior to returning to the condenser, the boiler feed pump turbine exhaust is conducted through the steam air preheater. As system conditions demand, the boiler feed pump turbine exhaust is sent directly to the condenser without going through the steam air preheater.

4 Claims, 2 Drawing Figures



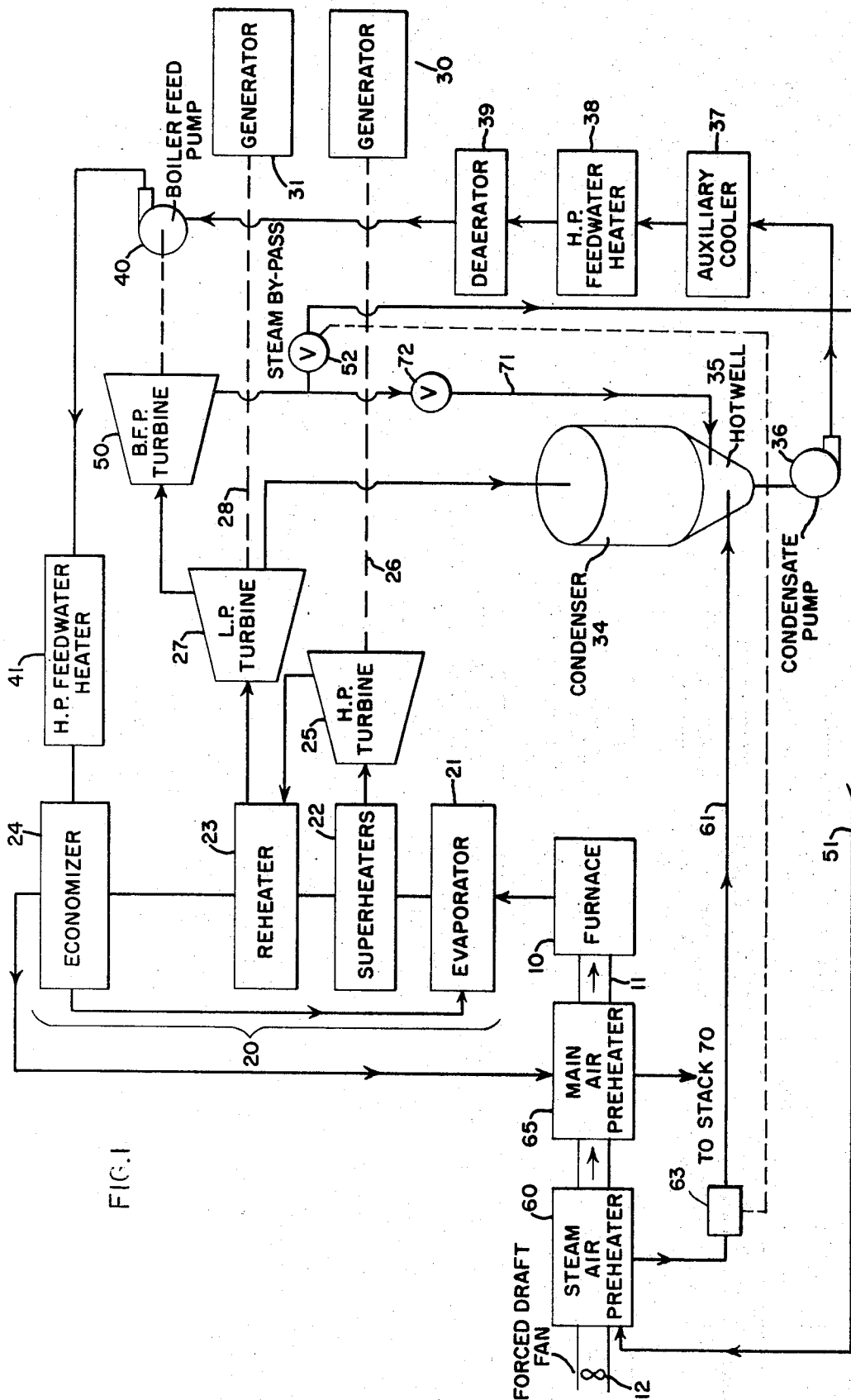


FIG. 1

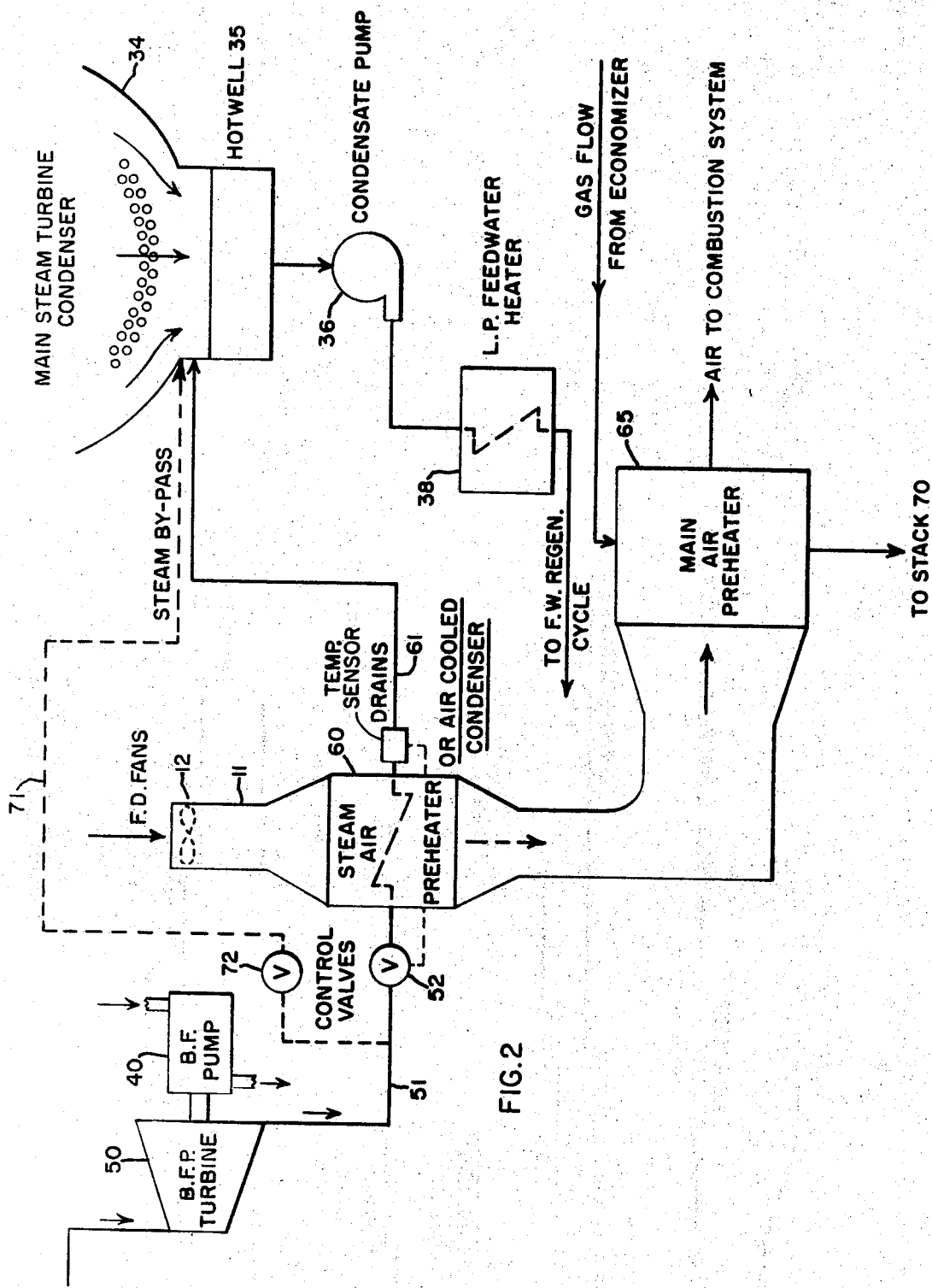


FIG. 2

STEAM AIR PREHEATER FOR A STEAM BOILER SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention is directed to a steam boiler system and more particularly to such a system employing air preheating means.

2. Description of the Prior Art

In steam boiler systems, preheating of intake air is well known, even to the extent of employing a plurality of heat exchangers for this purpose. One such heat exchanger is commonly known as a main air preheater. Flue gases at about 600° F, immediately before being exhausted through a stack, are routed through the main air preheater to provide flue gas-to-air heat transfer. The temperature of the flue gases is insufficient in certain cases (at low ambient temperatures) to raise the temperature of the incoming air to a desirable level. Therefore, additional air preheaters may be necessary. In the past, various points in a steam cycle were tapped for a supply of steam or hot water for additional air preheaters. For example, a common extraction point was where the steam pressure was from 60 to 150 psia, such as at a low pressure turbine or at a deaerator. Regardless of where the tap was taken, however, prior art devices failed to achieve maximum cycle efficiency.

Aside from requirements of combustion system and cycle efficiency, the temperature of the air entering the main air preheater section of the boiler must be high enough to prevent the temperature of the flue gases from falling below the dew point and the condensation point. In utility boilers the exhaust flue gases include nitrogen, carbon dioxide, water vapor and small quantities of sulphur dioxide. A combination of sulphur dioxide with water will result in the formation of sulfuric acid and condensation of this acid could cause corrosion damage to the components of the air preheater section of the boiler. Therefore, the temperature of any corrodible parts of the air preheater section should be maintained above the dew point of the flue gases.

In view of the above-mentioned problems, it is an object of this invention to increase the cycle efficiency of a steam boiler system beyond that previously achieved.

A more specific object is to utilize components of a steam boiler system previously unused for air preheating.

Finally, it is an object to prevent the condensation of deleterious components of the exhaust flue gases in an air preheater which is part of a boiler system by sufficiently heating the intake air.

SUMMARY OF THE INVENTION

In carrying out this invention, in one form thereof, a steam boiler system is provided wherein a main turbine is driven by steam produced in a boiler, which boiler is supplied by high-pressure water from a boiler feed pump. Exhaust flow from the main turbine is routed directly to a main condenser, with the exception of a small extraction flow routed through a boiler feed pump turbine. Prior to returning to the main condenser as condensate, exhaust steam from the boiler feed pump turbine is run through a steam air preheater disposed in the air intake of the steam boiler. Bypass piping is provided to run exhaust steam from the boiler

feed pump turbine directly to the main condenser as system conditions demand.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic representation of a steam boiler system according to this invention, and

FIG. 2 is a more detailed view of the steam air preheater shown in FIG. 1.

DESCRIPTION OF THE INVENTION

Referring to FIG. 1, the steam boiler system includes a combustion means 10, which may be a furnace of any well-known type wherein fuel is burned. Inlet duct means 11 is provided to conduct intake air from the atmosphere to the furnace. Upon exiting the furnace, the gases are at approximately 1,900° to 2,400° F. A boiler 20 is provided comprising evaporator 21, superheater 22, reheater 23, and economizer 24. Steam produced in evaporator 21 and superheater 22 is directed into high-pressure turbine 25 where it is expanded. Work is extracted through drive shaft 26 which powers dynamoelectric machine 30. Steam from high-pressure turbine 25 is re-energized by passing it through reheater 23, where it is heated to about 1,000° F and thence to low-pressure turbine 27, where it is re-expanded. In a manner similar to high-pressure turbine 25, low-pressure turbine 26 is provided with a drive shaft 28 which powers a dynamoelectric machine 31. Although two sets of turbines, drive shafts, and dynamoelectric machines are shown, it will be understood that this arrangement is for illustrative purposes only, and is not limiting.

Most of the steam exiting low-pressure turbine 27 is sent directly to main condenser 34 where it is condensed and then drained into the condenser hotwell 35. Hot water from hotwell 35 is pumped by condensate pump 36 through auxiliary cooler 37, low-pressure feedwater heater 38, and deaerator 39. Auxiliary cooler 37 and low-pressure feedwater heater 38 are merely heat exchangers of a well-known type employed to improve cycle efficiency. It will be understood that there may be several of these heat exchangers fed by condensate pump 36.

The flow next enters boiler feed pump 40 where it is pumped at a high level of pressure through high-pressure feedwater heater 41 and economizer 24. As with low-pressure feedwater heater 38, a plurality of heat exchangers may comprise high-pressure feedwater heater 41. Finally, the flow enters boiler 20 to complete the cycle.

Boiler feed pump 40 is driven by boiler feed pump turbine 50. In turn, boiler feed pump turbine 50 is powered by exhaust steam tapped from low-pressure turbine 27. The amount of steam required to drive boiler feed pump turbine 50 is quite low, about 7 percent of the total flow passing from low-pressure turbine 27 being sufficient. In the past, exhaust flow from boiler feed pump turbine 50 was immediately routed to condenser 34. The invention productively utilizes the exhaust flow heat of boiler feed pump turbine 50 to preheat intake air prior to its utilization to support the combustion process in the boiler.

The details of the steam air preheater arrangement of this invention are illustrated more fully in FIG. 2. In the following description of FIG. 2 it will be understood that the specific temperatures and other values given therein are representative values included to facilitate

better understanding of the invention. Referring now to FIG. 2, exhaust steam from boiler feed pump turbine 50, which has a quality of about 98 percent and a temperature of about 130° F, is passed through conduit 51 and control valve 52 which connect boiler feed pump turbine 50 to steam air preheater 60. Intake air from the atmosphere is supplied through inlet duct means 11 and steam air preheater by a forced draft fan 12. While this fan is shown upstream of the steam air preheater 60, it can be placed downstream of the preheater 60 if desired. The steam air preheater 60 picks up heat energy in steam air preheater 60 from steam coming from boiler feed pump turbine 50. Since the temperature of the flow in conduit 51 may not be much greater than the temperature of the intake air, steam air preheater 60 requires a highly efficient heat transfer surface. A suitable high efficiency heat transfer surface has been, and is currently available, to satisfy the requirements of this system. After passing through steam air preheater 60, the exhaust steam of boiler feed pump turbine 50 is conducted through drain 61 to condenser hotwell 35 where it re-enters the main steam cycle.

After passing through steam air preheater 60, the intake air is at about 90° - 150° F. The air next enters main air preheater 65 immediately prior to combustion in the furnace. Flue gases exhausting from economizer 24 are at about 600° F and are routed through main air preheater 65 prior to final exhaustion through stack 70.

Thus, main air preheater 65 is a flue gas-to-air heat exchanger. The efficiency of this preheater is quite high, with intake air entering the boiler at about 500° F.

As previously mentioned, exhaust steam from boiler feed pump turbine 50 is conducted through conduit 51 and control valve 52 to steam air preheater 60, from whence it goes to condenser hotwell 35 through drain 61. By appropriately setting control valves 52 and 72, the flow pressure and intake air temperature are regulated. A bypass is provided in order to relieve an excessive pressure buildup and thus prevent a large rise in air temperatures. Thus, conduit 51 is tapped by steam bypass 71 which contains control valve 72. Exhaust steam entering bypass 71 is conducted through valve 72 directly to condenser hotwell 35.

In operation, if, for example, the pressure in conduit 51 exceeds a certain limit, control valve 72 opens to bypass exhaust steam through steam bypass 71 and thus relieve the pressure in conduit 51. As the pressure returns toward its preselected level, valve 72 closes as much as is necessary. If the atmospheric temperature is very low, valve 72 may close entirely since all available flow from boiler feed pump turbine 50 is required to heat the intake air. On the other hand, the intake air temperature on a very warm day may be high enough so that valve 52 may be almost entirely closed and thus valve 72 may be almost entirely open.

A separate control is provided for valve 52. If the intake air temperature is very low, the temperature of the flow in drain 61 may also be very low. Thus, ice may form on the inside of the tubes of the steam air preheater 60. To prevent this, a temperature sensor 63 in drain 61 causes valve 52 to close so that all extraction flow from boiler feed pump turbine 50 is bypassed through conduit 71 if the temperature in drain 61 falls below a predetermined level.

Tests conducted with the invention have shown a cycle efficiency increase of about one half of 1 percent or even more over other intake air preheaters whose

extraction points are at different places in the steam boiler system. In an art such as this which is quite highly developed, an increase in overall efficiency of this magnitude is of great significance. Not only does the invention improve the efficiency of the entire steam boiler and steam turbine system, but it also helps eliminate corrosion within the main air preheating section of the boiler. The system guarantees through utilization of output from the boiler feed pump turbine that condensate will not form regardless of the ambient temperature. All that is required is an appropriate control valve modulation so that the temperature is maintained above the dew point of deleterious components of the flue gases.

While a specific embodiment of the invention has been described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from the invention. It is therefore intended in the appended claims to cover all such changes and modifications that fall within the true spirit and scope of this invention.

What is claimed is:

1. An improved steam boiler system of the type including a boiler, combustion means for heating intake air supplied to said boiler, inlet ducting for intake air being fed to said combustion means, a boiler feed pump supplying feedwater to said boiler, a main turbine driven by the output of said boiler, a boiler feed pump turbine for driving said boiler feed pump, said boiler feed pump turbine being driven by extraction flow of steam from said main turbine, and a condenser receiving exhaust from said main turbine, wherein the improvement comprises a steam air preheater disposed within said ducting and intermediate said boiler feed pump turbine and said condenser, a first conduit with a first control valve therein connecting said boiler feed pump turbine to said preheater for supplying exhaust steam from said boiler feed pump turbine to said preheater to transfer heat energy to said intake air, said preheater discharging its output to said condenser, and a bypass comprising a second conduit with a second control valve therein connecting said first conduit to said condenser, said second conduit tapped from said first conduit at a point upstream of said first control valve, first means responsive to a predetermined temperature of said output of said preheater for controlling said first valve, and said second valve responsive to a predetermined pressure of the boiler feed pump turbine exhaust, thereby varying the amount of steam supplied to said preheater.
2. A power plant comprising: at least one main turbine; a boiler supplying steam to the main turbine; a combustor supplying heat to the boiler including an inlet air duct supplying air to the combustor; a boiler feed pump supplying feedwater to the boiler, the boiler feed pump driven by a boiler feed pump turbine, the feed pump turbine driven by extraction steam from the main turbine;

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a steam air preheater disposed in the air inlet duct;
and,
a first steam conduit having a first valve therein, the
steam conduit interconnecting the boiler feed
pump turbine exhaust with the steam air preheater. 5
3. The power plant recited in claim 2 further includ-
ing a temperature sensor at the steam air preheater ex-
haust, the first valve connected with the temperature
sensor.

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4. The power plant recited in claim 2 further includ-
ing a condenser connected to the main turbine exhaust;
and, a steam bypass conduit including a second steam
conduit and a second valve, the second steam conduit
interconnecting the first steam conduit and the con-
denser at a point upstream from the first valve, the sec-
ond valve being a control valve responsive to the boiler
feed pump turbine exhaust pressure.

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