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J. S. HAMILTON, JR

3,515,102

DESUPERHEATER CONTROL SYSTEM

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2 Sheets-Sheet 1

FIG. 1

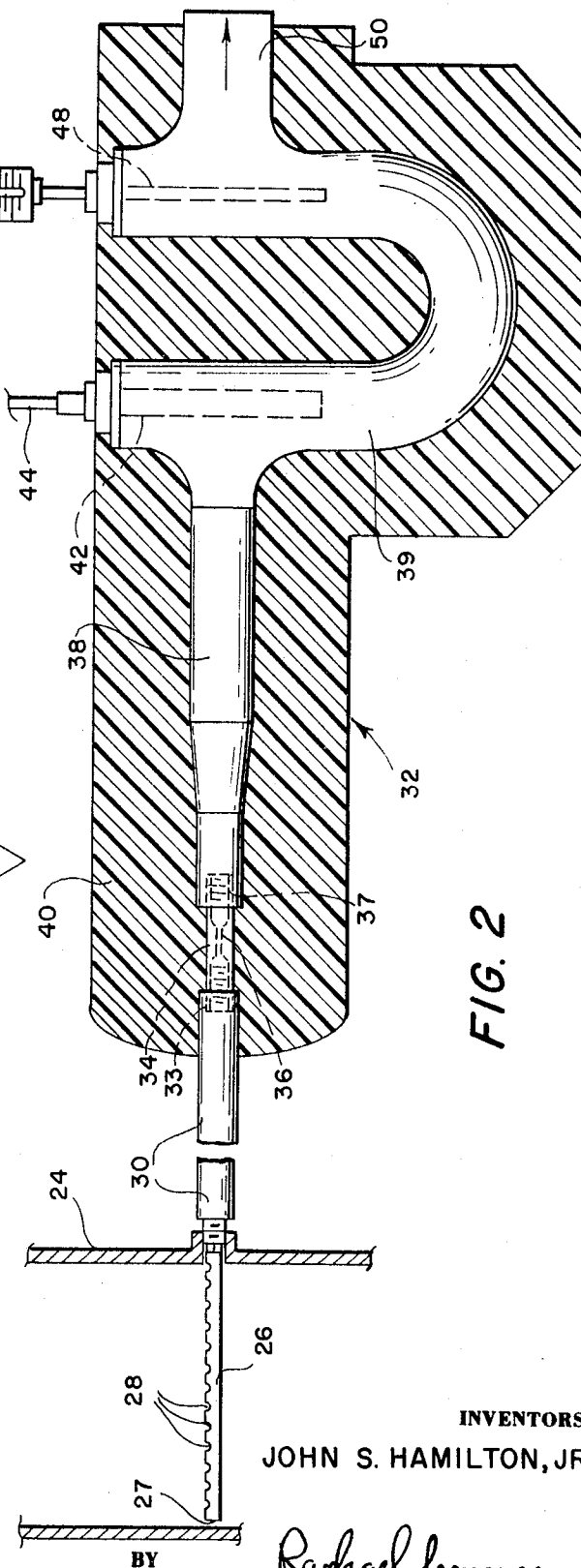
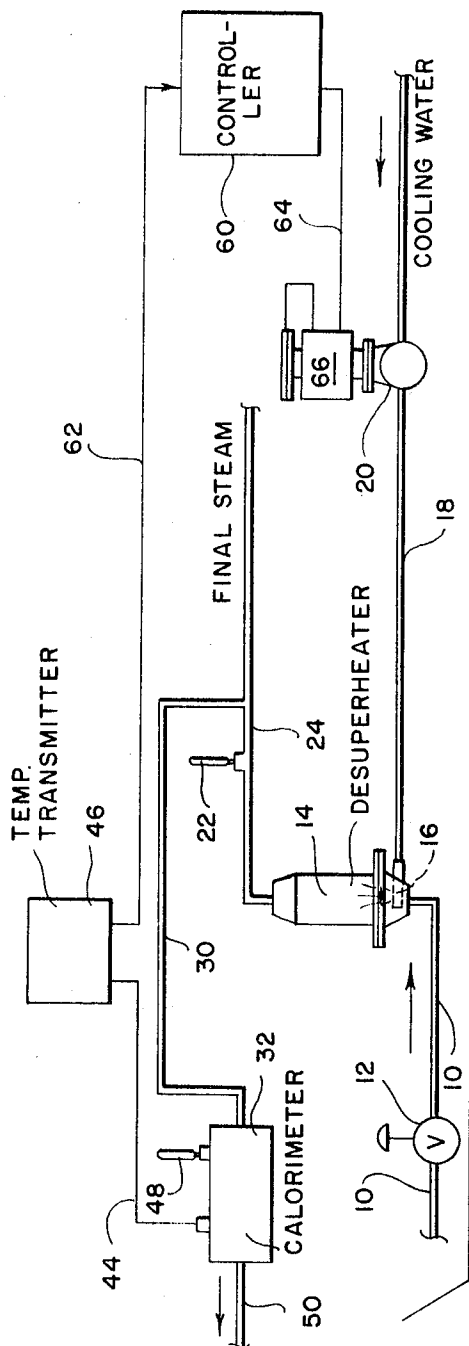


FIG. 2

INVENTORS
JOHN S. HAMILTON, JR.

BY *Raphael Lemmes*

ATTORNEY

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J. S. HAMILTON, JR

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2 Sheets-Sheet 2

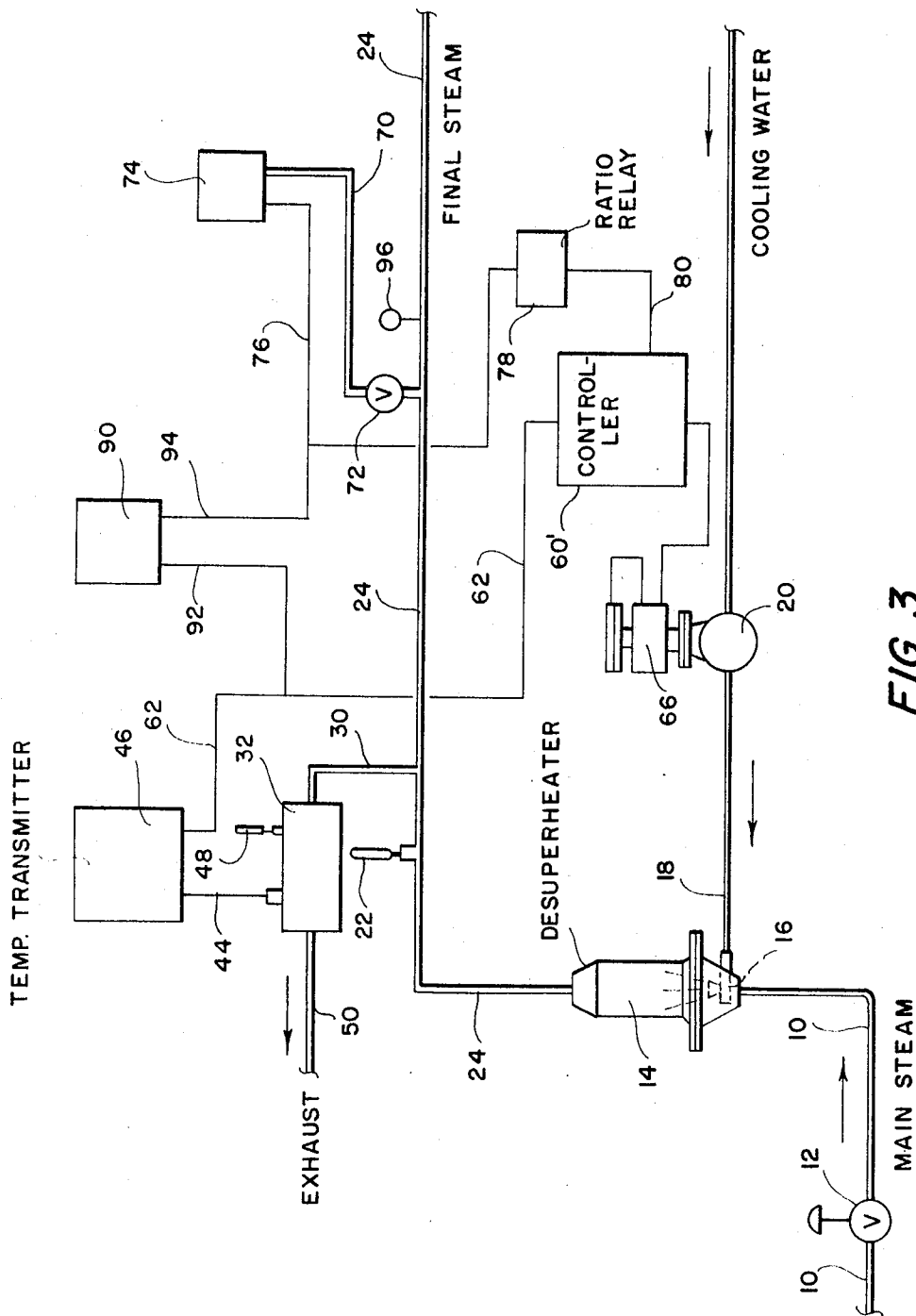


FIG. 3

INVENTORS
JOHN S. HAMILTON JR.

BY

Raphael Lemmes

ATTORNEY

1

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DESUPERHEATER CONTROL SYSTEM

John S. Hamilton, Jr., Monroe, La., assignor to Boiler Equipment and Controls, Inc., Monroe, La., a corporation of Louisiana

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9 Claims

ABSTRACT OF THE DISCLOSURE

A desuperheater is controlled at saturation temperatures or below. A sample of the desuperheated steam is fed into a throttling calorimeter where the sample is resuperheated. A temperature sensing element exposed to the resuperheated steam within the calorimeter develops a temperature control signal which is employed to regulate a control valve controlling the quantity of cooling water fed to a spray nozzle within the desuperheater. The control valve may also be controlled as a function of the pressure of the desuperheated steam.

BACKGROUND OF THE INVENTION

This invention relates to steam desuperheaters and, more particularly, to a steam desuperheater control system in which the steam temperature is controlled at saturation temperatures or below.

When water is heated in a closed vessel or boiler, the temperature of both the water and the steam at saturation has a value referred to as a saturation temperature corresponding to a given pressure. The saturated steam may be then superheated in two ways. One method is to pass the saturated steam over a separate heat transfer surface in the boiler to raise the temperature above the saturation temperature by a fixed value controlled by the area of heating surface and location within the boiler. Saturated steam may also be superheated by expanding the steam through an orifice, such as a valve. In the latter case, the reduction in pressure of the steam resulting from the expansion through the orifice is thermodynamically accompanied by an adiabatic change of state (a change in which there is no loss of total heat content). Since this reduction in pressure lowers the saturation temperature and since the heat content of a pound of saturated steam at this lower pressure is always less than the heat content of a pound of saturated steam at a higher pressure, the steam at the lower pressure becomes superheated.

While there are many applications in which superheated steam is desirable, there are also many situations in which superheated steam should not be utilized. Frequently, for example, the equipment to which the steam is applied is not suitable for the higher temperature of superheated steam. Superheated steam may not be compatible with rates of heat transfer in steam heating coils, and the effect of superheat in some process applications may result in comparatively rapid build-up of process materials on heat transfer surfaces. In the first case, superheated steam has only one-half a B.t.u. per pound of steam per degree F., which is the total amount of heat which can be given up in heat transfer surfaces until the steam has reached saturation temperature; but the same pound of steam gives up approximately 960 B.t.u. at a constant temperature as it is condensed into water or condensate. Additionally, the rate of heat transfer of a vapor to a metal or other surface is much lower for a dry vapor, as in the case of superheated steam, than for a completely wetted surface as would be the case in most heat transfer equipment where saturated or slightly wet

2

steam was applied to the heat exchanger. It is also desirable to eliminate superheat and operate at saturation as a means of lowering the operating temperatures to a point at which process materials do not dry on tube surfaces and accumulate at as rapid a rate as would occur at higher temperatures. There are also many industrial processes, such as chemical processes and the manufacture of sugar, paint, and paper, which require saturated, rather than superheated, steam.

Since a ready supply of superheated steam is frequently available, there are many applications in which a device for desuperheating superheated steam is necessary. Desuperheaters are known in the prior art for accomplishing this result, and these desuperheaters include means providing a lower temperature medium to absorb heat from the steam and thereby lower the superheat. This means could be in the form of a heat exchanger in which a lower temperature medium to absorb the heat and remove it from the system is employed. Most desuperheaters, however, remove the superheat by injecting water into direct contact with the superheated steam. The desuperheating occurs as a result of a transfer of heat from the superheated steam to the injected water, lowering the superheated steam temperature and transforming the water into steam at the same lower temperature.

It is often desirable to control the temperature and quality of the steam leaving the desuperheater. Although a number of desuperheater control systems have been suggested in the prior art, such systems have made use of a temperature measuring instrument to measure directly the temperature of the steam leaving the desuperheater and develop a control signal for regulating a valve in the cooling water supply line to the spray nozzle within the desuperheater. However, since the temperature of the steam will not change after it reaches a temperature corresponding to the saturation temperature at the pressure of the steam, the amount of spray water required cannot be satisfactorily controlled at saturation temperatures or below at conditions where one may wish to control a fixed amount of free moisture in the steam. As a result, none of the prior art desuperheating control systems have had the ability to maintain effective control at any other condition than above saturation temperature.

SUMMARY OF THE INVENTION

Accordingly, it is a principal object of the invention to provide an improved desuperheater control system.

More specifically, it is an object of the invention to provide a superheater control system which controls steam temperatures at saturation or at a fixed quality below saturation.

The present invention contemplates that a sample of the desuperheated steam provided by the desuperheater be resuperheated in, for example, a throttling calorimeter. The temperature of the resuperheated steam sample in the calorimeter is employed for developing a temperature control signal which is employed for regulating the cooling water supplied to the spray nozzle within the desuperheater.

It is also contemplated by the invention, in a second embodiment, that the control valve for the cooling water should also be under the control of the pressure of the desuperheated steam provided by the desuperheater. In this embodiment, a pressure control signal corresponding to the pressure of the desuperheated steam is combined with the temperature control signal for jointly regulating the cooling water.

The foregoing and other objects, advantages, and features of the invention and the manner in which the same are accomplished will become more readily apparent upon consideration of the following detailed description of the invention when taken in conjunction with the

accompanying drawings, which illustrate preferred and exemplary embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram showing a desuperheater control system of the invention;

FIG. 2 is a schematic diagram illustrating, in greater detail, a throttling calorimeter coupled to a steam line of the invention; and

FIG. 3 is a schematic diagram showing a second embodiment of a desuperheater control system of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Turning to FIG. 1, it will be seen that a desuperheater control system according to the invention includes a main steam line 10 which receives a supply of steam from a suitable source, such as a boiler. In order to control the pressure of the steam, a valve 12 is inserted in the main steam line. The steam received by the main steam line may, in a typical system, already be superheated. Alternatively, if the steam arriving at valve 12 is not superheated, the adiabatic expansion of the steam in control valve 12 may cause the steam received by main steam line 10 to become superheated. In either event, if the steam is intended for an apparatus or a process in which superheated steam is undesirable, it is necessary to desuperheat the steam.

The steam is therefore fed to a desuperheater 14 which includes a spray nozzle 16 receiving a supply of cooling water from a cooling water supply line 18. In order to regulate the amount of cooling water supplied to spray nozzle 16, a cooling water control valve 20 is provided. As will be explained more fully hereinafter, this control valve 20 is regulated so that a proper amount of cooling water is supplied to spray nozzle 16 to provide the proper amount of heat absorption and desuperheating in desuperheater 14. As previously explained, the water spray provided by spray nozzle 16 cools the superheated steam in desuperheater 14 and, in addition, the sprayed water is converted to steam at the same temperature. The result is that the superheated steam provided from main steam line 10 is converted to steam at saturation temperature or below in the desuperheater.

In order to monitor the temperature of the desuperheated steam leaving desuperheater 14, a thermometer 22 is provided in a final steam line 24 which receives desuperheated steam from desuperheater 14.

It is now necessary to provide means for resuperheating a sample of the desuperheated steam from final steam line 24.

Referring to FIG. 2, it will be seen that a steam sample is obtained by means of a steam sampling nozzle 26 extending across final steam line 24. Sampling nozzle 26 is in the form of a pipe which is closed at the far end 27 and which has a plurality of orifices 28 in a line along one side thereof. It is to be understood that nozzle 26 should be installed in line 24 in such a position that holes 28 will directly face the steam flow. The sample of steam received by nozzle 26 is conveyed through a pipe 30 to a throttling steam calorimeter 32 of conventional design. The pipe is coupled to an end 33 of an orifice nipple 34 having a passage of reduced diameter 36, the other end 37 of which is coupled to the main passageway 38 of the calorimeter. As is customary in the throttling calorimeter art, the passageway 38 is connected to a U-shaped passageway 39. It will be noted that the orifice nipple and passageways are positioned within an insulating housing 40.

Due to the reduced diameter portion 36 of orifice nipple 34, the sample of steam provided by nozzle 26 is subjected to adiabatic expansion and is again superheated. Since no heat loss accompanies the adiabatic expansion of the steam in the calorimeter, it is now possible

to set a control at a temperature corresponding to the condition at which it is desired to maintain the steam system. The temperature of the superheated steam sample within calorimeter 32 is measured by a measuring instrument 42 which may be any type of instrument, such as a thermostat, capable of providing a temperature signal in response to the temperature of the resuperheated steam within the calorimeter. The signal developed in instrument 42 is coupled by means of capillary 44 to a pneumatic temperature transmitter 46. Calorimeter 32 also includes a calibrated industrial type thermometer 48 and an exhaust port 50 which exhausts the steam to a constant pressure as required for control. The exhaust pressure could be controlled by a variety of means including, for example, condensers, vacuum pumps, or steam jet ejectors of conventional design. The exhaust pressure should be a sufficiently low pressure in order to provide a control temperature in the calorimeter at a superheated condition.

The throttling steam calorimeter may be of any standard type which, in the past, has only been used to determine the quality of steam or moisture content in the steam as related to boilers and steam piping systems. For example, 900 series steam calorimeters, as sold by Vossco, Inc., Niagara Falls, N.Y., would be suitable.

Although the temperature transmitter 46 could serve as a controller directly, in the system shown in FIG. 1, temperature transmitter 46 transmits a pneumatic temperature control signal to a pneumatic controller 60 over a line 62. It is to be understood that an electrical temperature transmitter and controller could be employed instead of the pneumatic components shown. Controller 60, which may be of any standard design, is set to provide a regulating signal along line or pipe 64 to a pneumatic control section 66 of cooling water control valve 20. It is to be understood that if the control system is electrical, control section 66 could be an electrical positioner for controlling the position of the valve. The quantity of cooling water provided to spray nozzle 16 is thus a function of the temperature of the resuperheated sample of desuperheated steam in throttling steam calorimeter 32. Since the temperature of the steam received from desuperheater 14 is measured in a superheated condition, it is possible to control the quality of the steam issuing from the desuperheater 14 at saturation temperature or at a fixed quality below saturation temperature, as determined by the setting of the controller and maintenance of a constant pressure at the sampling point.

In the more complex system shown in FIG. 3, the supply of cooling water is also made a function of the pressure of the desuperheated steam supplied by desuperheater 14 to final steam line 24. In addition to the system shown in FIG. 1, a pressure sampling pipe 70 receives a sample of the desuperheated steam through a valve 72, and this sample is provided to a pneumatic pressure transmitter 74 of conventional design. The pressure transmitter develops a pneumatic signal along a line 76 to a pneumatic ratio relay 78 of standard design which is selected to maintain a ratio or output condition consistent with the curvature of the saturation line on a Mollier diagram. The pressure control signal, thus modified by the ratio relay, is supplied along line 80 to a pneumatic controller 60'. Controller 60' then develops a regulating signal responsive to both the temperature control signal supplied by temperature transmitter 46 along line 62, in the manner described with reference with FIG. 1, and a pressure control signal supplied by ratio relay 78. This signal is now utilized to control control means 66 of cooling water control valve 20 to regulate the quantity of water injected by spray nozzle 16 into desuperheater 14 and thus control the degree of desuperheating in desuperheater 14.

In addition, a recording device 90 may be coupled through lines 92 and 94 to the temperature transmitter 46 and the pressure transmitter 74, respectively. This

recorder will then keep a record of the temperature and pressure conditions as monitored by the temperature transmitter 46 and pressure transmitter 74. A pressure gauge 96 may also be coupled to final steam line 24.

It is to be understood that the desuperheater, throttling steam calorimeter, temperature and pressure measuring devices, temperature and pressure transmitters, ratio relay, controller, and cooling water control valve may all be standard components of conventional design. The controller may include conventional controls such as an auto-manual bias cascade control station. Moreover, electrical controls may be substituted, within the scope of the invention, for the pneumatic controls shown.

While preferred embodiments of the invention have been shown and described, it will be apparent to those skilled in the art that changes can be made without departing from the principles and spirit of the invention, the scope of which is defined in the appended claims. Accordingly, the foregoing embodiments are to be considered illustrative rather than restrictive of the invention, and those modifications which come within the meaning and range of equivalency of the claims are to be included therein.

The invention claimed is:

1. A desuperheater control system comprising:
a main steam line for receiving superheated steam;
a desuperheater for desuperheating steam received from said main steam line to saturation temperature or below, said desuperheater including means to absorb heat from said superheated steam;
control means to control said means to absorb heat and thereby control the extent of desuperheating of said superheated steam;
means to resuperheat a sample of desuperheated steam received from said desuperheater;
means to develop a temperature control signal as a function of the temperature of said resuperheated sample;
and means responsive to said temperature control signal for regulating said control means to control the temperature of said desuperheated steam.
2. A desuperheater control system as recited in claim 1, wherein said means to absorb heat comprises spray means to spray cooling water in said superheated steam and said control means comprises a valve to control the flow of cooling water to said spray means.
3. A desuperheater control system as recited in claim 2, wherein said means to resuperheat a sample of said desuperheated steam comprises a throttling steam calorimeter, said calorimeter including means to adiabatically expand said desuperheated steam sample to resuperheat said steam sample and said means to develop a control signal comprises temperature measuring means within said calorimeter and exposed to said resuperheated steam.

4. A desuperheater control system as recited in claim 1, wherein said means to resuperheat a sample of said superheated steam comprises a throttling steam calorimeter, said calorimeter including means to adiabatically expand said desuperheated steam sample to resuperheat said steam sample and said means to develop a control signal comprises a temperature measuring means within said calorimeter and exposed to said resuperheated steam.

5. A desuperheater control system as recited in claim 1, further comprising valve means in said main steam line to control the pressure of said steam, said valve means tending to expand adiabatically and superheat said steam in said main steam line.

6. A desuperheater control system as recited in claim 1, further comprising means to develop a pressure control signal as a function of the pressure of said desuperheated steam received from said desuperheater, said control means being jointly regulated by said temperature control signal and said pressure control signal.

7. A desuperheater control system as recited in claim 6, further comprising ratio relay means for modifying said pressure control signal to maintain an output condition consistent with the curvature of the saturation line on a Mollier diagram.

8. A desuperheater control system as recited in claim 6, further comprising valve means in said main steam line to control the pressure of said steam, said valve means tending to expand adiabatically and superheat said steam in said main steam line.

9. A desuperheater control system as recited in claim 6, wherein said means to absorb heat comprises spray means to spray cooling water in said superheated steam and said control means comprises a valve to control the flow of cooling water to said spray means, and said means to resuperheat a sample of said desuperheated steam comprises a throttling steam calorimeter, said calorimeter including means to expand adiabatically said desuperheated steam sample to resuperheat said steam and said means to develop a control signal comprises a temperature measuring means within said calorimeter and exposed to said resuperheated steam.

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KENNETH W. SPRAGUE, Primary Examiner

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