United States Patent

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[72] Inventor **Douglas E. Penning**
Dublin Road, Southbury, Conn. 06488

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[54] **BOILER PROTECTIVE SYSTEM**
6 Claims, 2 Drawing Figs.

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[50] **Field of Search** ..... 73/345, 17, 17 A; 340/229; 122/504, 504.2

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Primary Examiner—Louis R. Prince
Assistant Examiner—Denis E. Corr
Attorney—Amster & Rothstein

ABSTRACT: A safety device for indicating when the water level is critically low in a steam boiler makes use of the fact that steam in a boiler becomes superheated when the boiler water level falls below the boiler's uppermost fire tubes. The present apparatus measures the steam temperature and the steam pressure and compares the two to determine whether they are related to one another in accordance with the temperature-pressure characteristic of saturated steam. If the measurements are not so related, the safety device initiates appropriate corrective action to prevent damage to the boiler.

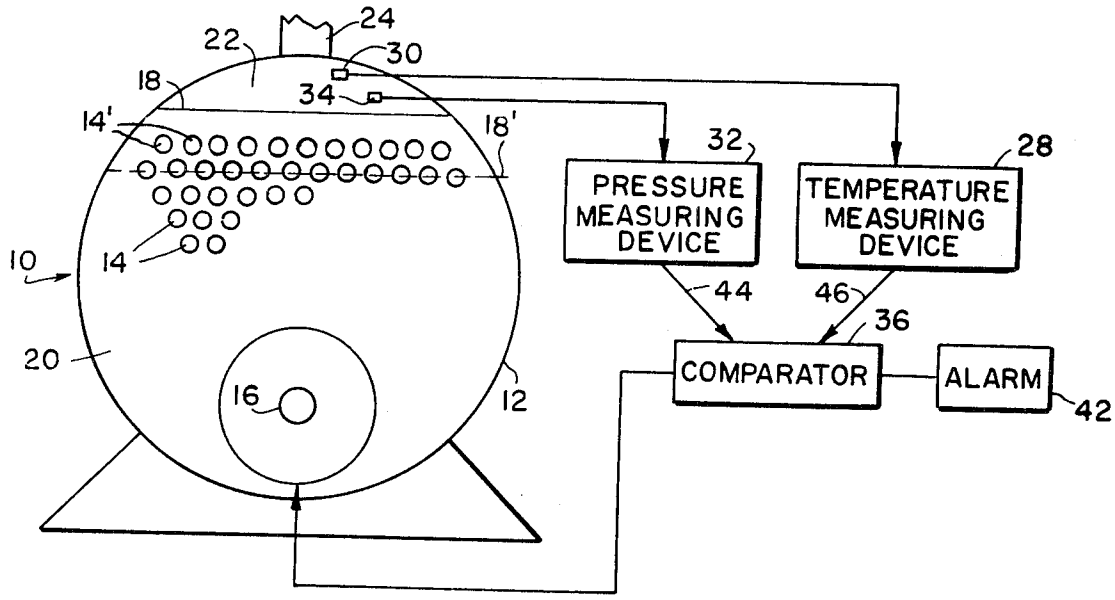


FIG. 1

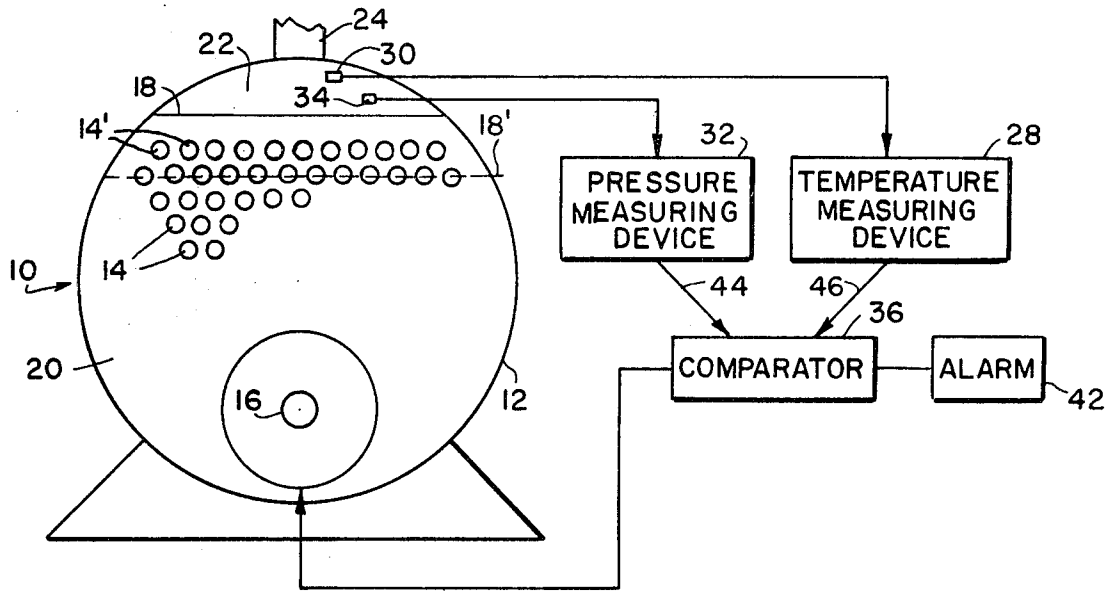
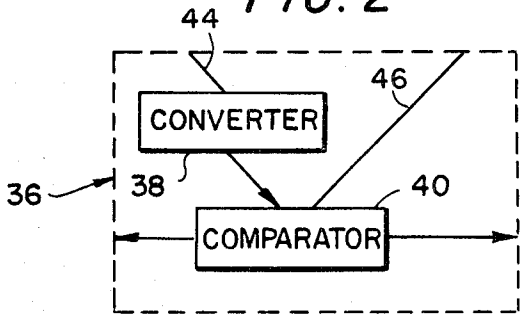


FIG. 2



INVENTOR.
DOUGLAS E. PENNING
BY Amster + Rothstein
ATTORNEYS

BOILER PROTECTIVE SYSTEM

This invention relates generally to water heating vessels and more particularly to a process and apparatus for automatically monitoring the operation of a boiler for determining when the boiler's water level becomes critically low and for initiating appropriate corrective action to prevent damage to the boiler.

A conventional safety device for monitoring water level in a steam boiler typically comprises an external water column adapted to reflect the water level in the boiler and a switch which is closed or opened when the water level falls below a selected point. Operation of this switch is normally designed to cut off the firing circuit which heats the boiler and to provide an alarm or some other indication that the boiler is not functioning properly. These conventional devices all require regular and extensive maintenance and testing, including daily cleaning of the water column to avoid scale buildup and daily testing of the switch equipment. So long as this is done regularly, conventional apparatus will adequately maintain a safe water level. However, most boiler failures are attributed to poor maintenance and inspection of conventional safety devices. There is thus a need for an automatic boiler safety device which does not require regular maintenance.

It is a primary object of the present invention to provide a safety device for monitoring the water level in a steam boiler which will continue to operate consistently and accurately even without regular maintenance.

It is another object of this invention to provide a boiler safety device which does not come in contact with the water reservoir of the boiler and hence is immune to scale buildup.

It is still another object of this invention to provide an automatic low-water control for steam boilers that is economical to manufacture and easy to install.

A boiler protective device in accordance with a preferred embodiment demonstrating objects and features of the present invention employs the fact that when the water level in a saturated steam boiler becomes critically low, the boiler's upper fire tubes become exposed above the water surface. The exposed fire tubes apply heat directly to saturated steam in the region above the water surface and super heat the steam. Since saturated steam has a distinct temperature for any given pressure and since the temperature-pressure characteristic of saturated steam is known, the superheated condition is detected by apparatus which measures the temperature and pressure of the steam and compares the temperature measurement with the pressure measurement to determine when these measurements are not related in accordance with the temperature-pressure characteristic of saturated steam. In a preferred embodiment of the invention, the comparing apparatus includes means for converting one of the measurements into an expected value of the other in accordance with the known pressure-temperature characteristic of saturated steam and means for comparing the expected value with the actual measurement. When the actual measurement and the expected value are not substantially equal, the apparatus initiates appropriate corrective action to prevent damage to the boiler.

Additional objects, features and advantages of the present invention will be apparent from the following detailed description of a presently preferred embodiment thereof, when taken in connection with the appended drawing wherein:

FIG. 1 is a schematic representation of a boiler protective system constructed in accordance with the present invention, and

FIG. 2 is a schematic representation of a comparator suitable for use in the system of FIG. 1.

A saturated steam device of the type wherein the present invention is employed comprises a steam and water chamber, with steam being generated by heating the water from below its surface. The present description will relate to a preferred embodiment of the invention as employed in a simple steam-generating boiler of the fire tube type. It is to be understood, however, that the present invention is applicable to numerous other boiler configurations, such as those high efficiency boilers of the water tube type which produce saturated steam in normal operation.

Referring to the drawing, boiler **10** in FIG. 1 comprises a steam and water containing vessel or boiler shell **12** having a water supply **20** with a steam region **22** and a steam outlet nozzle **24** located above the water level **18**. Nozzle **24** communicates with an appropriate steam utilization device not shown. The boiler shell encloses fire tubes **14**, shown only symbolically in end view in FIG. 1, which communicate with a burner **16** and conduct superheated gases, the product of combustion in burner **16**, through water supply **20** to heat the water. The detailed structure of fire tube boilers, such as boiler **10**, are well known in the art and will not be described here in detail.

In normal operation, the water level **18** is above the uppermost row of fire tubes **14'**, and the water is heated from beneath its surface **18**, producing saturated steam in region **22**. If water level **18** should fall below the uppermost fire tubes **14'**, heat transfer away from the exposed fire tubes would be substantially reduced and the temperature of the tubes would rise appreciably, creating a substantial danger of damage to the boiler and its surroundings. Conventionally, the water level is monitored by a water actuated switch which indicates when the water level is below a selected safe level. However, as indicated above, such control devices require constant and careful maintenance which is frequently not provided.

In accordance with the present invention, the function of the water level measuring device is supplemented, or in some situations supplanted, by a boiler protective system which monitors the condition of the steam in region **22**. So long as the steam is saturated, the water reservoir is being heated from beneath water surface **18**. If water level **18** falls critically low, for example, to level **18'**, the steam becomes superheated because heat is applied directly to the steam in region **22** by exposed fire tubes **14'**. The present invention monitors this condition and controls burner **16** to make appropriate adjustments to prevent damage to the boiler.

To determine whether the steam in region **22** is saturated or superheated, the present invention employs a temperature measuring device **28** having a temperature sensing probe **30** located in the steam space **22** of the boiler, and a pressure measuring device **32**, having a pressure probe **34** located within space **22**. It is to be understood that devices **28** and **32** and probes **30** and **34** are only representations and any of many well-known temperature-measuring and pressure-measuring devices could be used. It is also to be understood that temperature and/or pressure readings may be taken within nozzle **24** or elsewhere along the system.

To detect superheating, both the temperature and pressure measurements are applied to a comparator **36**, as shown by symbolic arrows **44** and **46**, where the measured temperature-pressure relationship is compared with the known temperature-pressure characteristic for saturated steam. A preferred method for making this comparison is shown in FIG. 2, where one measurement is converted into an expected value of the other in accordance with the known temperature-pressure characteristic of saturated steam, and the expected and measured valves are then compared. It is to be understood that either the temperature measure may be converted to a pressure reading or the pressure measure may be converted to a temperature reading.

The system shown in FIG. 2 converts the actual pressure reading into an expected temperature reading. This is accomplished in pressure-to-temperature converter **38**, which is mechanically or electrically linked to pressure sensing device **32**. Suitable devices for converting one measured quantity into another in accordance with a known nonlinear relation are well known in the art. For example, converter **38** may simply be an amplifier having a gain characteristic directly proportional to the temperature-pressure characteristic of saturated steam. Since the relationship between temperature and pressure for saturated steam is nonlinear, the amplifier would have a nonlinear gain characteristic. The comparison

may also be made by mechanical means. For example, a cam may be mounted on a shaft which turns in response to steam pressure as indicated by pressure-measuring device **32**. The cam may drive an indicator along a linear scale by means of a suitable cam follower. The cam may be machined to provide a pressure-to-temperature conversion which corresponds to the temperature-pressure characteristic of saturated steam.

However the conversion is made, the output of converter **38** is a mechanical or electrical indication of the expected temperature of steam in the boiler if the boiler is producing saturated steam. This expected temperature and the actual measured temperature from device **28**, which may also be reflected in mechanical or electrical terms in accordance with the type of converter **38** which is employed, are compared in comparator **40**. If the actual temperature and the expected temperature are substantially equal within a selected range of error, no corrective action is taken. If, however, the expected and measured temperatures are not substantially equal, the comparator provides an appropriate signal to activate an alarm **42** or to initiate appropriate corrective action, for example, by shutting off burner **16**, or both, as in the illustrative embodiment shown in the drawing.

Apparatus for providing appropriate control signals on the occurrence of an inequality between the measured and expected temperatures is well known in the art. For example, a simple electronic comparator having an output lead which assumes a voltage when one applied signal exceeds another or a pair of mechanical pointers having an area of mutual contact when both pointers are indicating approximately the same reading but making no contact when different readings are indicated may be used.

It is to be understood that the range of error within which substantial equality of the measured and expected value is determined may be selected according to the use to be made of the system. In a mechanical system for use in conjunction with a standard fire tube boiler, it has been found that the expected and measured temperatures should be deemed substantially equal so long as they are not more than 3° F. apart.

It is to be understood that the above-described embodiments are merely examples of the application of the novel principles of the present invention. Numerous additional embodiments will be devised by those skilled in the art without departing from the spirit or scope of the present invention.

What is claimed is:

1. A safety device for preventing overheating of a saturated steam boiler of the type including an enclosed vessel, a heat source, a liquid reservoir within said enclosed vessel, and one or more fire tubes positioned within said enclosed vessel beneath the surface of said liquid reservoir during normal operation of said boiler, said fire tubes communicating with said heat source for applying heat to said reservoir from beneath the surface thereof, said safety device comprising means for measuring the temperature of steam in said boiler, means for measuring the pressure of steam in said boiler, means for comparing said temperature measurement and said pressure measurement for determining whether said measurements are related in accordance with the known temperature-pressure characteristics of saturated steam, and means operative when said measurements are not related substantially in accordance with said known temperature-pressure characteristics for cooling the fire tubes exposed above the surface of said liquid reservoir.

2. A safety device in accordance with claim **1** wherein said comparing means includes means for converting one of said measurements to an expected value of the other of said measurements in accordance with the temperature-pressure characteristic of saturated steam and means for comparing said other measurement with said expected value for determining whether they are substantially equal.

3. A safety device in accordance with claim **2** wherein said one measurement is said pressure measurement and said other measurement is said temperature measurement.

4. Apparatus as defined in claim **1** including means for activating a warning device when said measurements are not related in accordance with said known temperature-pressure characteristic.

5. A safety device for preventing overheating of a saturated steam boiler comprising means for measuring the temperature of steam in said boiler, means for measuring the pressure of steam in said boiler, means for comparing said temperature measurement and said pressure measurement for determining whether said measurements are related in accordance with the known temperature-pressure characteristics of saturated steam, and means for limiting the application of heat to said boiler when said measurements are not related in accordance with said known temperature-pressure characteristics.

6. A method for preventing damage in a saturated steam device comprising the steps of:

a. measuring the temperature of said steam,
b. measuring the pressure of said steam,
c. converting one of said measurements to an expected value of the other measurement in accordance with the known pressure-temperature characteristic of saturated steam,
d. comparing said expected value to said other measurement to determine when said measurements are different by more than an acceptable amount, and
e. limiting the application of heat to said device when said measurements are different by more than said acceptable amount.