June 24, 1958 W. A. RAY 2,840,146

FLAME DETECTING MEANS

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FIG. 1.

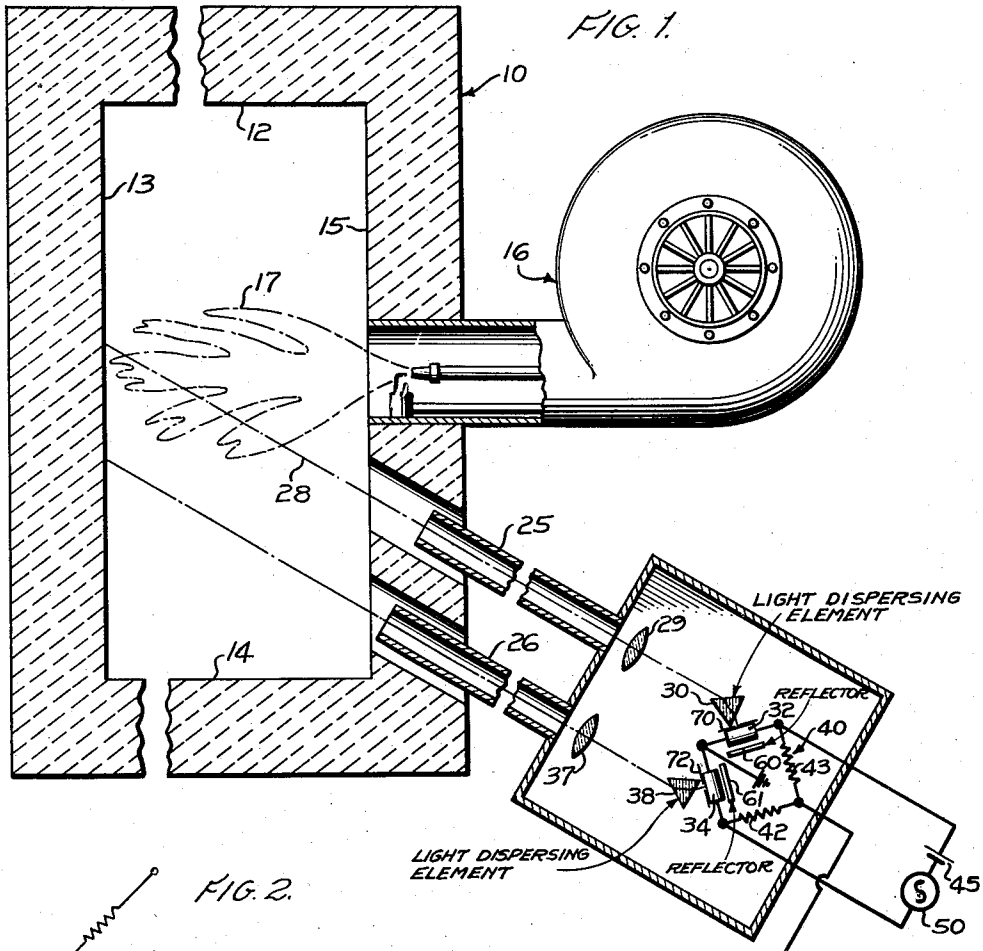


FIG. 2.

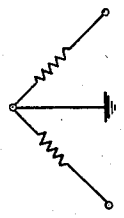
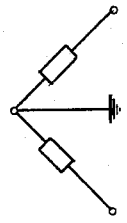


FIG. 3.



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FLAME DETECTING MEANS

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The present invention relates to means and techniques for detecting the presence of a flame and for controlling the flow of fuel to flame producing means.

The problem of detecting the presence of a flame in a furnace gives rise to certain difficulties, mainly because the radiation from the heated walls of the furnace may, unless certain precautions are taken, have the same effect as the radiation from the flame itself, with the result that a false indication may be produced, leading to the creation of a dangerous situation.

Briefly, the present invention relates to improved means and techniques for producing an indication or control which takes into account the radiation from the heated furnace walls as well as the radiation from the flame, by establishing a certain "differential effect," such differential effect being in accordance with the difference in radiation due, on the one hand, to the flame itself and, on the other hand, to the furnace walls or any other body heated by the flame.

For these general purposes, two radiation receiving means are provided, one to receive radiation from the flame and furnace wall, and the other means being arranged to receive radiation from the furnace wall alone, which is heated by the flame. The radiations as thus received are effectively measured and are each represented by corresponding electrical quantities, such quantities being effectively subtracted so as to produce a third electrical quantity, i. e., a net voltage which has a relatively large value when a flame is present and which has a relatively small value or zero value when there is no flame, such net voltage being amplified to produce either an indication or to control the flow of fuel to the flame producing means.

One aspect of the present invention involves the use of radiation receiving elements such as, for example, wires or thermocouples disposed in different arms of a bridge circuit to achieve the above-indicated differential effect.

Another aspect of the present invention involves the transmission of the energy from the flame and heated brick wall onto elements in different arms of a bridge circuit through a spectrum producing element whereby such elements are heated selectively in accordance with energy having a frequency characteristic of the flame and the heated furnace wall or brick work.

It is, therefore, a general object of the present invention to provide means and techniques of the character indicated above.

A specific object of the present invention is to provide improved means and techniques of this character which require no moving elements.

Another specific object of the present invention is to provide means and techniques of this character which are relatively insensitive to sporadic fluctuations in intensity of the flame.

Another specific object of the present invention is to provide an arrangement of this character which is capable of withstanding high ambient temperatures and

which does not become unstable, unsafe or lose its life under high temperature conditions.

Another specific object of the present invention is to provide an arrangement of this character which is quick to respond immediately after extinguishment of the flame, even though the furnace walls may yet be at a high elevated temperature and thus produce copious amounts of radiation.

Another specific object of the present invention is to provide an arrangement of this character which operates in accordance with a particular band of wave lengths in the flame spectra.

Another specific object of the present invention is to provide an arrangement of this character which avoids the use of filter elements and the disadvantages attendant upon the use of a filter.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. This invention itself, both as to its organization and manner of operation, together with further objects and advantages thereof, may be best understood by reference to the following description taken in connection with the accompanying drawings in which:

Figure 1 illustrates a conventional furnace with associated conventional flame producing means with related apparatus shown partly in structural form and partly in schematic form.

Figure 2 illustrates the condition wherein the radiation sensitive elements are resistance wires. Figure 3 illustrates the condition wherein the radiation sensitive elements are thermocouples.

The furnace **10** is of conventional structure and is considered to be lined with a refractory material such as fire brick, and is defined by the fire walls **12**, **13**, **14** and **15**. The conventional flame producing means **16** serves to produce flame **17**, such flame producing means being supplied with fuel which normally flows from the fuel inlet **20** through the solenoid valve **21** through the fuel outlet valve **22**, such outlet being deemed to be in communication with the conventional apparatus **16**.

The flame **17** may be considered as that being due either to the burning of oil or to the burning of gas or other fuel.

Two radiation channels are provided, namely, radiation channels **25** and **26**, in the form of tubes. The tube **25** is oriented so as to receive the radiation not only from the flame **17**, but also from the heated furnace wall **13** along a path indicated by the line **28**, such radiation being focused by a condensing lens **29** and applied through a suitable light dispersing means **30** such as a prism or diffraction grating onto the element **32**. The other radiation tube **26** is oriented so as to receive the radiation from one of the heated furnace walls only and such radiation passes through the lens **37** and impinges on the light dispersing element **38** in the nature of a prism or diffraction grating so that a selected band of wave lengths characteristic of the radiation from the heated furnace wall is directed onto the other radiation receiving element **34**. The optical system associated with the element **32** is such that the element **32** has selectively directed thereto radiation of a band of frequencies characteristic of the flame itself.

The radiation receiving elements **32** and **34** may either be a wire having appreciable electrical resistance or a thermocouple, such wire or thermocouple being either exposed to the atmosphere or enclosed in an evacuated chamber such as an evacuated glass or quartz envelope which, of course, allows the passage of the desired band of frequencies.

The elements **32** and **34** are disposed in different arms of the bridge circuit **40** to produce a differential effect. In the instance when the elements **32** and **34** are resistance

elements, the resistance of such elements changes in accordance with the radiation impinging thereon; and in that instance when the elements **32** and **34** are thermocouples, voltages are developed by such thermocouples in response to the amount of radiation impinging thereon. In either case, it is understood that the term "electrical characteristic" as used in connection with elements **32** and **34** has reference either to a change in property of the elements such as a change in resistance, or a change in an output voltage.

The element **32** is in a first arm of the bridge **40**, the element **34** is in a second arm of the bridge, the resistance **42** is in a third arm of the bridge and the resistance **43** is in a fourth arm of the bridge. The bridge is essentially a direct current type of bridge and is supplied with continuous current from the continuous voltage source **45**. The so-called "galvanometer arm" of the bridge comprises a D. C. amplifier **46** which serves to control the flow of fuel to the flame producing means **16**.

It is understood that in the presence of a flame, sufficient direct current voltage is applied to the amplifier **46** to cause solenoid valve **21** to be energized to thereby allow the flow of fuel to the burner **16**; and, when the flame **17** is extinguished for any reason whatsoever, the solenoid valve **21** is deenergized to allow the spring means normally associated with conventional solenoid valves of this character to interrupt the flow of fuel to the burner or flame producing means **16**.

The alternating current source 50 connected in the so-called battery arm of the bridge is for purposes of supplying a heating current to the serially connected radiation receiving elements **32** and **34** to thereby artificially heat the same to an elevated temperature so as to regulate its rate of response to radiant conditions. Preferably, radiation reflecting elements **60** and **61** are disposed adjacent to the elements **32** and **34** for directing the radiation from the furnace onto the elements **32** and **34** respectively and also for the purpose of directing that energy, produced artificially in elements **32** and **34** by electrical heating, in the direction of the furnace.

The various lenses, light dispersing elements and radiation receiving elements **32** and **34** are enclosed within a light tight box **60**, such box of course being in communication with the open ends of tubes **25** and **26**.

The element **32** is energized to produce an electrical quantity which represents the combined radiation of the flame and furnace wall; while, the element **34** is energized electrically to produce an electrical quantity which represents the radiation from the furnace wall itself. These two electrical quantities are effectively compared to produce a third electrical quantity which appears at the input terminals to the amplifier **46**.

The light dispersing element **30** serves to effectively separate the incident radiation into a spectrum as is well known with this type of element and only a portion of such spectrum corresponding to a particular band of frequencies is allowed to have its effect on the element **32**. This particular band of frequencies is one which is characteristic of the flame produced by the flame **17**. In order to separate the dispersed energy so that this result may be achieved, suitable means such as a slitted shield **70** is disposed between the elements **30** and **32** with energy of a particular band of frequencies only which is characteristic of the flame itself being allowed to impinge on the element **32**. This particular band of frequencies may correspond either to a particular emission band in the flame spectra or to a band of frequencies beyond the range of frequencies wherein copious amount of radiation results from the heated furnace wall. The radiation from the heated furnace wall is not appreciably unlike that

from a so-called "black body" which follows well known formulae and which has a well known energy versus frequency pattern with the maximum energy occurring at a particular frequency and with most of the energy lying within a relatively narrow frequency range. Thus, the element **34** may be subjected only to energy in this particular narrow frequency range which passes through a slit in the slitted plate **72** disposed between the elements **38** and **34**; while the element **32** may be subjected to energy from the flame having either a frequency band outside of such narrow frequency range or subjected to a frequency band within such narrow frequency range and in either case, such frequency band preferably corresponds to an emission band in the flame spectra.

It is noted that the arrangement is one in which differences in intensity of radiation are compared to produce a differential effect, and that the apparatus is preferably rendered frequency sensitive, using radiation dispersing and separating means, exemplified by the elements **30** and **38** but it is understood that the present invention in its broader aspects is not limited to the use of such radiation dispersing and separating means.

While the particular embodiments of the present invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from this invention in its broader aspects and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

I claim:

1. In apparatus for controlling the presence of a flame produced by a flame producing means, a body, flame producing means for producing a flame which is present in an enclosure having said body heated by said flame produced by flame producing means, first frequency selective means for separating energy radiated from said flame and having a frequency band characteristic of said flame, second frequency selective means for separating energy radiated from said body and having a frequency band characteristic of said heated body, and means for comparing the first mentioned energy with the second mentioned energy to control said flame producing means.

2. In apparatus for controlling the presence of a flame in the vicinity of a body heated by a flame produced by flame producing means, a body, a flame producing means for producing a flame to heat said body, a pair of radiation receiving elements, one of said elements receiving radiation from the flame and the body, the other one of said pair of elements receiving radiation from the body only, means for comparing the energy received on the one hand, by said one element with the energy received, on the other hand, by said other element to obtain a comparison between the two energies, means for controlling said flame producing means to deactivate the same when said comparison indicates substantial equality between said energies, and frequency selective means for subjecting said one element to energy having a frequency band which is characteristic of the flame, and frequency selective means for subjecting said other element to energy having a frequency band characteristic of said body.

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