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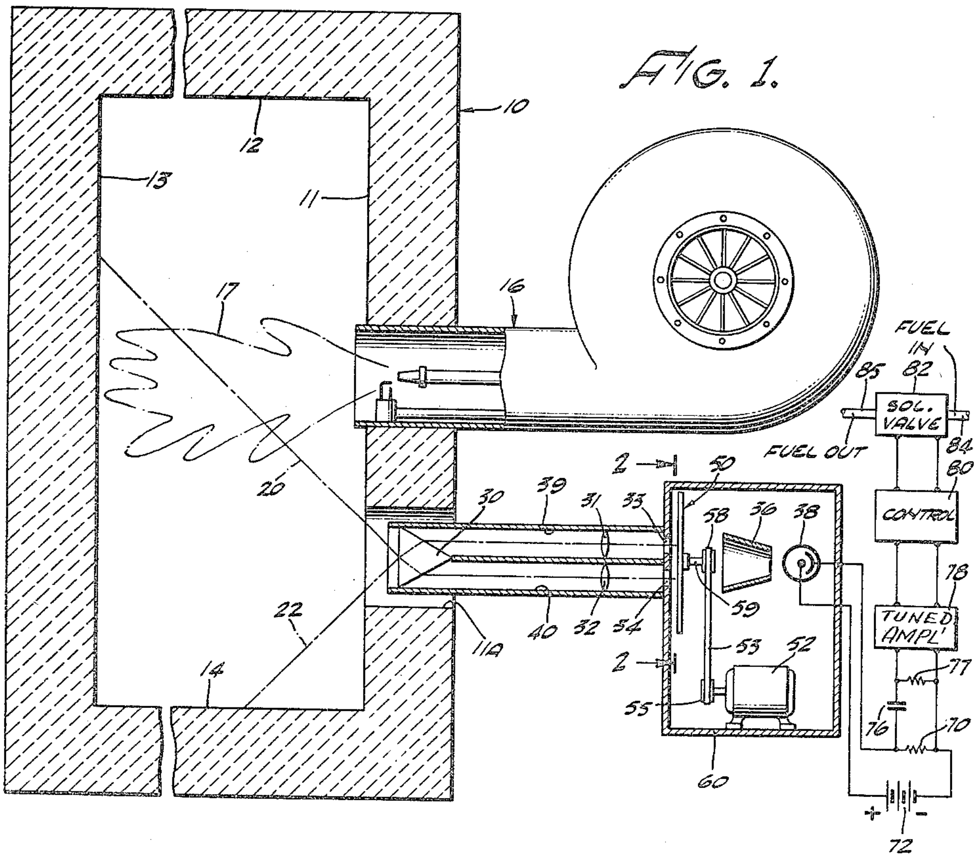

FIG. 1.

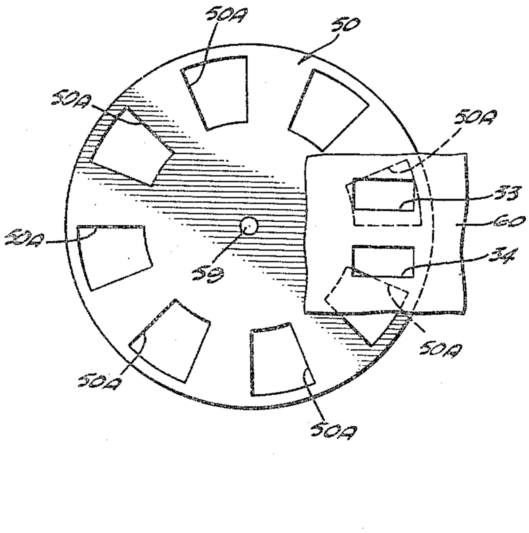

FIG. 2.

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FLAME RESPONSIVE SAFETY CONTROL SYSTEM USING PRISM AND LIGHT CHOPPER

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6 Claims. (Cl. 158—28)

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

The problem of detecting the presence of a flame in a furnace gives rise to certain difficulties, mainly, because the radiation energy from the heated walls of the furnace may, unless certain precautions are taken, have the same effect as the radiation energy 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 energy from the heated furnace walls as well as from the flame, and producing what may be termed to be a differential effect which is sufficiently large in magnitude to produce an indication or control, such differential effect being measured in terms of difference in radiation energy between, on the one hand, the radiation energy from the flame, and on the other hand, the radiation energy from the heated furnace wall or any other body which is heated by a flame.

This result is accomplished, generally, as described more fully hereinafter, by directing the combined radiation energy from the flame and walls, on the one hand, and the radiation energy from the walls, on the other hand, alternately onto a single photocell which serves to develop a fluctuating output voltage, such output voltage being amplified by an amplifier which is preferably selective to the frequency of fluctuations that are due to the flame, the output of the amplifier being used to control a solenoid valve which in turn controls the flow of fuel to the flame.

It is, therefore, a general object of the present invention to provide new and improved means and techniques of this character.

A specific object of the present invention is to provide means and techniques of this character which produce the intended result without substantial interference as a result from either the inherent sporadic fluctuations in intensity of the flame, or induction or pickup of the fundamental or harmonic frequency of neighboring power circuits.

Another specific object of the present invention is to provide an arrangement of this character which is suitable for either gas or oil heated furnaces.

Another specific object of the present invention is to provide means and techniques of this character which obtain the above mentioned differential effect in a novel manner using novel apparatus.

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 apparatus embodying features of the present invention associated with the flame in a conventional furnace having conventional flame producing means associated therewith.

Figure 2 is a view taken generally on the line 2—2 of Figure 1.

Figure 1 shows a furnace **10** defined by the interior walls **11**, **12**, **13** and **14**. Conventional flame producing means designated by the general reference numeral **16** serves to burn fuel and produce the flame **17**. The wall **11** is provided with an opening **11A** to allow the novel apparatus now described in detail, to view certain conditions inside the furnace **10**. The optical system, generally, is arranged to receive radiation energy from the flame **17** along the general path designated by the line **20** and to receive radiation energy from the heated furnace wall **14** along the general path indicated by the line **22**.

The optical system includes, generally, a prism or radiation energy directing means **30** disposed in the front end of radiation energy tubes **39**, **40**, a pair of lenses **31**, **32**, a pair of apertures **33** and **34**, a radiation energy applying or collecting cone **36**, all of which serves to direct radiation energy onto a photocell **38**. The lens **31** is disposed in the first radiation energy channel **39** to focus the radiation energy from the wall **14** onto the photocell **38**; and, likewise, the lens **32** is in the second radiation channel **40** to focus the radiation energy from the flame **17** onto the photocell **38**. Radiation channels or light tubes **39** and **40** terminate at the apertures **33** and **34**, such apertures **33**, **34** being alternately and recurrently blocked, in an optical sense, by the rotating apertured disk **50** which is suitably apertured to allow the combined radiation energy from the flame and wall, on the one hand, and the radiation energy from the furnace wall, on the other hand, to impinge on the photocell **38**. Such rotation of disk **50** converts the incoming radiation energy into energy pulses. Also such rotating disk **50** serves as an element for alternately and sequentially applying the radiation energy from channels **39** and **40** onto the photocell **38**. As described, the prism **30**, of course, directs the radiation energy from the wall **14** into the channel **39** and such prism likewise directs the combined radiation energy from the flame **17** and wall **13** into the channel **40**. The apertured disk or shutter **50** is rotated at a relatively high speed by the motor **52** through the flexible belt **53** which passes over, on the one hand, the pulley **55** on the motor shaft and, on the other hand, the pulley **58** on the shutter shaft **59**. The shaft **59** is suitably journaled for rotation in conventional bearings (not shown), while the motor **52** is mounted on the floor of the rectangular light-tight box **60** which has the two aforementioned rectangular apertures **33** and **34** therein. The radiation channels **39** and **40** may be either rectangular or circular, but arranged to exclude extraneous radiation from entering the apertured portions **33** and **34**.

Thus, when the flame **17** is present the photocell **38** is alternately subjected to the combined radiation energy from the flame **17** and wall, on the one hand, and from the wall **14** of the furnace on the other hand. Since the radiation energy from the flame **17** is substantially greater than the radiation energy from the furnace wall **14**, the photocell **38** is recurrently subjected to relatively large radiation intensities, with the result that the relatively large and rapidly varying voltage is developed across the load resistance **70**, such load resistance **70** being serially connected with the photocell **38** and source **72**. Preferably, the photocell **38** is of the 931A type. The voltage developed across resistance **70** is thus a quantity, the magnitude of which is representative of the combined radiation energy between, on the one hand, the radiation energy from the flame and walls and the radiation energy from the furnace walls on the other hand, and the cyclical variation of such quantity is in accordance with the speed of rotation of the shutter **50** and the number of apertured windows **50A** in the shutter **50**. Preferably this cyclical variation is made relatively high in relationship to the average frequency of the sporadic fluctuations of the flame **17** and sufficiently removed from the fundamental or harmonic frequency of neighboring power supply circuits such as commercial 60 cycle power supply circuits, thereby preventing the determination from being obscured either by the flame flutter or by pickup or induction from neighboring supply circuits.

It is noted that in one revolution of the shutter **50**, the photocell **38** "sees" the flame **17** eight times, i. e., the number of apertures **50A** in disc **50**. Further, in one revolution of the disc **50**, the photocell **38** "sees" the furnace wall twice this amount, namely, 16 times. This is so since the photocell "sees" the wall **13** when the flame **17** is being simultaneously viewed and, in addition, the photocell **13** "sees" the wall **14** alone when the flame is not being viewed. Consequently, the fluctuating output voltage appearing across resistance **70** may be considered as having two components, namely, a low frequency component corresponding to those fluctuations produced by the flame alone, and a high frequency component, of twice the frequency of said low frequency component.

The cyclically varying voltage having such low and high frequency components thus appearing across resistance **70**, when a flame is present, is applied through condenser **76** to the input resistance **77** of the amplifier stage **78**. Preferably the amplifier stage **78** is "tuned" or "peaked" at a frequency corresponding to the cyclical variation or frequency of such low frequency voltage component developed across resistance **70**. Such "tuned" or "peaked" amplifier stage **78** thus serves as a means for discriminating between such low and high frequency components of the voltage developed across resistance **70**. Tuned amplifiers serving the purpose of amplifier stage **78** are well known in the art and are disclosed in section 7–1 of chapter 7 of Radio Engineering, third edition, by Frederick E. Terman, 1947. The voltage developed at the output terminals of the amplifier stage **78** is applied to the control circuit **80**, which is considered conventional for controlling the energization of the solenoid valve **82**, such valve **82** serving to control the flow of fuel which normally flows between the fuel inlet line **84** and the fuel outlet line **85** extending to the conventional burner or flame producing means **16**. The valve **82** is open when a flame is present, but is allowed to close under the influence of springs conventionally associated with this type of valve, immediately upon cessation of the flame, i. e., immediately upon cessation of the raditaion energy from the flame.

When the flame is extinguished for any reason, there is, of course, no radiation energy from the flame **17** and, as shown in the drawings, the photocell **38** alternately "sees" the walls **13** and **14** of the furnace and, since these two walls have substantially the same or somewhat different temperatures, the radiation energy from the same is substantially the same or somewhat different. The photocell **38** is, of course, subjected to this difference, but under these conditions a relatively small voltage appears across the resistance **70**, and across resistance **77** with the result that the solenoid **82** is allowed to become de-energized, thereby preventing further flow of fuel to the burner.

It is apparent that instead of using a rotary shutter **50** a reciprocating shutter may be used if desired; likewise, the design or shape of the windows **50A**, and their number, is considered to be one of design and is preferably such that there is a voltage of relatively large average intensity which varies cyclically and which has a low and a high frequency component as described above, developed across resistance **70** when there is a flame and a voltage of relatively small average intensity which varies cyclically and has only such high frequency component across the resistance when there is no flame. Thus, by the means described above which involves the "tuned" or "peaked" amplified stage **78**, a differential effect is produced since the channel **39** passes radiation from the fire brick walls **14**, while the other channel **40** passes radiation energy emanating not only from the flame **17**, but also from the fire brickwall **13**, along the path represented by line **20**, such line **20** intersecting the inner wall **13**. In effect, taking into consideration the frequency selective nature of the amplifier **78**, the output of the two radiation channels **39** and **40** is subtracted electrically so that with a "flame on" condition the net voltage developed across control **80** is considered as that being due to the flame alone and with a "flame off" condition the net voltage developed across control **80** is considered to be zero.

While a prism **30** is preferred for directing the radiation, other light refracting or light reflecting means may be used, adjusted, however, as described above.

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 their scope.

I claim:

1. In a flame detecting and controlling arrangement of the character described, flame producing means for producing a flame, a body heated by the flame, means for alternately and sequentially collecting and delivering radiation energy pulses from, on the one hand, said flame and said body heated by said flame, and on the other hand, from said body alone, with the radiation energy pulses from the body, in each instance, being substantially equal and occurring at equally spaced intervals to thereby develop radiation energy pulses varying cyclically at two different frequencies, a radiation responsive electrically operable device operably associated with said collecting and delivering means, means located between said collecting and delivering means and said device for applying said cyclically varying radiation energy pulses onto said radiation responsive device, said device in response to said radiation energy pulses developing a control voltage having two components varying at a low frequency and a high frequency, said low and high frequencies corresponding to said two differing frequencies developed by said cyclic varying radiation energy pulses, and control means responsive to only said low frequency component of said control voltage to control the flow of fuel to said flame producing means so that the flow of fuel is maintained in the presence of and discontinued in the absence of said low frequency component of said control voltage.

2. In flame detecting and controlling apparatus of the character described wherein it is desired to control a flame which heats a body, flame producing means for producing a flame, a body heated by the flame, means collecting and delivering radiation energy from, on the one hand, said body and said flame, and, on the other hand, from said body alone, alternately and sequentially, with the radiation energy from the body, in each instance, being substantially equal and occurring at equally spaced intervals, radiation responsive electrical means operably associated with said collecting and delivering means to develop a cyclically varying electical control voltage having low and high frequency components in accordance with said alternate and sequential delivery of radiation energy to said radiation responsive electrical means, and means controlling the flow of fuel to said flame producing means in accordance with only said low frequency component of said control voltage so that the flow of fuel is maintained in the presence of and discontinued in the absence of said low frequency component of said control voltage.

3. In flame detecting and controlling apparatus of the character described, flame producing means for producing a flame, a furnace wall heated by the flame, a first radiation energy collecting and delivering channel, a second radiation energy collecting and delivering channel, means subjecting said first channel to radiation energy from said wall of said furnace, means subjecting said second channel to radiation energy from said wall and also to radiation energy of said flame, a single radiation responsive electrical means operably associated with said first and second channels, means located between, on the one hand said first and second channels, and on the other hand, said radiation responsive electrical means for alternately and sequentially applying the radiation energy from said first and second channels to said radiation responsive electrical means, with radiation energy from the wall, in each instance, being substantially equal and occurring at equally spaced intervals to develop a control voltage which varies at two different frequency components, one at a low frequency in accordance with radiation energy from said flame alone, and the other at a high frequency in accordance with radiation energy from said body alone, frequency discriminating means connected with said radiation responsive electrical means to receive said control voltage with its said two frequency components and to produce an output of only said low frequency component, and control means connected with said discriminating means for controlling the flow of fuel to said flame, said control means being sensitive to said low frequency component so that the flow of fuel is maintained in the presence of and discontinued in the absence of said low voltage frequency component.

4. In flame detecting and controlling apparatus of the character described, wherein a flame heats a body, flame producing means for producing a flame, a body heated by said flame, radiation energy collecting and delivering means, a single radiation responsive electrical means operably associated with said radiation energy collecting and delivering means, said radiation energy collecting and delivering means being located between, on the one hand, said flame and body, and on the other hand, said radiation responsive electrical means, means for alternately and sequentially applying radiation energy from, on the one hand, said flame and said body, and on the other hand, from said body alone, onto said radiation responsive electrical means, with the radiation energy from the body in each instance, being substantially equal and occurring at equally spaced intervals to develop in said radiation responsive electrical means a control voltage having two varying frequency components, one varying at a low frequency and the other at a high frequency, control means for controlling the flow of fuel to said flame, said control means being sensitive and responsive to the presence of said low frequency component, and means receiving from said radiation responsive electrical means said high and low frequency components of said control voltage and transmitting to said control means only said low frequency component so that the flow of fuel to said flame is maintained in the presence of and discontinued in the absence of said low frequency component.

5. In flame detecting and controlling apparatus of the character described wherein a flame heats a body, flame producing means for producing a flame, a body heated by said flame, a single radiation responsive electrically operable device, a first radiation energy collecting and delivering channel, radiation energy directing means located between, on the one hand, said flame and body, and on the other hand, said device, for directing radiation energy from said body and flame into said first channel, a second radiation energy collecting and delivering channel, said radiation energy directing means directing radiation energy from said body to said second channel, said radiation responsive electrically operable device being operably associated with said first and second channels, means alternately and sequentially communicating said first and second channels with said device, with the radiation energy from the body, in each instance being substantially equal and occurring at equally spaced intervals to develop an electrical control voltage having two components varying at a low frequency and a high frequency, the low frequency corresponding to radiation energy from said flame alone, and the high frequency corresponding to said body alone, control means for controlling the flow of fuel to said flame, said control means being sensitive and responsive to said low frequency, and means receiving from said radiation responsive electrical means said high and low frequency components of said control voltage and transmitting to said control means only said low frequency component so that the flow of fuel to said flame is maintained in the presence of and discontinued in the absence of said low frequency component.

6. In flame detecting and controlling apparatus of the character described wherein a flame heats a body, flame producing means for producing a flame, a body heated by the flame, a radiation responsive electrically operable device, a first radiation energy collecting and delivering channel for delivering radiation energy from said body onto said device, a second radiation energy collecting and delivering channel for delivering radiation energy from said flame and said body onto said device, said device being operably associated with said first and second channels, a member located, on the one hand, between said first and second channels, and on the other hand, said device, said member being movable to place said first and second channels alternately and sequentially in communication with said device, with the radiation energy from the body, in each instance, being substantially equal and occuring at equally spaced intervals, means including said device for deriving a control voltage having two differing frequency components, one frequency being low and corresponding to radiation energy from said flame alone, and the other frequency being high and corresponding to radiation energy from said body alone, control means for controlling the flow of fuel to said flame, said control means being sensitive and responsive to the presence of said low frequency, and frequency discriminating means receiving said high and low frequencies and transmitting to said control means only said low frequency so that the flow of fuel to said flame is maintained in the presence of and discontinued in the absence of said low frequency component.

References Cited in the file of this patent

UNITED STATES PATENTS

1,755,970	Singleton	Apr. 22, 1930
1,811,895	Ranger	June 30, 1931
1,970,103	Runaldue	Aug. 14, 1934
1,996,233	Darrah	Apr. 2, 1935
2,304,641	Jones	Dec. 8, 1942
2,404,147	Strickland	July 16, 1946
2,404,903	Cohen	July 30, 1946
2,621,808	Blakeney	Dec. 16, 1952
2,696,876	Hartung	Dec. 14, 1954