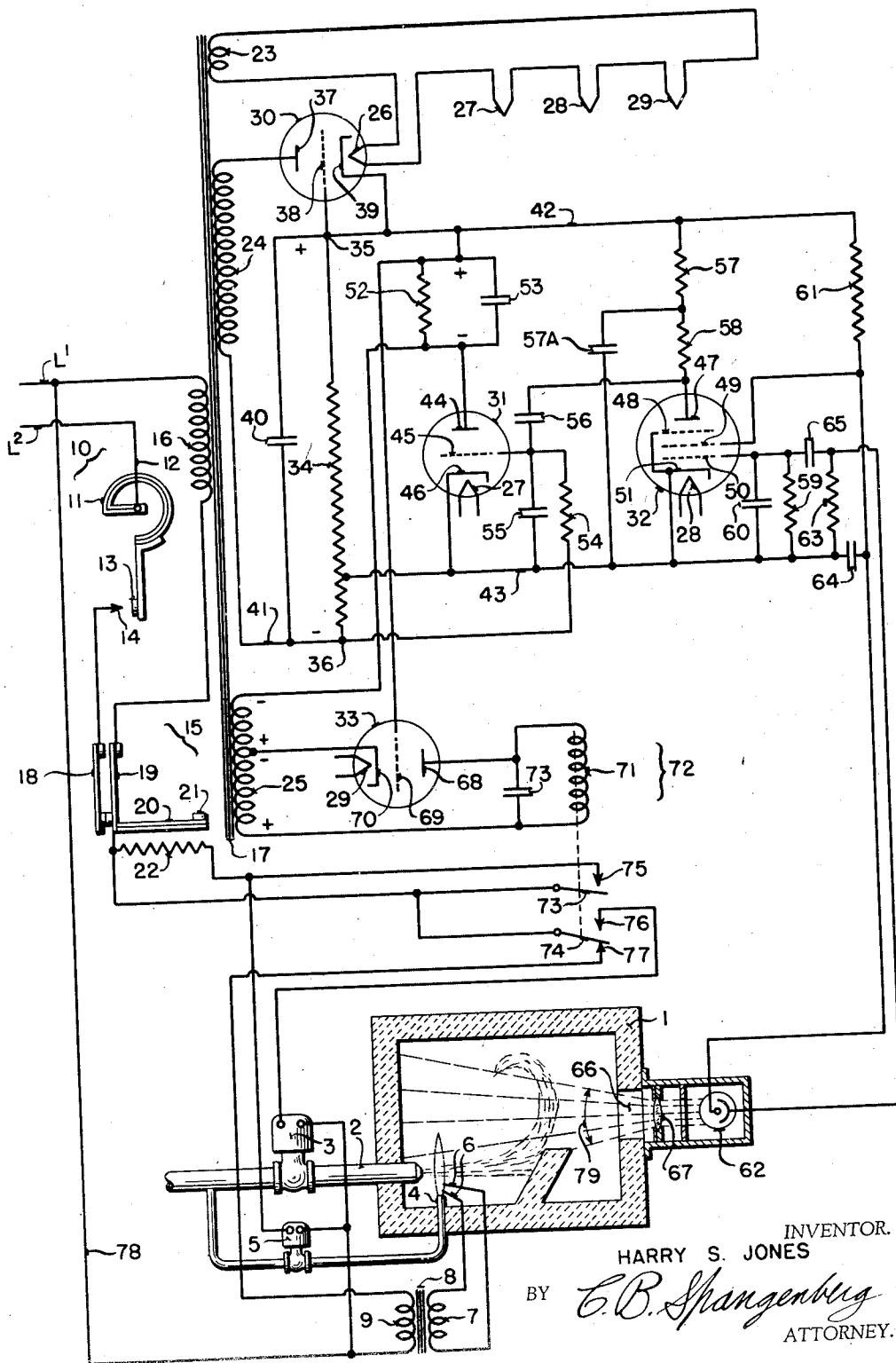


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CONTROL APPARATUS

Harry S. Jones, Philadelphia, Pa., assignor to
The Brown Instrument Company, Philadelphia,
Pa., a corporation of Pennsylvania

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The present invention relates to light-sensitive control systems.

An object of the invention is to provide a light-sensitive control system which is capable of distinguishing between steady sources of illumination and fluctuating sources of illumination.

A specific object of the invention is to provide an improved safety control system for a fuel burner which responds in one sense to the presence of a flame at said burner and responds in another sense to the absence of flame at said burner.

Another specific object of the invention is to provide a safety control system for a fuel burner which relies in its operation upon the characteristic fluctuation in intensity of illumination of a fuel burner flame.

A further specific object of the invention is to provide a safety control system for a fuel burner which utilizes a light-sensitive device, exposed to the fuel burner flame, as the flame responsive element and which is insensitive to light radiating from the walls of the fuel burner combustion chamber.

A still further specific object of the invention is to provide a safety control system for a fuel burner which utilizes a light-sensitive device, exposed to the fuel burner flame, as the flame responsive element and in which the need of filters or specially designed optical systems are not required.

A further specific object of the invention is to provide a safety control system for a fuel burner which utilizes a light-sensitive device exposed to the fuel burner flame as the flame responsive element, which light-sensitive device may be exposed to light emanating from an area including substantially all of the fuel burner flame whereby critical focussing adjustments are unnecessary.

Light-sensitive safety control systems for fuel burners have heretofore been proposed in the art. These prior art systems were provided with a light-sensitive device, such as a photocell, which was simply exposed to the interior of the combustion chamber. Such systems did not prove satisfactory, however, in that they frequently failed to respond properly upon extinguishment of the flame because the glowing walls of the combustion chamber provided sufficient illumination to keep the light-sensitive device energized. The fuel supply valves consequently were allowed to remain open even though the flame

had become extinguished and as a result disastrous explosions usually followed.

Attempts were subsequently made in the prior art to overcome such defective operation by providing a light filter between the light-sensitive device and the combustion chamber, which light filter was so chosen and designed that only light from the flame was transmitted to the light sensitive device. These improved systems also were usually provided with an especially designed critical optical system for focussing the light-sensitive device on a brilliant spot in the flame to prevent the transmission of light to the light-sensitive device from other parts within the combustion chamber, for example, from the walls therein. These expedients, however, have the disadvantage that they cut down the amount of light reaching the light-sensitive device and thereby decrease the sensitivity of the system and furthermore are expensive. The use of a special optical system not only further increases the cost appreciably but renders the system extremely delicate and critical of adjustment.

The disadvantages of the prior art systems have been overcome by the system of my present invention in which advantage is taken of the fluctuating characteristic of the light emanating from a fuel burner flame. The light emanating from the walls of the burner is steady compared with the light given off by the flame and therefore the presence or absence of a flame is readily detected by the system of my present invention without requiring the use of specially designed filters and optical systems.

The various features of novelty which characterize my invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, however, its advantages and specific objects attained with its use, reference should be had to the accompanying drawing and descriptive matter in which I have illustrated and described a preferred embodiment of the invention.

The single figure of the drawing shows a fuel burner having a combustion chamber 1 which is supplied with gas through a conduit 2 in which an electrically operated or other suitable valve 3 is provided for controlling the flow of gas to the chamber 1.

A pilot burner 4 is provided which is controlled by an electrically operated or other suitable valve 5, and means are provided for igniting the pilot flame including a pair of electrodes 6 which are connected to the terminals of a sec-

ondary winding 7 of an ignition transformer 8 having a primary winding 9 which is adapted to be energized from the alternating current supply lines L¹ and L².

The fuel valve operating circuit of my control system is controlled by means of a thermostat 10 which may be located in a room or space to be heated. The thermostat 10 may be of any suitable construction and includes a bimetallic element 11 connected by means of conductor 12 to line L², and a contact blade 13 adapted to engage a stationary contact 14 which is connected to line L¹ through a thermal switch 15 and winding 16 of a transformer 17.

The thermal switch 15 is preferably of the form disclosed in the Patent 1,958,081 issued to F. S. Denison May 8, 1934. As shown more or less diagrammatically in the drawing, this switch comprises a stationary arm 18 and a movable arm 19 biased for movement away from arm 18 but normally held in engagement with the latter by means of a bimetallic element 20. Element 20 is rigidly secured at one end to a block 21 and is arranged to be heated by a coil 22 when the latter is energized through a circuit which will later be described. Upon energization of coil 22 for a predetermined period of time, element 20 will be warped sufficiently in the clockwise direction to permit arm 19 acting under spring or other bias to separate from switch arm 18 thereby interrupting the circuit including thermostat 10. The switch 15 will remain locked in this position until manually returned to its normal closed position.

The transformer 17 which supplies power for the control system comprises the primary winding 16, and secondary windings 23, 24 and 25. Secondary winding 23 is used to energize the heater filaments 26, 27, 28 and 29, of electric discharge devices 30, 31, 32 and 33, respectively. Secondary winding 24 supplies energy to the discharge device 30 which is shown as a triode and is operated as a rectifier to establish a continuous potential across a resistor 34 of the correct polarity to render terminal 35 thereof positive with respect to terminal 36. Triode 30 comprises an anode 37, a control electrode 38, a cathode 39, and the heater filament 26. Control electrode 38 is connected to cathode 39 so that the device acts substantially as a diode. The rectifier circuit may be traced from the upper terminal of winding 24, as it appears in the drawing, to anode 37, cathode 39, resistor 34, across which a condenser 40 is connected, and a conductor 41 back to the lower terminal of winding 24.

A conductor 42, connected to positive terminal 35 of resistor 34, serves as a positive supply line for the electric discharge devices 31 and 32. A conductor 43, connected to a tap at a suitable point on resistor 34, serves as a negative supply line. The discharge device 31 is shown as a triode, comprising an anode 44, a control electrode 45, a cathode 46, and the heater filament 27. The discharge device 32 is shown as a pentode, comprising an anode 47, a suppressor electrode 48, a screen electrode 49, a control electrode 50, a cathode 51, and the heater filament 28.

The output circuit of discharge device 31 may be traced from positive supply line 42 through a resistor 52, across which a condenser 53 is connected, anode 44, and cathode 46 to the negative line 43. Control electrode 45 is normally biased sufficiently negative to limit the flow of current in the output circuit of triode 31 to an insignificant value, this bias being obtained from

that part of resistor 34 between the negative terminal 36 and the point of engagement of conductor 43 therewith. This biasing connection may be traced from cathode 46, through conductor 43, resistor 34, terminal 36, and a protective resistor 54 to control electrode 45. The input circuit of triode 31 also includes a condenser 55 connected between control electrode 45 and conductor 43, and a condenser 56 connected between control electrode 45 and anode 47 of discharge device 32. The condenser 56 serves to couple the output circuit of pentode 32 with the input circuit of triode 31. Condenser 55 is employed to by-pass undesirable high frequencies which might otherwise affect the input circuit of triode 31.

The output circuit of pentode 32 may be traced from the positive supply line 42 through resistors 57 and 58, anode 47 and cathode 51 to the negative supply line 43. A filtering condenser 57A is connected between the common terminal of resistors 57 and 58 and the conductor 43. Suppressor electrode 48 is connected to cathode 51. The input circuit of pentode 32 includes a resistor 59 and a condenser 60 connected in parallel between control electrode 50 and conductor 43. The connection of control electrode 50 and cathode 51 through resistor 59 serves to render pentode 32 normally conductive. Condenser 60 functions as a by-pass condenser, similarly to condenser 55. The input circuit of pentode 32 also includes a branch which may be traced from the positive line 42, through a resistor 61, a light-responsive device 62, illustrated as a photo-electric cell, and a resistor 63 to the negative line 43. The common terminal of resistor 61 and cell 62 is connected to screen electrode 49 of pentode 32, and to conductor 43 through a filtering condenser 64. The common terminal of resistor 63 and cell 62 is connected to control electrode 50 through a coupling condenser 65.

The photo-electric cell 62 is mounted in any convenient manner outside an opening 66 in the wall of combustion chamber 1, so as to be exposed to light emanating therefrom. A lens 67 may be provided so as to concentrate the rays from a large area within the chamber 1 upon the cell 62.

When no flame exists within the chamber 1, the light if any, falling upon the photo-electric cell 62, is relatively steady, so that the resistance of the cell and hence the current flowing through it is substantially constant. There is then no transfer of energy through condenser 65 and the input circuit of pentode 32 accordingly is unaffected by the condition of the photo-electric cell 62. The output current of pentode 32, therefore, remains substantially constant, and consequently no transfer of energy is effected through condenser 56 to the input circuit of triode 31. Under this condition the triode 31 is maintained non-conductive.

When a flame is burning within the chamber 1, however, the light falling upon photo-electric cell 62 will not be steady but will flicker, that is, fluctuate in intensity, and as a result the conductivity of the photo-electric cell 62 will fluctuate in a corresponding manner. Such fluctuations in the conductivity of photo-electrical cell 62 produces similar fluctuations in the flow of current through resistance 63 and thereby produces a fluctuating potential drop across the latter. The fluctuations in the potential drop across resistance 63 are transmitted by condenser 65 and produce corresponding fluctuations in the potential of the control electrode 50 of discharge

device 32 relatively to the potential of cathode 51. These fluctuations in potential applied to the input circuit of the discharge device 32 are amplified thereby and the amplified fluctuations are applied through the condenser 56 to the input circuit of discharge device 31. The discharge device 31 thereupon is intermittently rendered conductive to produce a fluctuating potential drop across resistance 52 which is smoothed out by the condenser 53. The potential drop across resistance 52 accordingly is substantially steady and is employed to control the flow of current in the output circuit of the electric discharge device 33 and thereby the operation of the valves 3 and 5, which control the supply of fuel to the chamber 1, through means to be described.

It will be noted from the foregoing description of the circuit operation that the circuit operates to produce a potential drop across resistance 52 in response to the subjection of the photoelectric cell 62 of a flickering or fluctuating source of light and that the circuit is unresponsive to the subjection of the photoelectric cell 62 to a steady source of light.

The discharge device 33 is shown as a triode and includes an anode 68, a control electrode 69 and a cathode 70 in addition to the heater filament 29 referred to hereinbefore. The output circuit of triode 33 may be traced from the lower terminal of secondary winding 25 as it appears in the drawing through a winding 71 of a relay 72, across which a condenser 73 is connected, anode 68 and cathode 70 to a tap suitably located on the secondary winding 25. The input circuit of triode 33 may be traced from cathode 70 through the upper part of secondary winding 25 and resistance 52 to the control electrode 69.

When a flame is not burning within the combustion chamber 1, the potential drop across resistance 52 is substantially zero and the triode 33 is maintained substantially non-conductive by the potential impressed on the input circuit thereof by the upper section of winding 25. When a flame is burning within the combustion chamber, however, a potential drop is produced across resistance 52 as noted hereinbefore, and this potential drop is of the correct polarity to oppose the potential of the upper part of winding 25 so that the triode 33 is rendered conductive. This effects energization of the relay winding 71 and actuation of a pair of switch arms 73 and 74 from a lower position as seen in the drawing to an upper position. In its lower position switch arm 74 is in engagement with a contact 77, and in its upper position it is in engagement with a contact 76. Switch arm 73 is not in engagement with any contact in its lower position but in its upper position is in engagement with a contact 75.

When the temperature of the room or space to be controlled is at its desired value, all parts of the system are in the positions shown in the drawing, and the burner is not in operation. When the temperature of the room or space falls below the value it is desired to maintain, thermostat 10 operates to move switch arm 13 against contact 14, thereby completing an energizing circuit for the transformer primary winding 16. This energizing circuit may be traced from line L¹ through winding 16, thermal safety switch 15, and thermostat 10 to line L².

Closure of the thermostat switch arm 13 into engagement with contact 14 also completes energizing circuits for heater coil 22 of thermal

switch 15, valve 5 and primary 9 of the ignition transformer 8. The energizing circuit for valve 5 and heater coil 22 may be traced from line L¹ through a conductor 78, valve 5, heater coil 22, thermal switch 15, and thermostat 10 to line L². The circuit through primary winding 9 of the ignition transformer 8 may be traced from line L¹, through conductor 78, winding 9, contact 77, switch arm 74, thermal switch 15 and thermostat 10 to line L².

The normal result of opening valve 5 and energizing the ignition transformer primary winding 9 is the appearance of a flame at the pilot burner 4. The appearance of a flame at the pilot burner is detected by the flame responsive circuit described and effects energization of the relay winding 71. Energization of winding 71 effects movement of switch arms 73 and 74 into engagement with their upper contacts 75 and 76 respectively and also effects opening of the circuit to the ignition transformer primary winding 9 at contact 77. Movement of switch arm 74 into engagement with contact 76 closes an energizing circuit for the main valve 3 and movement of switch 73 into engagement with contact 75 closes a shunt circuit about the safety switch heater coil 22. The energizing circuit for valve 3 may be traced from line L¹ to conductor 78, valve 3, contact 76, switch arm 74, thermal safety switch 15 and thermostat 10 to the line L². Normally a flame will subsequently appear at the main burner and the system will then be in full operation. It is noted that in the arrangement illustrated the photoelectric cell 62 will then be subjected to light from both the main and pilot burners.

If the main and pilot burner flames become extinguished while the burner is in operation, the flame responsive circuit will effect de-energization of the relay winding 71 with consequent closing of valve 3 and energization of the thermal safety switch heater coil 22. The ignition transformer 8 will then be re-energized and if a pilot flame does not reappear within a predetermined time depending upon the adjustment of the thermal safety switch, the system will be de-energized by the action of the thermal safety switch under the influence of heater coil 22.

Similarly, if the pilot flame fails to appear during initiation of the system operation, relay 71 will not become energized and after a predetermined time the thermal safety switch 15 will operate to de-energize the system.

It may be necessary in some cases to prevent the spark at the ignition electrodes 6 from giving a false indication of the presence of a flame. This end may be obtained by positioning the electrodes 6 outside the cone of rays to which the photoelectric cell 62 is subjected or by positioning the structure supporting the electrodes 6 between the spark location and the photoelectric cell 62 thereby shielding the latter from the spark.

It will be apparent to those skilled in the art that if desired the pilot burner 4 and its associated valve 5 may be dispensed with. If it is desired to do this, the main valve 3 should be connected in circuit so as to open immediately upon closure of the thermostat contacts 13 and 14, and the ignition electrodes 6 should be placed closely adjacent the nozzle of the main burner so as to permit ignition of the fuel being ejected from the main burner. Such a modification may be readily effected, for example, by connecting the left terminal of valve 3 as seen in the drawing

to the right hand terminal of the heating resistance 22 instead of to contact 76. It is noted that in such modification a further reduction of equipment may be effected by connecting the right hand terminal of resistance 22 to contact 76 whereby the switch arm 73 and contact 75 may be dispensed with.

The operation of the safety control system described relies in its operation upon the fact that the illumination and position of the flame in the usual fuel burner fluctuates due to variations in the fuel supply, variations in B. t. u. content of the fuel, and variation in the flow of combustion supporting air to the burner. With the apparatus described no filters or especially designed optical systems are required to prevent the apparatus from responding to light emanating from the burner walls or other parts within the burner chamber 1 because the amplifier employed responds only to fluctuations in light intensity and does not respond to the comparatively steady light received from the burner walls or other burner parts. The apparatus described has a further advantage that the cone of rays to which the detecting unit is responsive can have a large vertex angle, for example, as shown at 79 in the drawing and can include many objects other than the flame itself and still function satisfactorily.

While in accordance with the provisions of the statutes, I have illustrated and described the best form of my invention now known to me, it will be apparent to those skilled in the art that changes may be made in the form of the apparatus disclosed without departing from the spirit of my invention as set forth in the appended claims, and that in some cases certain features of my invention may sometimes be used to advantage without a corresponding use of other features.

Having now described my invention, what I claim as new and desire to secure by Letters Patent is:

1. A safety control system for a fuel burner including in combination, means to establish a flame at said burner, relay means to control said first mentioned means having a first position in which said first mentioned means is permitted to establish a flame at said burner and having a second position in which said first mentioned means is prevented from establishing a flame at said burner, and means to control said relay means including a light sensitive device exposed to light from said flame, a source of voltage, an electric discharge device having an input circuit and an output circuit, a connection between the output circuit of said discharge device and said control means including said voltage source, said control means being adapted to assume its first position when current flows in said output circuit and being adapted to assume its second position when substantially no current flows therein, a connection between said voltage source and said light sensitive device, and a circuit presenting high resistance to the flow of direct current therethrough but readily passing fluctuating current to electrically couple said last mentioned connection to the input circuit of said discharge device.

2. The combination of claim 1 wherein said light-sensitive device is constructed to respond to substantially all of the radiation within the visible spectrum emanating from said flame.

3. The combination of claim 1 wherein said burner is located within an enclosure and said

light sensitive device is also exposed to relatively steady light which emanates from a wall of said enclosure.

4. The combination of claim 1 wherein said burner is located within an enclosure and said light sensitive device is constructed to respond to substantially all of the radiation within the visible spectrum emanating from said flame and is also exposed to relatively steady light which emanates from a wall of said enclosure.

5. A safety control system for a fuel burner including in combination, means to establish a flame at said burner, a device to control said first mentioned means, and means to control said device including a light sensitive device exposed to light from said flame, a source of voltage, an electric discharge device having an input circuit and an output circuit, a connection between the output circuit of said discharge device and said control device including said voltage source, a connection between said voltage source and said light sensitive device, and a circuit presenting high resistance to the flow of direct current therethrough but readily passing fluctuating current to electrically couple said last mentioned connection to the input circuit of said discharge device.

6. A safety control system for a fuel burner including in combination, means to establish a flame at said burner, means to control said first mentioned means, and means to control said control means including a light sensitive device exposed to light from said flame, a source of voltage, an electric discharge device having an input circuit and an output circuit, a connection between the output circuit of said discharge device and said control means including said voltage source, an impedance, a connection including said voltage source, said impedance and said light sensitive device, and a circuit presenting high resistance to the flow of direct current therethrough but readily passing fluctuating current to couple said impedance to the input circuit of said discharge device.

7. The combination of claim 6 wherein said light-sensitive device is constructed to respond to substantially all of the radiation within the visible spectrum emanating from said flame.

8. The combination of claim 6 wherein said burner is located within an enclosure and said light sensitive device is also exposed to relatively steady light which emanates from a wall of said enclosure.

9. The combination of claim 6 wherein said burner is located within an enclosure and said light sensitive device is constructed to respond to substantially all of the radiation within the visible spectrum emanating from said flame and is also exposed to relatively steady light which emanates from a wall of said enclosure.

10. A safety control system for a fuel burner including in combination, means to establish a flame at said burner, means to control said first mentioned means, and means to control said control means including a light-sensitive device exposed to light from said flame, a source of voltage, an electric discharge device having an input circuit and an output circuit, a connection between the output circuit of said discharge device and said voltage source including said control means, an impedance, a connection including said voltage source, said impedance and said light-sensitive device, and a circuit having a capacitive reactance therein and presenting high resistance to the flow of direct current there-

through but readily passing fluctuating current to couple said impedance to the input circuit of said discharge device.

11. A safety control system for a fuel burner including in combination, means to establish a flame at said burner, means to control said first mentioned means, and means to control said control means including a light-sensitive device exposed to light from said flame, a source of voltage, an electric discharge device having an input circuit and an output circuit, a connection between the output circuit of said discharge device and said voltage source including said control means, a second discharge device having an input circuit and an output circuit, reactive means to couple the output circuit of said second discharge device to the input circuit of said first mentioned discharge device, a connection including said voltage source and said light-sensitive device, and a circuit presenting high resistance to the flow of direct current therethrough but readily passing fluctuating current to couple said last mentioned connection to the input circuit of said second discharge device.

12. In combination, a source of illumination, a control device to be adjusted in one sense and in an opposite sense in accordance with the presence and absence respectively of fluctuations in intensity of said source of illumination, a light sensitive device exposed to light from said source, a source of voltage, an electric discharge device having an input circuit and an output circuit, a connection between the output circuit of said discharge device and said control device including said voltage source, a connection including said voltage source and said light sensitive device, and a circuit presenting high resistance to the flow of direct current therethrough but readily passing fluctuating current to couple said last mentioned connection to the input circuit of said discharge device.

13. In combination, a source of illumination, a device to be adjusted in one sense and in an opposite sense in accordance with the presence and absence respectively of fluctuations in intensity of said source of illumination, a light-sensitive device exposed to light from said source,

a source of voltage, an electric discharge device having an input circuit and an output circuit, a connection between the output circuit of said discharge device and said control device including said voltage source, a second discharge device having an input circuit and an output circuit, reactive means to couple the output circuit of said second discharge device to the input circuit of said first mentioned discharge device, a connection including said voltage current source and said light-sensitive device, and a circuit presenting high resistance to the flow of direct current therethrough but readily passing fluctuating current to couple said last mentioned connection to the input circuit of said second discharge device.

14. A safety control system for a fuel burner including means to establish a flame at said burner, a device to control said means, a source of electrical energy, a circuit connecting said source of energy and said device, and means including a light sensitive device exposed to said flame to control the conductivity of said circuit and thereby the operation of said device in response to sustained fluctuations in the intensity of illumination of said flame, said last mentioned means being insensitive to illumination of steady intensity.

15. A safety control system for a fuel burner including in combination, means to establish a flame at said burner, and means responsive to sustained fluctuations in the intensity of illumination of said flame but insensitive to illumination of steady intensity to control said flame establishing means.

16. A safety control system for a fuel burner including in combination, means to establish a flame at said burner which flame has the characteristic of fluctuating in intensity of illumination, and means including a light sensitive device exposed to the region normally including said flame to operate said system in a sense to prevent the presence of a flame at said burner when the illumination of said light sensitive device is substantially steady.

HARRY S. JONES.