

Oct. 13, 1942.

F. C. EVANS ET AL  
SMOKE DETECTION SYSTEM  
Filed Dec. 10, 1938

2,298,757

2 Sheets-Sheet 1

FIG. 1

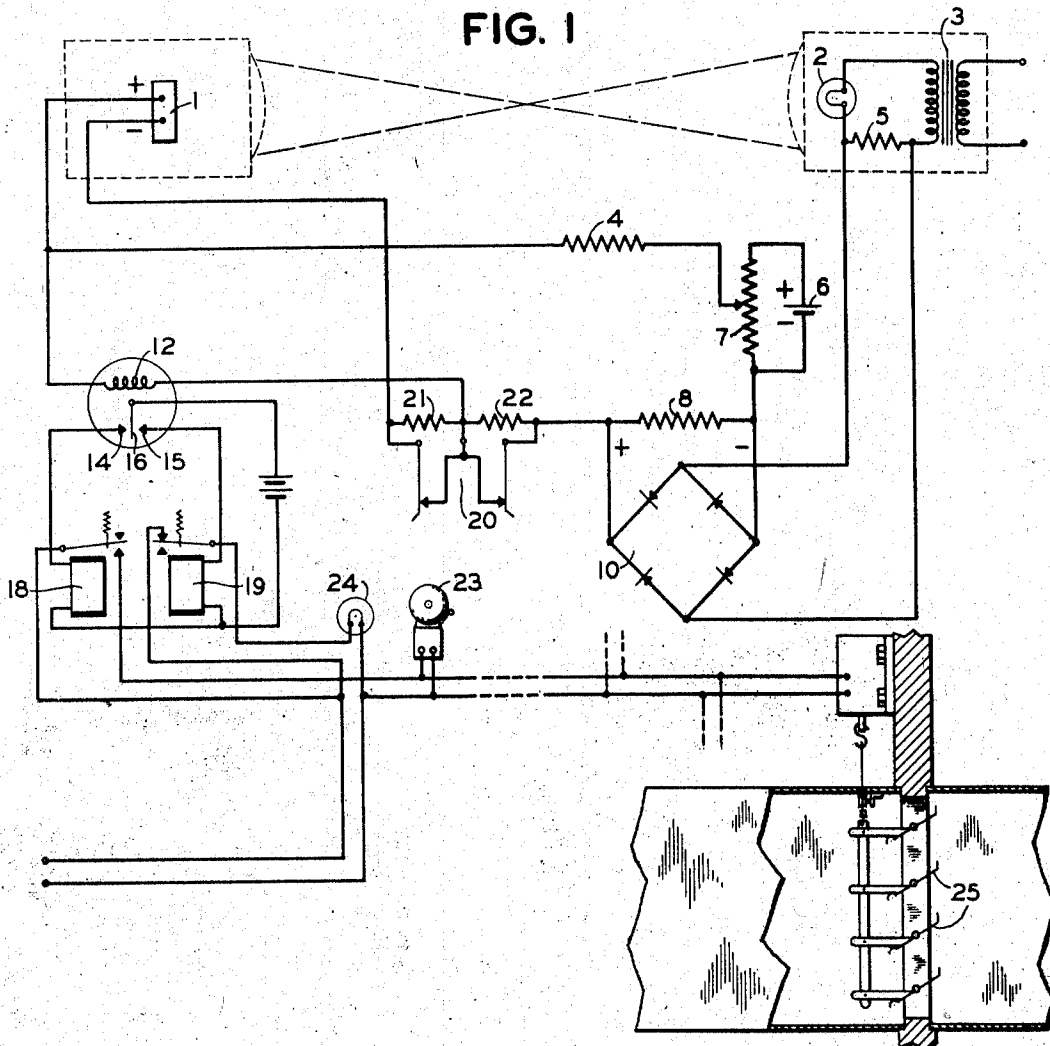


FIG. 3

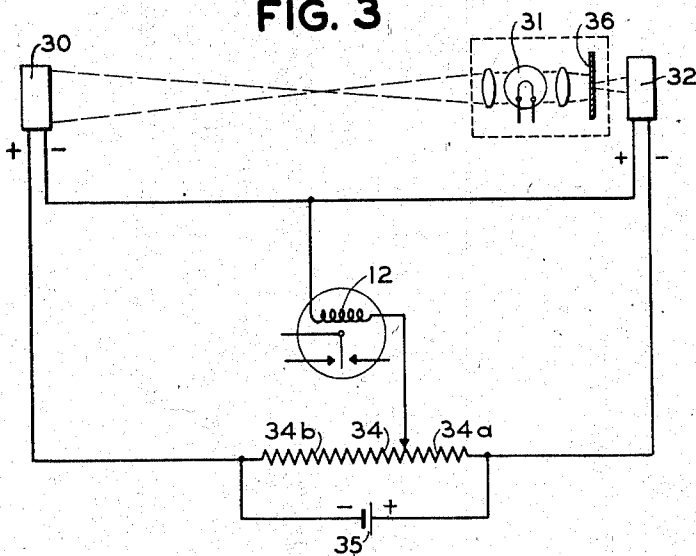
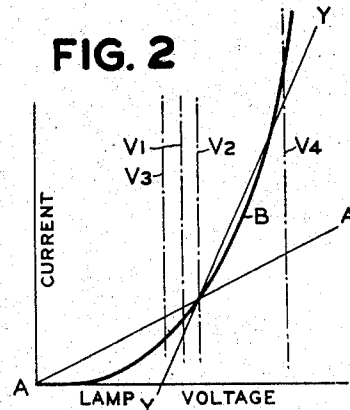


FIG. 2



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## SMOKE DETECTION SYSTEM

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2 Sheets-Sheet 2

FIG. 4

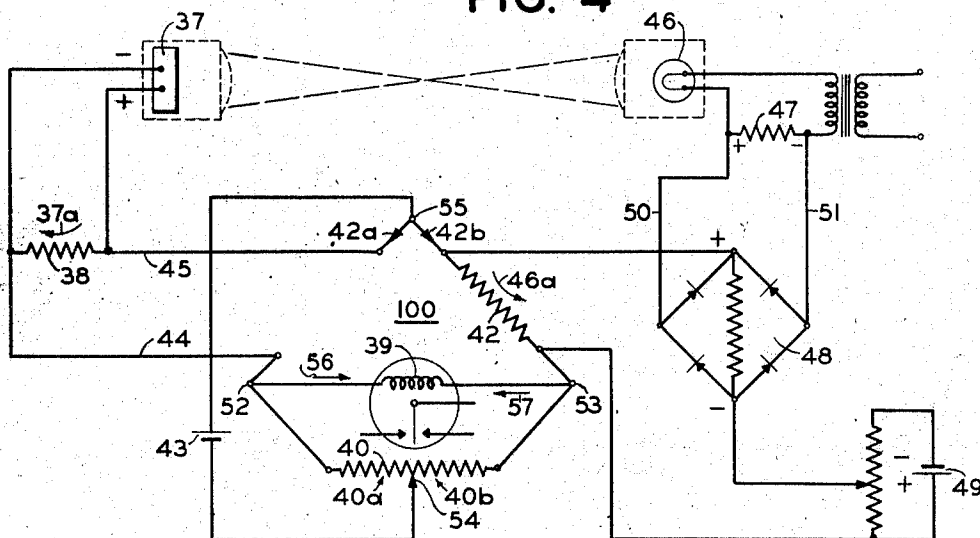
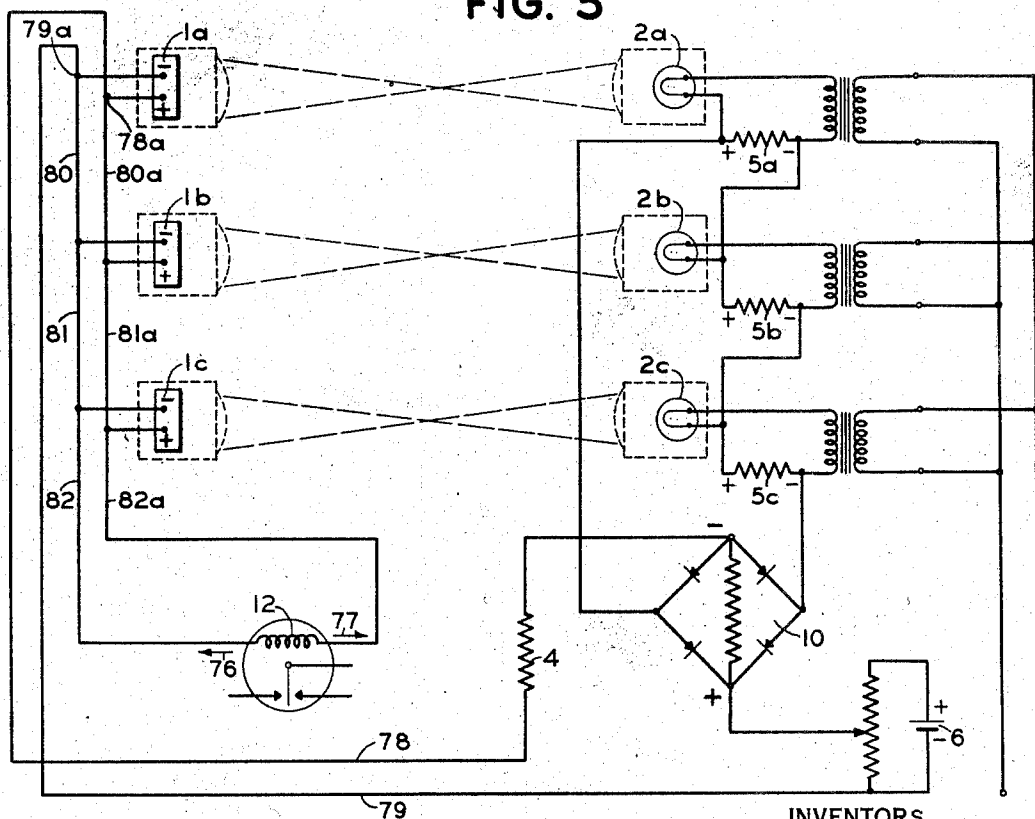


FIG. 5



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## UNITED STATES PATENT OFFICE

2,298,757

## SMOKE DETECTION SYSTEM

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Application December 10, 1938, Serial No. 244,988

10 Claims. (Cl. 177-311)

This invention relates generally to light-sensitive smoke detecting systems adapted primarily for purposes of operating alarm devices or electrical release devices of various types. The invention is particularly adapted for use as a fire detection system for closing dampers and stopping fans in air-conditioning or ventilating systems wherein it is necessary to detect fire conditions when existing either in the air conditioning system or in or near the premises served by such system.

It has been suggested in the prior art that thermostatic fire detectors of various kinds are suitable for use in air-conditioning systems but these are found to be inadequate since the surrounding air is cooled to such an extent that thermostatic devices are very likely to be inoperative under most conditions. In order to detect fire promptly and reliably it is necessary to use light-sensitive smoke detecting devices which are sensitive enough to detect thin wisps of smoke circulating through air conditioning or ventilating systems, thereby obtaining positive and rapid operation of alarm circuits and damper-operating devices for disabling the air-conditioning system.

Air-conditioning systems operating to reduce the temperature of the air or to rapidly circulate the air are almost certain to disable the usual sprinkler fire extinguishing systems as well as various other fire alarm systems since the conditioned air impelled at high velocities from duct outlets lowers the ambient temperature around automatic sprinkler heads and thermostatic fire detectors. Consequently it is absolutely necessary to disable the air-conditioning or ventilating system in order to allow the ordinary fire protection devices to operate in the proper manner and to prevent extensive smoke damages from internal and external fires. This invention provides a new method and means whereby smoke detectors are adapted for detecting fire conditions and disabling the air-conditioning system both by shutting down fan motors and closing dampers throughout the duct system to prevent circulation of smoke and spread fire. After all air circulation is stopped the ordinary fire detecting devices are able to operate in their intended fashion.

The smoke detecting system used to accomplish the above mentioned results must be unusually sensitive and also reliable to the extent that ordinary fluctuations in the commercial power systems will not cause false alarms and false operation of dampers in the air-conditioning system. Accordingly the primary object of

this invention is to provide a light-sensitive smoke detecting system of high sensitivity wherein the sensitivity is maintained over a wide range of voltage fluctuations in the electrical supply circuit and which provides stable supervision over an air-conditioning system.

Another object of this invention is to provide a light-sensitive smoke detecting circuit wherein high sensitivity is maintained over a wide range of voltage fluctuation by means of a bridge circuit, a predetermined degree of unbalance in the bridge being necessary for causing operation of the load circuit.

A further object of this invention is to provide a light-sensitive smoke detecting system wherein high sensitivity is maintained over a wide range of voltage fluctuation by means of a bridge circuit containing a means for converting voltage fluctuations to current fluctuations whereby the bridge is maintained in a balanced condition despite the disproportionate change in the light-sensitive cell output due to the disproportionate change in the light output of the light source during voltage fluctuation.

Still another object of this invention is to provide a light-sensitive circuit of high sensitivity which is unaffected by a wide range of voltage fluctuation and which requires only a single light-sensitive cell.

A further object of this invention is to provide a light-sensitive circuit which prevents false alarms or false operations of load circuits due to voltage fluctuations.

Another object of this invention is to provide a light-sensitive circuit wherein trouble conditions may be supervised from a remote point.

Another object of this invention is to provide a light-sensitive circuit for use in smoke detecting systems wherein a bridge coupling circuit prevents false alarms due to voltage fluctuation and wherein unbalance of the bridge circuit in one direction will cause an alarm and unbalance in another direction will cause a trouble indication.

A further object of this invention is to provide a light-sensitive circuit which maintains its sensitivity when the intensity of light falling upon the light-sensitive cell changes in spite of the characteristic of boundary layer photovoltaic cells whereby their E. M. F. falls off as light intensity decreases, and in spite of this falling off being other than a straight line function.

A still further object of this invention is to provide a new and improved sensitive circuit for compensating fluctuations in voltage, dis-

tinguishing between alarm conditions and trouble conditions and which is much simpler in structure than similar compensating circuits shown in the prior art.

Further objects and advantages of this invention will be evident from consideration of the following description of the embodiments shown in the drawings wherein:

Fig. 1 is a circuit diagram of the preferred form of smoke detecting system;

Fig. 2 is a graph showing the relation between compensating current and light-sensitive cell output in the new and improved bridge circuit designed in accordance with this invention;

Fig. 3 is a circuit diagram of a modification of the circuit shown in Fig. 1;

Fig. 4 is a circuit diagram of a still further modification of the circuit shown in Fig. 1, in which all elements of the detecting system are properly supervised; and

Fig. 5 is a circuit diagram of another modification of this invention wherein supervision of a plurality of smoke detection units is provided.

As described above, the two principal problems in controlling air-conditioning systems by means of a sensitive smoke detector are prevention of false operation due to voltage fluctuation and the operation of trouble alarms in the event of light-source failure or failure of any other part of the smoke detection system. The compensation of voltage fluctuation in accordance with the invention will be described first.

Fig. 1 shows a light sensitive receiving device 1 and a light source 2, both of which are arranged in such a manner that the passage of smoke between the two elements will be detected by the light-sensitive cell 1. The receiving cell 1 is of the type which generates an E. M. F. in response to light impinging thereon and may be selenium or copper oxide cells of the conventional form, for example, those cells generally known as photovoltaic or boundary layer type cells. The compensating part of the circuit consists of a bridge connected between the light source and the light-sensitive cell. The bridge includes the light-sensitive cell 1 in one arm thereof, a balancing resistor 4, an auxiliary source of potential 6, a potentiometer 7 and any suitable means for introducing a compensating voltage which, as is shown in Fig. 1, may be a rectifier 10 in another arm thereof. A galvanometer relay 12 is connected across the arms of the bridge for the purpose of detecting unbalance of the bridge and also for the purpose of controlling auxiliary apparatus such as alarms or various elements of an air-conditioning system such as dampers and fans.

If the light source 2 is to be connected to the usual 110-volt A. C. supply circuit by means of transformer 3, potential for operating the bridge is tapped across a small resistor 5 so that said potential may be rectified in rectifier 10. It will be obvious that the light source 2 may be operated from a direct current supply in which case the compensating voltage may be obtained directly without the need of rectifier 10. The resistor 5 is connected across the rectifier 10 for the purpose of introducing a compensating E. M. F. into the bridge which will vary in accordance with the voltage fluctuations from the 110-volt circuit and across the resistor 5.

When the voltage source fluctuates, the light emitted by source 2 will also fluctuate, but in a much greater proportion than the change in voltage. In fact, the light beam varies approximately as the fourth power of the change in the ener-

gizing voltage where the light source 2 is an ordinary tungsten incandescent lamp. The light-sensitive cell 1 detects the resulting fluctuation in the light beam, and since its emission characteristic is nearly linear, its current output also varies as the fourth power of the change in voltage. The potential across the resistor 5 is rectified in rectifier 10 and impressed across resistor 8 causing a change in the current on one arm of the bridge, but the output of the light-sensitive cell 1 is raised to approximately the fourth power of the change in potential across resistor 8 whereby the bridge is unbalanced at the very time that it should be balanced. In order to overcome the above-mentioned unbalance, the battery 6 and potentiometer 7 are added to the usual bridge circuit.

The operation of the bridge circuit shown in Fig. 1 can best be described with reference to Fig. 2 of the drawings. The lines A—A and A—B show the relation of compensating current to light-sensitive cell output in an ordinary bridge circuit which would not include battery 6 and potentiometer 7. The straight line A—A of Fig. 2 shows the variation in the compensating current as the lamp voltage across resistor 5 varies in accordance with fluctuation of the 110-volt source. Curve A—B in Fig. 2 shows the fluctuation of light-sensitive cell output as the light increases from lamp 2 in accordance with fluctuations in the 110-volt source. It is evident from Fig. 2 that the bridge is approximately balanced only for slight fluctuations of lamp voltage between  $V_1$  and  $V_2$ . In fact, this range of compensation is entirely too small in very sensitive smoke detecting circuits of the kind necessary for use in fire protection systems, since, as shown by the graph, comparatively small fluctuations in lamp voltage will unbalance the bridge and cause a false alarm.

The characteristic curve Y—Y in Fig. 2 shows the effect of insertion of battery 6 and potentiometer 7 in one arm of the bridge. In the new bridge circuit, the slope of the compensating current characteristic has been changed to substantially correspond with the slope of the light-sensitive cell characteristic A—B so that a long range of compensation is available. This change in the range of compensation is accomplished by connecting the battery 6 and potentiometer 7 so that a long range of compensation is available. This change in the range of compensation is accomplished by connecting the battery 6 and potentiometer 7 so that at zero voltage across resistor 5 there is still a bias voltage from battery 6 in the bridge circuit, which changes the slope of the compensating current characteristic to such an extent that it corresponds very closely to the slope of the light-sensitive cell output. In other words, the voltage fluctuations across the 110-volt source have been converted to current variations which vary almost exactly in proportion to the current variation of the light-sensitive cell output over a wide range. As a result of the change in current variation in the bridge, the output of the light-sensitive cell flows through galvanometer relay 12 in one direction to balance the current flow from resistors 4, 7 and 8 through the galvanometer relay in the opposite direction, the ultimate result being that the contact of the galvanometer relay is maintained in a neutral position for voltage variations from  $V_3$  to  $V_4$ . From the description of Fig. 2 it is evident that although the voltage source may fluctuate over a considerable range, the galvanometer relay will

remain in a neutral position due to the very small differences in current flowing through it from each side of the bridge, whereby false alarms due to voltage fluctuation are prevented.

It is also necessary that devices used for fire detection be under constant supervision by a central office attendant in order to prevent failure of the alarm system owing to faulty operation of the various components of the system. In accordance with a further feature of the invention, the galvanometer relay 12 is arranged to not only operate an alarm circuit and control an air-conditioning system, but also to operate a trouble alarm in the event that either the operating voltage source or the light source 2 should fail, or, as will be shown later, if the lines leading to the receiver which houses the sensitive cell 1 should be accidentally broken. Relay 12 is provided with alarm contact 14 and trouble alarm contact 15, contact 14 closing a circuit through the alarm relay 18 upon an unbalance of the bridge when the cell 1 is obscured by smoke, and contact 15 closing the circuit through the trouble relay 19. When the light source 2 either burns out or is extinguished due to power source failure, the output of the light-sensitive cell 1 becomes zero and the potential across resistor 8 also becomes zero, leaving the potential from the source 6 across potentiometer 7 as the only voltage within the bridge circuit. As is evident from the drawing, the battery 6 and potentiometer 7 will energize the galvanometer relay in the opposite direction to that of the cell 1. The contact 16 of relay 12 will then engage contact 15 to energize the trouble relay 19 and open the associated trouble alarm circuit to cause a trouble indication at a central office.

If, on the other hand, smoke passes between the light source 2 and the cell 1, the output of cell 1 will decrease a certain amount and unbalance the bridge circuit in the opposite direction as compared with a trouble condition whereby contact 16 of relay 12 will engage contact 14 to energize the alarm relay 18 and alarm 23 to give an alarm indication at the central office. The alarm relay 18 may also be used for the purpose of controlling damper 25, as shown, or a fan motor in an air-conditioning system whereby the presence of smoke in an air-conditioning system will cause the smoke detector apparatus to completely disable the air-conditioning system and consequently completely prevent the circulation of smoke within the air-conditioned premises. The smoke detector apparatus is also useful in shutting down the air-conditioning apparatus if a fire should occur within the ducts or filters of the system.

Provision is also made for testing the smoke detecting system in order to check its operative condition at regular time intervals. A three-position switch 20 is connected across two resistances 21 and 22 which are in turn connected in each loop of the bridge circuit. The switch 20 may be opened to remove the shunt from resistance 21 and simulate the passage of smoke between cell 1 and light source 2 by a corresponding unbalance of the bridge circuit. The current in the cell arm of the bridge is reduced a given amount to simulate an alarm condition so that relays 12 and 18 operate to sound an alarm or disable an air-conditioning system. The switch 20 may also be operated to open the shunt across resistor 22 thereby introducing a large amount of resistance in the voltage source side of the bridge to simulate failure of

the voltage source. Battery 6 and potentiometer 7 now come into play to operate the relays 12 and 19 to indicate a trouble condition.

Under certain conditions it may be desirable to protect a large area by means of a multiplicity of light sensitive cells with a separate light source associated with each, or a number of independent areas each protected by means of a light sensitive cell with a light source, all of which may be controlled by a single control unit, i. e., a single sensitive galvanometer relay. Also, in air-conditioning installations, practical considerations often necessitate the mounting of the light source, the receiver which houses the sensitive cell, and the control unit which houses the auxiliary equipment such as the sensitive galvanometer relay, rectifier, and various components of the bridge circuit at points remote from each other. This introduces therefore the additional problem of providing a means whereby all lines interconnecting these units will be properly supervised so as to initiate a trouble signal should any or all of them be accidentally or maliciously disconnected. Such may be done as follows:

The fundamental equivalent of the circuit shown in Fig. 1 may be seen as in Fig. 5. It will be seen that light sensitive cell 1a causes a current to flow through galvanometer relay 12 in direction 76 while the compensating voltage which, as is also shown in Fig. 1, is obtained by means of a rectifier 10 and biasing cell 6, causes a compensating current in the opposite direction as shown by arrow 77. When the emission from the cell 1a is balanced by the compensating current, no current will flow through the sensitive galvanometer relay. Light sensitive cells of the type described above have a characteristic such that when connected in multiple their emissions are additive, that is, each contributes current independently of the others. Thus any number of light sensitive cells as shown, as 1a, 1b, 1c, etc., may be connected in multiple and their total emission balanced by means of compensating current obtained from the voltage drops occurring across resistors (8a, 8b, 8c, etc.) which will be in proportion to the number of light sensitive cells.

Supervision of lines interconnecting receivers, light sources and sensitive relays is provided as follows: It will be noted that in the circuit arrangement as shown in Fig. 5, an accidental break in any one of the lines 80, 80a, 81, 81a, 82, 82a, etc. will give a false alarm. If, however, lines 78 and 79 are connected as at 78a and 79a, and a break should occur in any of the lines 78a, 79a, 80, 80a, 81, 81a, etc., current can flow through the sensitive relay 12 only in the direction as indicated by arrow 76 which causes the initiation of a trouble alarm. Note also that if either of lines 82 and 82a are broken, the sensitive relay 12 is totally disconnected from the system which leaves the relay armature free to seek its normally preset position, which is such that the armature makes on the trouble contact, so that a trouble alarm is initiated. It will be evident that all the refinements shown for the circuit as in Fig. 1 are applicable to the fundamental circuit shown in Fig. 5 without departing from the spirit of the invention.

A still further modification of the circuit is shown in Fig. 4 in which only one light sensitive cell is employed and in which the light sensitive cell 37 is supervised so as to initiate a trouble

signal should either of its leads 44 or 45 as shown in Fig. 4 be broken.

Referring to Fig. 4 light sensitive cell 37 and resistor 38 which form one leg of a bridge may be housed in a separate and distinct receiver unit which may be situated at some point remote from and connected to the bridge 100 by means of lines 44 and 45. Cell 37 when illuminated by light source 46 causes a current to flow through resistor 38 in the direction indicated by arrow 37a. Likewise, the compensating current which is obtained as described for the circuit shown in Fig. 1 causes a current to flow through resistor 42 in the direction indicated by arrow 46a. A sensitive galvanometer relay 39 is connected across points 52 and 53 of the bridge 100 and a battery 43 is connected to points 54 and 55 of the bridge 100. Battery 43 causes current to flow in the bridge as shown by arrows 42a and 42b. The bridge circuit 100 is completed through potentiometer 40 and by adjusting the variable tap 54 so as to vary the resistors in legs 40a and 40b, the bridge may be brought to a balance whereby no current flows through sensitive galvanometer 39.

Now should smoke or any other opaque object intercept the light beam, emission from cell 37 will decrease, thus decreasing the total current flowing through resistance 38 and upsetting the voltage relations existing in the bridge in such a direction that current will flow through galvanometer relay 39 in a direction shown by arrow 56 and cause the initiation of a smoke alarm as described for the circuit shown in Fig. 1. If, however, the A. C. supply to the light source 46 falls or if the filament of light source 46 burns out, emission from cell 37 as indicated by 37a becomes zero as does the compensating current as indicated by the arrow 46a. The bridge would then remain balanced were it not for the fact that the biasing battery 43 causes a current to flow through the resistance 42 in a direction opposite to that indicated by arrow 46a and unbalances the bridge in a manner which causes current to flow through galvanometer relay 39 in the direction indicated by arrow 57. This direction of current initiates a trouble alarm as discussed for the circuit shown in Fig. 1.

Furthermore, should either of lines 50 or 51, which connect resistance 47 of the light source unit to the rectifier 48 in the control unit, and across which the compensating voltage appears, become disconnected for any reason when the bridge is in its normal balance, the compensating voltage which causes current to flow in the direction indicated by 46a by means of rectifier 48 drops to zero, and likewise unbalances the voltage relations existing in bridge 100 in such a manner that current flows through galvanometer relay 39 in the direction shown by arrow 57 and causes the initiation of a trouble alarm.

Likewise when the bridge 100 is normally balanced, if either line 44 or 45 to the receiver unit becomes disconnected, resistance 38 which constitutes one leg of bridge 100 is effectively disconnected from the bridge, thus causing an unbalance in the voltage relations in such manner that battery 43 causes current to flow through sensitive galvanometer relay 39 in the direction shown by arrow 57 thus initiating a trouble alarm.

It is important to note that for the circuits shown in Figs. 4 and 5, one and only one condition exists under which a smoke alarm is initiated and that is when the light beam from source 46 is intercepted by smoke or any opaque object, and that the rupture of any or all lines which inter-

connect the light source with the power lines or to the control unit and the receiver to the control unit causes the initiation of a distinctive trouble signal.

Several modifications of this invention are possible, among them being that shown in Fig. 3 of the drawings. This smoke detector is different in that two light sensitive cells are used instead of one as shown in Fig. 1. The cell 30 receives light from the light source 31, the combination being used to supervise the passage of smoke through an air conditioning duct or for any other suitable purpose. The other cell 32 is arranged to receive less illumination than cell 31 and serves as the compensating element which compensates for changes in the quantity of light due to voltage fluctuation. Cells 30 and 32 are arranged in balanced relation to one another in the arms of a bridge circuit. The same type of galvanometer relay 12 is used in this circuit as in the circuit shown in Fig. 1. The cells 30 and 32 are connected directly to one end of the galvanometer winding and through the potentiometer 34 to the other end of the galvanometer relay winding. The battery 35 is connected across the potentiometer 34, the purpose of which will be explained later.

Galvanometer relay 12 is connected to alarm and trouble circuits in the same manner as shown in Fig. 1 and is intended to operate alarm and trouble relays such as 18 and 19 in Fig. 1 in the same manner as described above.

The cells 30 and 32 are connected in the bridge with the polarities indicated in the drawing and operate in such a manner that their outputs balance one another in the winding of relay 12 so that variations in power supply voltage have no effect on the relay 12 and thereby false alarms are prevented. The compensating cell 32 is arranged to receive less light than cell 30, as stated previously, by interposing the light slit 33 between the light source 31 and the cell 32. Since the output of cell 30 is greater than that of cell 32, a greater portion of potentiometer 34 will have to be incorporated in the bridge arm containing cell 30 in order to balance the bridge. When the light source 31 is extinguished due to power failure or filament failure, the outputs of the cells 30 and 32 will be reduced to zero and their internal resistances will be equal.

It will now be evident that an unbalanced bridge results and current now flows from the plus terminal of battery 35 and divides into two paths. The first path consists of the cells 30 and 32 in series and the second path consists of the potentiometer 34. The potential of battery 35 will be equally divided between cells 30 and 32 but will be unequally divided between the two legs of the potentiometer 34, marked 34a and 34b. It will now be obvious that a potential difference will exist across the terminals of the sensitive galvanometer relay 12 and a current will flow therein in a direction opposite to that which results in case of a smoke alarm and cause the initiation of a trouble alarm as described for the circuit shown in Fig. 1.

From the above description of the smoke detecting circuit it is evident that applicants provide an extremely sensitive system of general application which maintains its sensitivity through wide fluctuations of energizing voltage. The system further provides a means for preventing false alarms due to breaks in any outside wiring, to power failure, and light source filament failure, and means for indicating such failure for

supervising the system at all times by means of trouble indicating apparatus. It is further evident that applicant's have accomplished this result by means of a simple light-sensitive circuit wherein an amplifier is not necessary and only a single light source and a single light-sensitive cell meet all requirements.

Various modifications may be made in the system embodying our invention without departing from the spirit and scope thereof and we desire therefore that only such limitations shall be placed thereon as are imposed by the prior art or as set forth in the appended claims.

We claim:

1. In combination, a source of light, a source of fluctuating voltage for energizing said source of light, a photocell for receiving light from said source through a supervised area, the output of said cell varying in accordance with the fluctuations of said voltage, means responsive to said source of fluctuating voltage for producing an output corresponding to fluctuations in said voltage variable at substantially the same rate as the cell output in the normal operating range and means responsive to the resultants of said outputs.

2. In combination, a source of light energized by a source of fluctuating voltage, a photocell for receiving light from said source through a supervised area, the output of said cell varying in proportion to a power greater than one of said voltage, means responsive to current flow to said light source to produce an output corresponding to fluctuations in said voltage and variable at substantially the same rate as the cell output in the normal operating range, a source of constant output in circuit with said cell output and said current responsive output which is substantially equal to the difference in absolute value of said other outputs within said range and means responsive to the resultant of the outputs whereby variation of the lamp current gives one response and obstruction of the area deenergizes the cell to give an opposite response.

3. In combination, a source of light, a source of voltage subject to fluctuation for energizing said source of light, a photocell for receiving light from said source through a supervised area, the output of said cell varying in proportion to a power greater than one of said voltage, means responsive to current flow through said light source for producing an output corresponding to fluctuations in said voltage and variable at substantially the same rate as the cell output in the normal operating range, whereby the resultant of said output is substantially constant in said range and means responsive to the resultant of the outputs whereby variation of the lamp current gives one response and any obstruction of the area deenergizes the cell to give an opposite response.

4. In combination, a first circuit comprising a source of light and means for energizing said source, a second circuit comprising a light sensitive device for receiving light energy from said source through a supervised area and converting said light energy into electrical energy, an alarm circuit and a trouble signal circuit, switching means in the alarm and trouble circuits, voltage responsive means common to said first circuit and said second circuit for operating said switching means to close the alarm circuit in response to voltage change in said second circuit resulting from interception of light and biasing means connected to the voltage responsive means for

operating the same to close the trouble circuit in response to abnormal decrease of voltage in said first and second circuits.

5. In combination, a source of light, a source of voltage for energizing said source of light, a photoelectric cell for receiving light from said source through a supervised area, a galvanometer relay having an alarm signal contact and a trouble signal contact, means for deriving a voltage from said source of voltage and applying it to said relay to urge its armature to said alarm contact, biasing means for urging the armature of said galvanometer relay to its trouble contact, means for applying the cell output to said relay in opposition to said derived voltage to normally position the relay armature in a neutral position and urge it toward the trouble contact, whereby any obstruction of said area reduces the cell output and the derived voltage operates the armature to the alarm contact, and a circuit fault which abnormally reduces said derived voltage allows said biasing means to operate the relay armature to the trouble contact.

6. In combination, a source of light, a source of voltage for energizing said source of light, a photoelectric cell for receiving light from said source through a supervised area, switching means comprising an armature, an alarm signal contact and a trouble signal contact, means for deriving a voltage from said source of voltage and applying it to said switching means to urge its armature to said alarm contact, biasing means for urging said armature to said trouble contact, means for applying the cell output to said switching means in opposition to said derived voltage to normally position said armature in a neutral position and urge it toward the trouble contact, whereby any obstruction of said area reduces the cell output and the derived voltage operates the armature to the alarm contact, and a circuit fault which abnormally reduces said derived voltage allows said biasing means to operate said armature to the trouble contact.

7. In combination, a source of light, a source of voltage for energizing said source of light, a circuit connected at one of its ends in circuit with said source of voltage for deriving a voltage therefrom, a galvanometer relay having an alarm signal contact and a trouble signal contact and connected across the other end of said circuit, said derived voltage being applied to said relay to urge its armature to said alarm contact, biasing means for urging the armature of said relay to said trouble contact and a photoelectric cell connected across said circuit intermediate of the ends thereof and receiving light from said source across a supervised area, the output of said cell opposing said derived voltage to normally position said relay armature in a neutral position and urge it toward the trouble contact.

8. In combination, a source of light, a source of voltage for energizing said source of light, a circuit connected at one of its ends in circuit with said source of voltage, switching means having an alarm signal contact and a trouble signal contact, operating means for said switching means connected across the other end of said circuit and light sensitive means connected across said circuit intermediate of the ends thereof and receiving light from said source across a supervised area.

9. In combination, a source of light, a source of voltage for energizing said source of light, a photoelectric cell for receiving light from said source through a supervised area, a galvanometer

relay having an alarm signal contact and trouble signal contact, means for deriving a voltage from said source of voltage and applying it to said relay to urge its armature to said alarm contact, biasing means for urging the armature of said galvanometer relay to its trouble contact, means for applying the cell output to said relay in opposition to said derived voltage to normally position the relay armature in a neutral position and urge it toward the trouble contact, whereby any obstruction of said area reduces the cell output and the derived voltage operates the armature to the alarm contact, and a circuit fault which abnormally reduces said derived voltage allows said biasing means to operate the relay armature to the trouble contact and a second biasing means for operating said relay to close the trouble contact when the third mentioned means fails.

10. In combination, a source of light, a source of voltage for energizing said source of light, a photoelectric cell for receiving light from said source through a supervised area, switching

means comprising an armature, an alarm signal contact and a trouble signal contact, means for deriving a voltage from said source of voltage and applying it to said switching means to urge its armature to said alarm contact, biasing means for urging said armature to said trouble contact, means for applying the cell output to said switching means in opposition to said derived voltage to normally position said armature in a neutral position and urge it toward the trouble contact, whereby any obstruction of said area reduces the cell output and the derived voltage operates the armature to the alarm contact, and a circuit fault which abnormally reduces said derived voltage allows said biasing means to operate said armature to the trouble contact and a second biasing means for operating said armature to close the trouble contact when the fourth mentioned means becomes faulted.

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