

May 30, 1950

J. C. HESSON
SMOKE DETECTOR

2,509,497

Filed Sept. 8, 1947

4 Sheets-Sheet 2

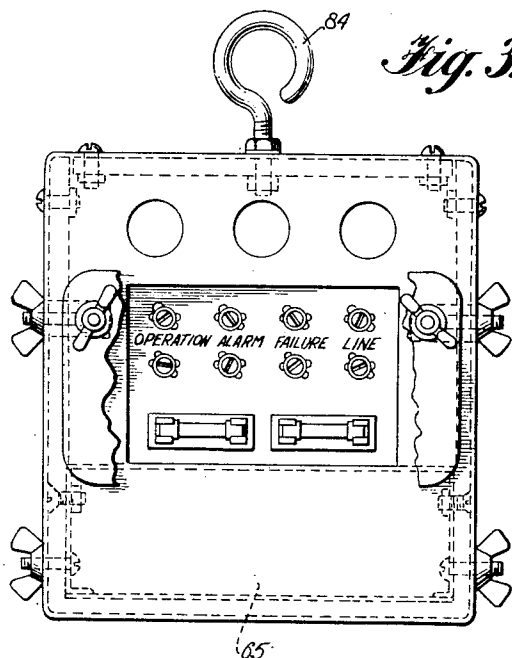


Fig. 4.

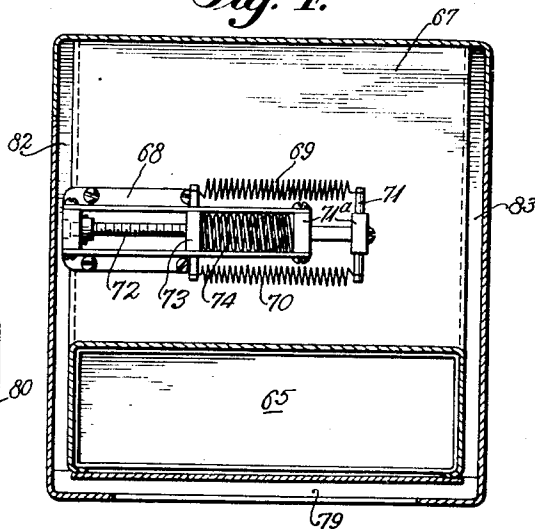
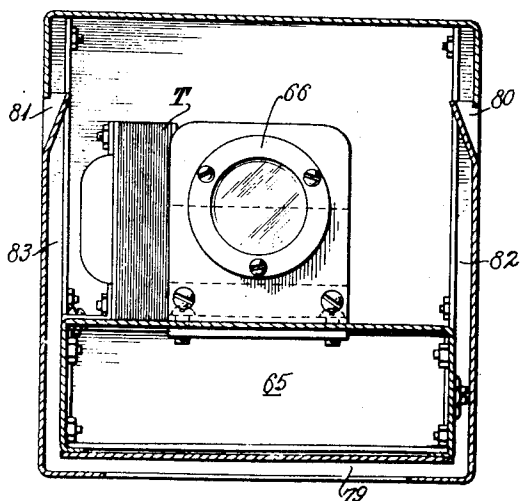


Fig. 5.



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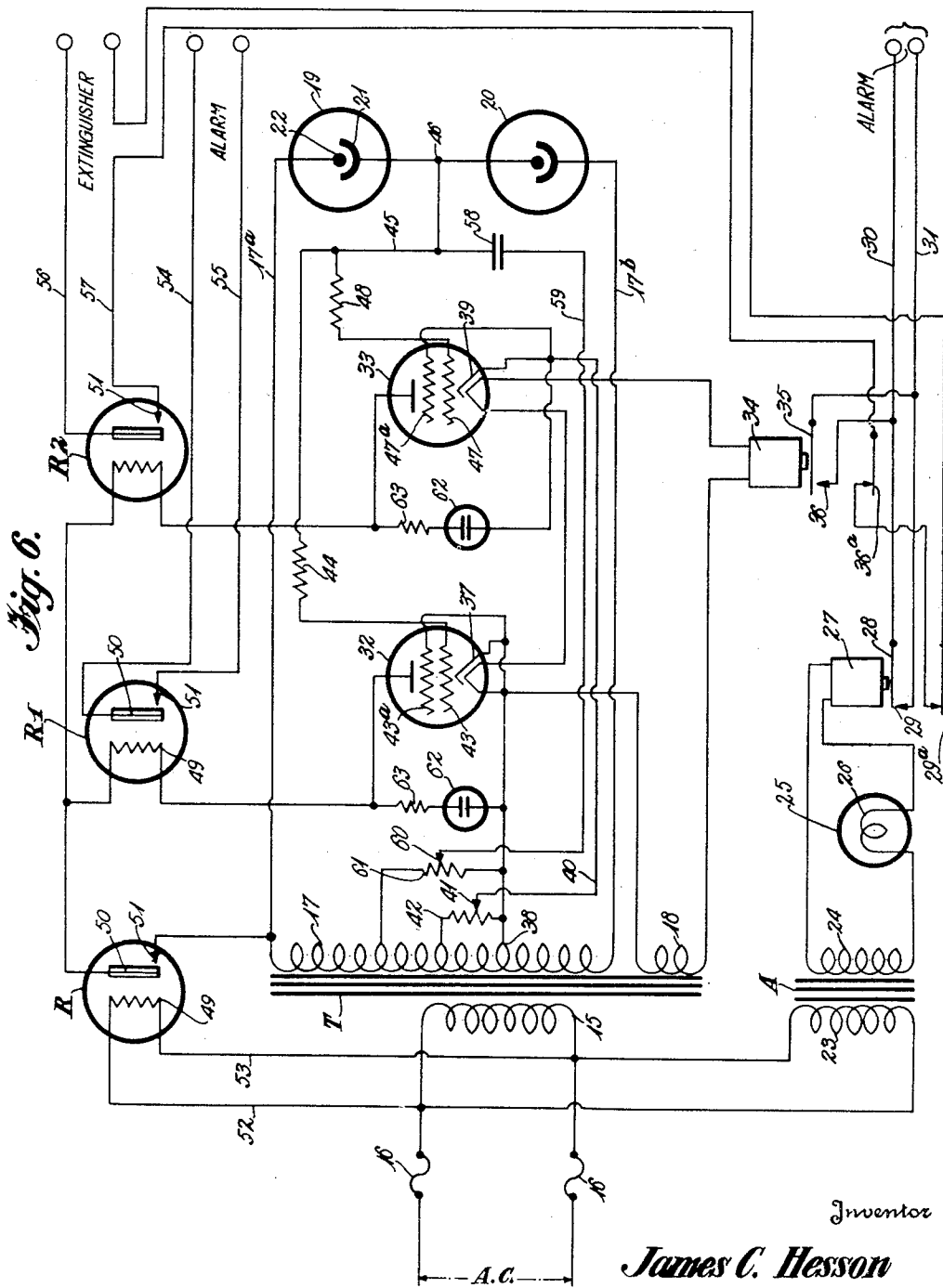
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4 Sheets-Sheet 3



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4 Sheets-Sheet 4

Fig. 9.

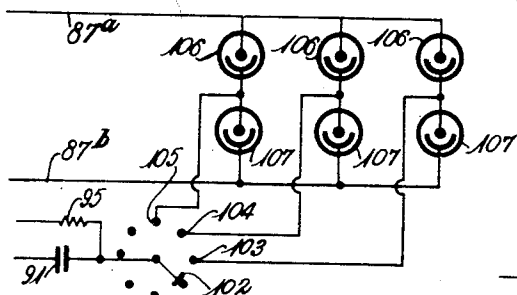


Fig. 10.

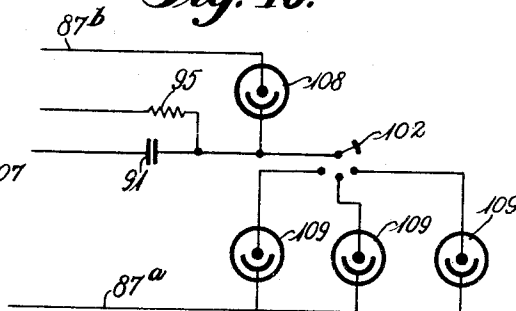


Fig. 8.

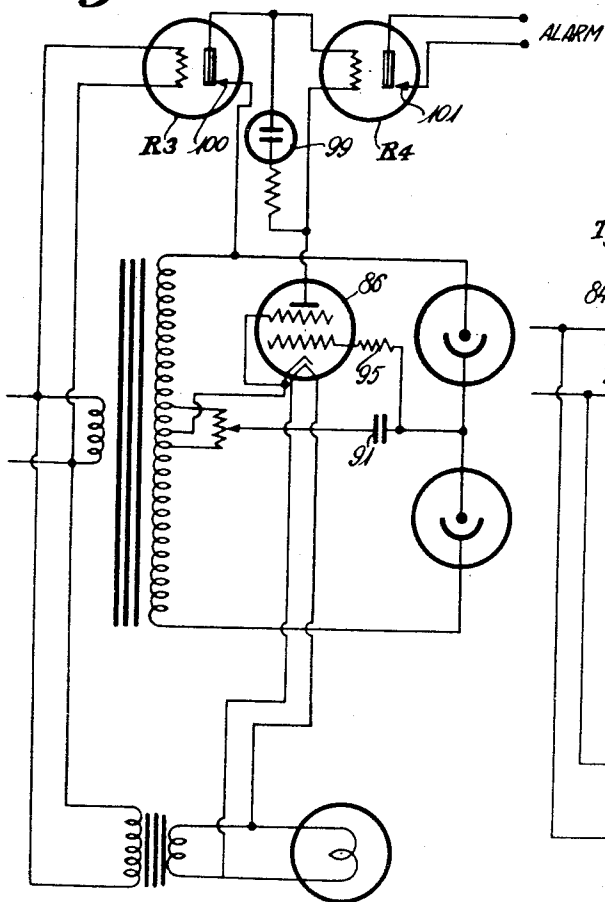
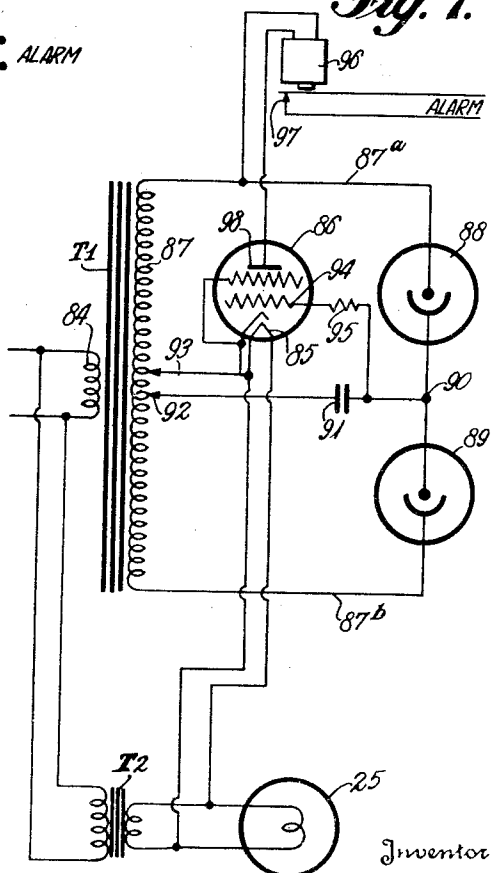


Fig. 7.



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UNITED STATES PATENT OFFICE

2,509,497

SMOKE DETECTOR

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Application September 8, 1947, Serial No. 772,670

13 Claims. (Cl. 177—311)

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This invention relates to smoke detector units for sensing the presence of smoke in fur vaults, on shipboard and in other locations where an automatic system of fire detection or extinguishment is desired. More particularly, the invention relates to an electronic system of detecting smoke and giving a response, either in the form of an alarm, or by setting a sprinkler system or other automatic extinguisher into operation or in combining these two functions and bringing them into operation successively.

Where the system provides for two stage operation, it functions by first giving an alarm, and then by setting an extinguishing system into operation. In such two stage systems dust may collect on the equipment to produce a condition which simulates that resulting from the presence of smoke and may be made to give an alarm whereby the system may be recalibrated before it actually sets the fire extinguishing means into operation. In other words, it provides for an automatic indication resulting from the system drifting out of calibration so that the parts may be reconditioned before the fire extinguishing means is put into operation under false alarm conditions.

The system contemplates the performance of several functions without the addition of extraneous means for carrying them out. In general, the system provides for the use of a balanced phototube system with means for actuating an alarm circuit when the system is out of calibration, or when a lamp filament burns out, or when there is any other failure which should be corrected, and, under proper conditions, setting the fire extinguishing means into action.

Briefly stated, the system embodies two phototube units, one of which serves as a reference and the other as a detector, both of them being supplied with light from a single source so that variations in light intensity due to the lamp itself will affect the two tubes similarly, hence small changes in lamp voltage, for example, will not disturb the calibration of the system or set it into operation under conditions which do not make it necessary.

The invention will be more fully understood from the following description when it is read in connection with the drawings in which:

Figure 1 is a side elevation, with parts broken

away, of a preferred form of smoke detector unit embodying the present invention.

Figure 2 is a top plan view with parts broken away to show the interior construction of the unit.

Figure 3 is an end view of the unit looking from right to left in Fig. 1.

Figure 4 is a section on line 4—4 of Fig. 1 showing the means for varying the intensity of the light which is directed onto the reference phototube.

Figure 5 is a section on line 5—5 of Fig. 1 showing the smoke entry and exit openings in the unit.

Figure 6 is a complete circuit diagram of a preferred form of the invention.

Figure 7 is a circuit diagram of a simplified form of smoke detector arranged for single stage operation.

Figure 8 is a circuit diagram of the system shown in Fig. 7, with the addition of time delay means for protecting certain of the tubes used in the unit.

Figure 9 is a smoke detector unit especially arranged for use on shipboard, utilizing the single stage arrangement of Fig. 7 with a reference phototube for each detector tube.

Figure 10 is a modification of the system shown in Fig. 9, whereby a single reference phototube may be employed in place of the plurality of reference tubes which are necessary in the arrangement of Fig. 9.

The invention will first be described with respect to the circuit diagram of Figure 6 which shows the preferred form of the invention, and thereafter the structural elements of the units will be described, and their relation to the circuit shown in Figure 6 pointed out.

In Figure 6 reference character T designates a transformer the primary winding 15 of which is supplied with current from a conventional source of alternating current through the usual protective devices indicated at 16. Transformer T has a main secondary winding 17 and an auxiliary secondary winding 18, the former of which supplies current to the series-connected phototubes 19 and 20 over line wires 17a and 17b. These tubes are of the usual two element type comprising a curved cathode 21 and an anode 22 placed in spaced relation to the cathode. They

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serve, therefore, as rectifiers in that electric current can flow in one direction only through them, that is, from the anode 22 to the cathode 21. In accordance with usual practice these phototubes have the characteristic of passing current in direct proportion to the intensity of light impinging on them, that is, the stronger the light the greater the conductivity. To a lesser degree the conductivity of the tube is proportional to the voltage across the tube. It will be evident, therefore, that for the purpose of the present invention the particular design of tube employed is not critical so long as the two tubes 19 and 20 are substantially alike, that is, alike within manufacturing tolerances. Consequently, when the two tubes 19 and 20 are exposed to the same conditions, the voltage drops across them will be substantially the same and the current flow through the two tubes will also be the same. That is, the photo tubes will be in balanced relation in the circuit.

Also, connected to the alternating current source is the primary 23 of a transformer A the secondary 24 of which supplies a lamp 25 so disposed as to direct its beam on both the phototubes 19 and 20, and being closely spaced with respect to the reference tube 19. The detector tube 20 is more remotely located with respect to lamp 25 so that the smoke to be detected is between the lamp 25 and the detector tube 20, thus permitting variations in the electrical conductivity of the tube 20 for control purposes.

Inasmuch as continued functioning of the lamp 25 is vital to operation of the system, there is included in circuit with the filament 26 of this lamp a relay 27, having an armature 28, which during the energized condition of the lamp holds the contact 29 open. If, however, the filament 26 should burn out or be de-energized, de-energizing the relay 27, the armature 28 would drop closing contact 29 and completing an alarm circuit which includes the conductors 30 and 31. Relay 27 also controls a second contact 29a which forms a part of an extinguisher circuit. When the relay is energized, indicating normal conditions, the contact 29a is held closed so that the extinguishing circuit can be closed when necessary. If relay 27 is de-energized the contact 29a opens so that the extinguishing circuit cannot be closed under conditions not requiring it.

Unbalance of the circuit including the phototubes 19 and 20 is caused to actuate successively an alarm circuit, and then an extinguishing circuit, and for this purpose there is provided in the system two gas-filled tetrodes of the thyatron type, these tubes being designated 32 and 33 respectively. This type of tube is well known in the art and is characterized by its ability to trigger into action when the control grid reaches a critical positive potential. So long as the control grid is not positive enough to ionize the gas within the tube, there is no current flow, and even though the anodes and cathodes are energized, the current consumed is practically nil. The filaments of the tubes 32 and 33 are connected in series relation with the auxiliary secondary 18 of transformer T, and this circuit also includes a relay 34 having an armature 35 adapted, when the relay is de-energized, to close a contact 36. This relay 34 also includes a front contact 36a included in the extinguisher circuit, and serving to prevent completion of the extinguisher circuit under improper conditions. It will be observed that the armature 35 and contact 36 may complete the alarm circuit through con-

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ductors 30 and 31, and thus give an indication whenever one of the filaments of tubes 32 and 33 burns out or for any reason the flow of current in this filament circuit ceases. De-energization of relay 34 also opens the extinguisher circuit at 36a. The tubes 32 and 33 include both screen grids and control grids to be referred to later.

The operation of the system is based upon an unbalancing of the phototube circuit connected with the phototubes 19 and 20. More specifically, operation of an alarm circuit to show that the system is out of calibration or that there is some smoke in the smoke path occurs when the phototubes are unbalanced to one degree, whereas a greater unbalance will cause operation of the extinguisher circuit, both of these operations being accomplished through the two thyatron tubes 32 and 33 in response to a change in potential of the control grids of those tubes.

More specifically, the thyatron tube 32 has its cathode 37 connected to the secondary 17 of transformer T at point 38. The cathode 39 of tube 33, on the contrary, is more positive than the cathode 37, being connected to line wire 40 and slider 41 of potentiometer 42 which is shunted across a portion of the secondary 17. It will be obvious that by moving the slider 41, the potential of cathode 39 may be changed to secure desired operating differentials between the two tubes 32 and 33.

The control grid 43 of tube 32 is connected through a high resistance 44, and line 45 to a control point 46 between the phototubes 19 and 20. By virtue of this connection, it will appear that when the conductivity of detector tube 20 is reduced, by smoke passing between it and lamp 25, the potential of point 46 will be increased thereby rendering the control grid 43 more positive than normal, and therefore, initiating a current flow between the anode and cathode of tube 32 which serves, through means yet to be described, to energize the alarm circuit over conductors 54 and 55. The screen grid 43a performs its usual function. The control grid 47 of tube 33 is connected through high resistance 48 and line wire 45 with the point 46, and functions in a manner similar to that described to cause a triggering action of tube 33 under appropriate conditions to close the extinguisher circuit when the conductivity of tube 20 has been reduced to a point where such action is called for. Screen grid 47a here is also conventional.

The life of gas filled tubes of the thyatron type is affected by the time of application of potential to the anode of the tube after the tube is first put into operation. Consequently, it is desirable for increasing the life and reliability of the apparatus that the tubes 32 and 33 be protected by a time delay relay designated R in Figure 6. This relay is shown diagrammatically as consisting of a heater element 49, a bimetallic armature 50, and a fixed contact 51. Upon the application of current to the heater 49 for a predetermined period, the bimetallic element 50 will flex closing the contact 51, and the circuit controlled thereby. The use of relay R is optional, and since its sole function is to increase the life of the thyatrons it may be omitted without altering the effectiveness of the circuit for the purpose intended. Such omission is, therefore, contemplated where tube life is not a controlling factor.

In the arrangement illustrated, the heater 49 of tube R is supplied with current from the alternating current source through line wires 52

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and 53. The element 50 and contact 51 of tube R control the circuit for heater 49 of tube R1 so that a short delay of approximately ten seconds takes place between the energization of heater 49 of tube R and the closing of contact 51 of tube R. Similarly, energization of the heater of tube R1, after a short delay, closes contact 51 of tube R1 thus completing the alarm circuit through line wires 54 and 55. The heater of relay R2 controls its contact 51 to complete a circuit to the extinguisher mechanism through line wires 56 and 57.

The operation of the relay circuit is accomplished in the following manner. When the heater of tube R is energized, the contact 51 is closed after a short interval so as to energize the heaters of relays R1 and R2. This places a potential on the anodes of tubes 32 and 33 but no current flows until one of these tubes is triggered into action. As indicated, when the filaments of tubes 32 and 33 are energized, and the heaters 49 of relays R1 and R2 are energized, both the anodes and cathodes of the tubes 32 and 33 have potential applied to them. However, so long as the control grids of the tubes do not carry sufficient positive bias to trigger the tubes into action, there is no current flow through the tubes, and hence the relays R1 and R2 cannot operate. When the conductivity of tube 20 is reduced by the passage of smoke between it and lamp 25, the potential of point 46 becomes more positive than under balanced conditions, thus placing a positive bias on control grid 43 of tube 32 triggering that tube into action and causing a flow of current through the heater circuit 49 of relay R1. After a predetermined interval of perhaps ten seconds, the contact 51 of relay R1 is closed to complete the alarm circuit connected to line wires 54 and 55 thus giving an indication that the phototube circuit has been unbalanced, either due to collection of dust on the parts, or to the presence of an incipient condition which may call for fire extinguishing action. If the condition becomes more aggravated, to further decrease the conductivity of tube 20, the point 46 becomes still more positive placing sufficient bias on the control grid 47 of tube 33 to trigger the tube into action, and through contact 51 of relay R2 closing the circuit to the fire extinguishing mechanism through line wires 56 and 57. It will be obvious that the time delay of the various relays of R1 and R2 can be made to suit conditions, and that any desired time lag can be interposed between the successive operations of these devices.

It has been pointed out above that the balanced phototubes 19 and 20 tend to eliminate the effects of voltage fluctuations and also to compensate for variations in light intensity from the lamp 25. Large voltage fluctuations may cause the voltage at point 46 to vary substantially, and consequently it is preferred to further stabilize the circuit by including a condenser 58 connected through line 59 to a slider 60 on a potentiometer 61 shunted across a portion of the secondary 17 of transformer T. By adjusting the slider 60 it is possible to make the point 46 assume any desired voltage value on the positive half cycle of voltage undulation. This voltage introduced by condenser 58 is balanced by an opposing direct current voltage built-up on the condenser 58 by the phototube current. Consequently, when the direct current voltage unbalance at point 46 decreases due to a line voltage decrease, the opposing alternating

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current voltage caused by condenser 58 also decreases so that the tubes 19 and 20 remain substantially balanced. Hence, by adjustment of the potentiometer 60 a condition may be established where the operation of either tube 32 or 33 produces the same effect on the circuit, in spite of substantial variation in the supply voltage of the circuit. Consequently, while the bias for each of the tubes 32 and 33 is different, a compromise position can be established where the operation of either tube is substantially independent of supply voltage variations over the range between 85 and 135 volts. Under ordinary conditions the position of slider 60 is such that the condenser 58 introduces a positive voltage, whereas the normal direct current bias due to phototubes 19 and 20 is negative. When the power is suddenly turned off for a fraction of a second and then turned on again, the time delay relays R1 and R2 do not close even though the tubes 32 and 33 conduct for a fraction of a second due to the voltage surge thus eliminating any possibility of a false actuation of the alarm or extinguisher circuit due to voltage surges in the circuit. This accounts for the desirability of using a thermal delay relay instead of an ordinary magnetic type of relay.

It will be evident that the system is so designed that a normal failure of parts will not produce a false operation. If for example the filament of the lamp 25 burns out the phototubes 19 and 20 receive no light and hence become non-conducting so that very little if any current can be provided to charge condenser 58. Thus tubes 32 and 33 cannot ordinarily operate. Likewise if the filament of one of the tubes 32 or 33 burns out, each of the tubes 32 and 33 is deprived of a hot filament for heating its cathode and thus cannot operate. However to provide against a possible operation of the extinguisher circuit because of some instability which might develop to operate tube 33, due to a failure of the filament of lamp 25 or one of the tubes 32 and 33, the extinguisher circuit will be opened by the opening of contact 29a of relay 27 or by the opening of contact 36a of relay 34. Thus only an alarm is possible in the event of a failure of the filament of lamp 25 or one of the tubes 32 and 33, the extinguisher circuit being open either at 29a or 36a. Also, if relay R should fail to close its contact or one of the heaters should burn out or open circuit, the tubes 32 and 33 or one of them would be left without necessary operating plate voltage and hence could not trigger.

It is desirable to have some indicating means to show when the tubes 32 and 33 have the necessary plate voltage for operation. For this purpose there is shunted between the anode and cathode of tube 32 a neon lamp 62 having a series-connected resistor 63. This lamp draws only a fraction of a milliamperes of current and hence does not otherwise affect the circuit. As long as there is an alternating current potential on the circuit both electrodes of the lamp glow. If, however, the voltage falls or the tubes are rendered conducting, the neon lamp is extinguished. More specifically, when tube 32 is non-conducting, both plates of neon lamp 62 glow but when the tube becomes conducting, the voltage from anode to cathode of the neon lamp becomes very low during the positive half cycle and is not sufficient to cause the lamp to glow during this positive half cycle. Consequently, the lamp 62 glows only during the negative half cycle and acts as if direct current were impressed upon it. Associated

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with tube 33 is a neon lamp 64 and a resistor 83 the action of which is similar to that just described in connection with tube 32 and its associated neon lamp.

Having described the circuits which are used in apparatus of the present invention, the structural units will now be described.

Referring to Figures 1 to 5, inclusive, it will be seen that the unit comprises a box-like structure including a base 65 upon which the lamp 25 is mounted between the reference phototube 19 and the detector phototube 20. A lens 66 carried by the base concentrates the beam from lamp 25 on the detector tube 20 but no such means is necessary in connection with reference tube 19 because of its proximity to the lamp 25. The intensity of the light falling upon the reference tube 19 is however controlled by a variable screen 67 shown in detail in Figure 4. Fixed on the unit is a guide 68. A block 73 slides in this guide and attached to it are springs 69 and 70 reacting between the block and a support 71. A threaded rod 72 can be turned to move the sliding block 73 to which one end of a helix 74 is attached, the other end being attached at 71a to support 71, this helix being disposed over an aperture between the lamp 25 and the reference phototube 19. Consequently, when the block 73 is moved to the left in Fig. 4, the turns of the helix are opened up, allowing more light to impinge on the phototube 19, but when the block 73 is moved toward the right, the turns of the helix become more closely spaced thus reducing the amount of light which strikes the phototube 19. This provides a ready means for securing accurate initial calibration of the phototube 19.

Carried on the support at the right of reference tube 19 is a relay and tube unit, supporting the two thyratrons 32 and 33, the relays R, R1, and R2, and the relays 27 and 34. At the left of the concentrating lens 66, and rotatably supported on the base 65, are two grids 75 and 76. The coarse grid 75 may serve to calibrate the tube 32, for example, preventing 10% of the light from lamp 25 from striking the detector phototube 20. By rotating the shaft 78, by means of a screwdriver applied to the slotted end of the shaft, this grid may be placed in a nearly vertical position where it offers the maximum resistance to the flow of light. When the calibration has been accomplished, the grid is lowered to the position shown in Figures 1 and 2. Similarly, the fine grid 76 may be raised to a vertical position through the shaft 77. The grid 76 prevents 20% of the light from passing through it and may be used to calibrate the thyatron 33 for extinguisher purposes. It will be evident that the pivoted disposition of the test grids makes it possible to determine whether the cutoff is too great or too little, the grids having their maximum effect when raised to nearly vertical position.

As here shown the entire unit comprises a closed casing with the exception of an opening 79 at the bottom of the casing and outflow openings 80 and 81 at the top. Consequently, smoke may enter at the bottom and pass through the passageways 82 and 83 before escaping through the outlets 80 and 81. The unit may be suspended by hooks 84 secured to the top of the casing.

The preferred form of the invention just described provides for two stage operation, that is, the giving of an alarm when the smoke condition starts or when the calibration of the instrument is affected by accumulation of dust and dirt, and

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extinguishing action when the smoke concentration exceeds a fixed value. In certain situations such as on shipboard automatic extinguishment is not desired, and hence it is only necessary to provide means for giving an alarm when a dangerous condition arises, or when the unit becomes inoperative due to the burning out of a lamp or the like. Where a single stage of operation only is needed, the device may be simplified and one example of a circuit embodying this simplification is found in Figure 7.

In Figure 7 the primary 84 of transformer T1 is supplied with alternating current from any suitable source. This source also supplies the primary of a transformer T2. Transformer T2 provides current for lamp 25 and the filament 85 of a thyatron tube 86. It will be clear that the failure of any filament will cause a condition which will actuate the alarm now to be described. The secondary 87 of transformer T1 supplies the phototubes 88 and 89 in series as before, over line wires 87a and 87b, noting however, that here the tube 88 serves as the detector tube and the tube 89 serves as the reference tube and that current flows normally through the single thyatron used. The point 90 between the tubes 88 and 89 is connected through condenser 91 to a midpoint on the secondary 87 as at 92. The filament is connected by wire 93 to that secondary in order to place the filament at desired potential for satisfactory operation. The control grid 94 is connected through the resistor 95 to the point 90. Relay 96 which controls the alarm circuit through contact 97, is connected between the anode 98 of tube 86 and the circuit for the phototubes 88 and 89. With the circuit energized as shown, and with the light directed on the tubes 88 and 89, the relay 96 remains energized and the tube 86 is conducting. When, however, smoke to be detected passes between the lamp 25 and the phototube 88 this will cause the potential of point 90 to be reduced, thus stopping current flow in the tube 86 and de-energizing the relay 96 to close the alarm circuit at 97. It will be noted, therefore, that the system shown in Figure 7 operates on the theory of continuous energization of the tube 86 so that the relay 96 is normally energized and only becomes de-energized when current flow through the tube 86 is discontinued.

The system shown in Figure 7 operates without time delay, the alarm circuit being closed immediately upon failure of current flow in tube 86 and consequent de-energization of relay 96. When a time delay is desired in connection with tube 86, the scheme shown in Figure 8 may be adopted.

Referring to Figure 8, the parts there shown are identical with those in Figure 7 except that in Figure 8 the relay 96 of Figure 7 is replaced by the time delay thermal relays R3 and R4 with a neon lamp 99 to indicate the condition of current flow through the tube 86. In Figure 8, the relay R3 upon energization of its heating coil will after a time delay, close the contact 100 to supply heating current to the heater of relay R4, provided tube 86 is conducting. The arrangement is such that the contact 101 of relay R4 will only be closed to complete the alarm circuit 70 when current flows through tube 86. The neon lamp 99 will indicate whenever there is a drop in potential around the heater circuit of relay R4.

As indicated above, the dominant feature of the present invention is the use of balanced phototubes for giving a desired indication. An-

other possible application of this principle to smoke detection is its use on shipboard where a series of holds are continuously sampled for the presence of smoke through draw tubes extending to visible smoke tubes at a central point. With such an apparatus, it is essential that each draw tube be sampled separately, because this is the only way in which the smoke concentration in each hold can be determined.

Figure 9 of the drawing shows a portion of a system in which two balanced phototubes could be used in connection with each smoke tube, and wherein a single alarm and detecting circuit would be effective. In tracing the circuits of Fig. 9, it will be observed that this figure replaces the phototubes 88 and 89 of Fig. 7 so that phototubes 106 and 107 are supplied by line wires 87a and 87b, the condenser 91 and resistor 95 being connected as in Fig. 7.

In Figure 9 the condenser 91 and resistor 95 are the ones shown in Figure 7. Associated with a plurality of parallel connected pairs of phototubes, is a rotary switch comprising a rotary contact 102 driven by means such as an electric motor and adapted to successively engage contacts 103, 104 and 105 in its travel. For purposes of simplification only three of these are shown connected to balanced phototubes comprising detector tubes 106 and reference tubes 107. The various smoke tubes all terminate at a common point but each pair may have a separate light source. The response of the alarm circuit will be determined by the unbalance of a pair of tubes 106-107 as it is put in circuit by switch 102. The motor which drives the rotary contact 102 may be connected to the alarm relay so that when smoke is detected in any smoke tube and operates the alarm, this automatically breaks the circuit of the actuating motor and stops the contact at the point where the dangerous condition is registered.

Where a single light source is utilized for all of the smoke tubes, a single reference phototube only is required as indicated at 108 in Figure 10. Here the rotary contact 102 serves to connect the detecting phototubes 109 into the circuit successively, so that each of them operates in conjunction with the reference tube 108 to determine whether or not there is smoke in the particular tube which is being sampled, assuming that the arrangement of Fig. 10 is used to replace the phototubes 88 and 89, it will be noted that line wire 87a is connected to the cathodes of detector tubes 109 and that line wire 87b is connected to the anode of reference tube 108. If the scheme of Fig. 10 is to be used with a two-stage system similar to that of Fig. 6, the reference tube 108 of Fig. 10 will take the place of reference tube 19 in Fig. 6, and detector tubes 109 will replace the reference tube 20.

It is to be understood, therefore, that the systems of Figs. 9 and 10 are not by any means limited to single stage operation and that the details may be modified to suit conditions without altering the basic principles of the invention.

Although only a few forms of the invention have been illustrated, it will be obvious from a reading of the specification and claims that changes may be made in the details within the scope of the claims without departing from the spirit and scope of the invention.

Having thus described the invention, I claim:

1. In a smoke detecting unit, a source of alternating current including a transformer, a pair of phototubes connected in series relation, across

the secondary of said transformer and arranged to receive current therefrom, a source of light focused upon said phototubes, means providing a smoke path between said light source and one of said phototubes for varying the drop in potential across said tubes, and a condenser independently connected between a point on said transformer secondary which has a low potential relative to the connections of said phototubes and a point between said phototubes for imposing a potential on said latter point.

2. In a smoke detector unit, a base having a source of light mounted thereon, a reference phototube closely adjacent to said source on one side thereof, a detector phototube on the other side of said source and placed remotely therefrom, means for equalizing the intensity of the light from said source impinging upon said phototubes, electric means responsive to a differential in the intensity of the light from said source impinging upon said phototubes, and grid means disposable between said source and said detector phototube for varying the intensity of light impingement on said detector phototube to calibrate said unit for response to a predetermined differential in the intensity of the light impinging upon said phototubes.

3. In a smoke detecting unit, an alarm circuit and a fire extinguishing circuit, a pair of phototubes arranged in series relation, a source of light disposed to direct its beam upon said phototubes but being located closer to one phototube than to the other, a plurality of gas-filled trigger tubes arranged to be triggered into action successively as the intensity of light directed upon said remotely located phototube is varied, and a connection between a point between said phototubes and the control grids of said trigger tubes for controlling the potential of the latter, predetermined variations in the intensity of light falling upon said remotely located phototube acting to vary the potential of said control grids for triggering said trigger tubes and energizing said alarm and extinguishing circuits in succession.

4. In a smoke detecting unit, a source of light, phototube means responsive to variations in the intensity of light received from said source, indicating means responsive to a decrease of one degree in light intensity applied to said phototube means, fire extinguishing means responsive to a decrease of a greater degree in light intensity applied to said phototube means, signal means responsive to failure of said light source, and control means associated with said signal means to prevent response by said extinguishing means upon failure of said light source.

5. In a smoke detecting unit, an alarm circuit and a fire extinguishing circuit, a pair of phototubes arranged in series relation, a source of light disposed to direct its beam upon said phototubes but being located closer to one phototube than to the other, a plurality of gas-filled trigger tubes arranged to be triggered into action successively as the intensity of light directed upon said remotely located phototube is varied, and a connection between a point between said phototubes and the control grids of said trigger tubes for controlling the potential of the latter, and means for imposing predetermined variations in the intensity of light falling upon said remotely located phototube to vary the potential of said control grids for calibrating said trigger tubes to energize said alarm and extinguishing circuits in succession.

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6. In a smoke detecting unit, an alarm circuit and a fire extinguishing circuit, a pair of phototubes arranged in series relation, a source of light disposed to direct its beam upon said phototubes but being located closer to one phototube than to the other, a plurality of gas-filled trigger tubes arranged to be triggered into action successively as the intensity of light directed upon said remotely located phototube is varied, means associated with said source of light and said trigger tubes to indicate failure of any of the associated units and to open said extinguishing circuit upon such failure, and a connection between a point between said phototubes and the control grids of said trigger tubes for controlling the potential of the latter, predetermined variations in the intensity of light falling upon said remotely located phototube acting to vary the potential of said control grids for triggering said trigger tubes and energizing said alarm and extinguishing circuits in succession.

7. In a smoke detecting unit, an alarm circuit and a fire extinguishing circuit, a pair of phototubes connected in series relation to a source of alternating current, a source of light disposed to direct its beam upon said phototubes but being located closer to one phototube than to the other, a plurality of gas-filled trigger tubes arranged to be triggered into action successively as the intensity of light directed upon said remotely located phototube is varied, a condenser connected between said current source and a point between said phototubes for adjusting the potential of said latter point, and a connection between a point between said phototubes and the control grids of said trigger tubes for controlling the potential of the latter, predetermined variations in the intensity of light falling upon said remotely located phototube acting to vary the potential of said control grids for triggering said trigger tubes and energizing said alarm and extinguishing circuits in succession.

8. In a smoke detecting unit, an alarm circuit and a fire extinguishing circuit, a pair of phototubes arranged in series relation, a source of light disposed to direct its beam upon said phototubes but being located closer to one phototube than to the other, a plurality of gas-filled trigger tubes arranged to be triggered into action successively as the intensity of light directed upon said remotely located phototube is varied, a connection between a point between said phototubes and the control grids of said trigger tubes for controlling the potential of the latter, predetermined variations in the intensity of light falling upon said remotely located phototube acting to vary the potential of said control grids for triggering said trigger tubes and energizing said alarm and extinguishing circuits in succession, and means providing a slight delay between the triggering of said trigger tubes and the energizing of said circuits to prevent functioning of said circuits when said trigger tubes momentarily respond to voltage surges in the unit.

9. In a smoke detecting unit, a plurality of pairs of associated phototubes each pair being connected in series relation to a source of alternating current, light means disposed to direct a beam of light upon each of said phototubes, a gas-filled trigger tube, a condenser connected to said source of alternating current, a rotary switch for connecting a point between successive pairs of phototubes to said condenser and the control grid of said trigger tube, said condenser being independently connected to said source of alter-

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nating current at a point of low potential relative to the connections of said phototubes for imposing a potential on the point between said phototubes and said grid being responsive to variations in the potential of the point between said phototubes to cause said trigger tube to respond to variations in the light directed on one of a connected pair of said phototubes, and an alarm circuit responsive to the action of said trigger tube.

10. In a smoke detecting unit, a source of light, a plurality of associated phototubes comprising a reference phototube closely adjacent to and a detector phototube located remotely from said light source, said phototubes each being connected between points of relatively high potential difference, a gas-filled trigger tube, means connecting the control grid of said trigger tube to said phototubes to control the potential of said grid for causing said trigger tube to respond to variations in the intensity of the light directed on one of said phototubes, a condenser connected between said phototubes and a source of relatively low potential for imposing a potential upon the phototubes and alarm means responsive to the action of said trigger tube.

11. In a smoke detecting unit, a source of light, a plurality of associated phototubes comprising a reference phototube closely adjacent and a series-connected detector phototube located remotely from said light source, said phototubes each being connected between points of relatively high potential difference, a gas-filled trigger tube, means connecting the control grid of said trigger tube to a point between said reference and detector phototubes to control the potential of said grid for causing said trigger tube to respond to variations in the intensity of the light directed on said detector phototube, calibrating means for imposing predetermined variations in light intensity on said detector phototube, a condenser independently connected to a point between said reference and detector phototubes and to a source of relatively low potential for imposing a potential on said point, and alarm means acting in accordance with the response of said trigger tube.

12. In a smoke detecting unit, a source of light, phototube means responsive to variations in the intensity of light received from said source, indicating means controlled by a gas-filled trigger tube which is actuated in response to a difference in its grid potential resulting from interception of such a portion of the light directed toward said phototube means as will effect a predetermined variation in the light intensity applied to said last mentioned means, and fire extinguishing means controlled by a second gas-filled trigger tube which is actuated in response to a difference in its grid potential resulting from interception of such a greater portion of the light directed toward the phototube means as to effect a variation of a greater degree in the light intensity applied to said last mentioned means.

13. In a smoke detecting system, a continuously energized source of light, phototube means responsive only to variations in the intensity of light received from said energized source, electro-responsive indicator means arranged to be energized upon a predetermined decrease in the intensity of the light received from said energized source by said phototube means, electro-responsive fire extinguishing means arranged to be energized upon a further decrease in the intensity

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of the light received from said energized source by said phototube means, said indicator means and said fire extinguishing means each including a thyatron tube having a two-electrode gas-filled tube connected between the anode and cathode thereof to indicate voltage potential therebetween and energization of said thyatron.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date	
892,241	Freise	June 30, 1908	15
1,785,393	Sawford	Dec. 16, 1930	

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Name	Date
Vedder	June 16, 1931
Logan	May 15, 1934
Grant	Jan. 26, 1937
Dawson	Dec. 27, 1938
Evans	Apr. 7, 1942
Cahusac	Nov. 10, 1942
Michel	Feb. 2, 1943
Wilson	Sept. 10, 1946
Mayle	Dec. 30, 1947