May 9, 1967 T. N. VASSIL 3,319,069

SMOKE DETECTING RADIATION SENSITIVE FIRE ALARM SYSTEM

Filed Aug. 27, 1964

4 Sheets-Sheet 1

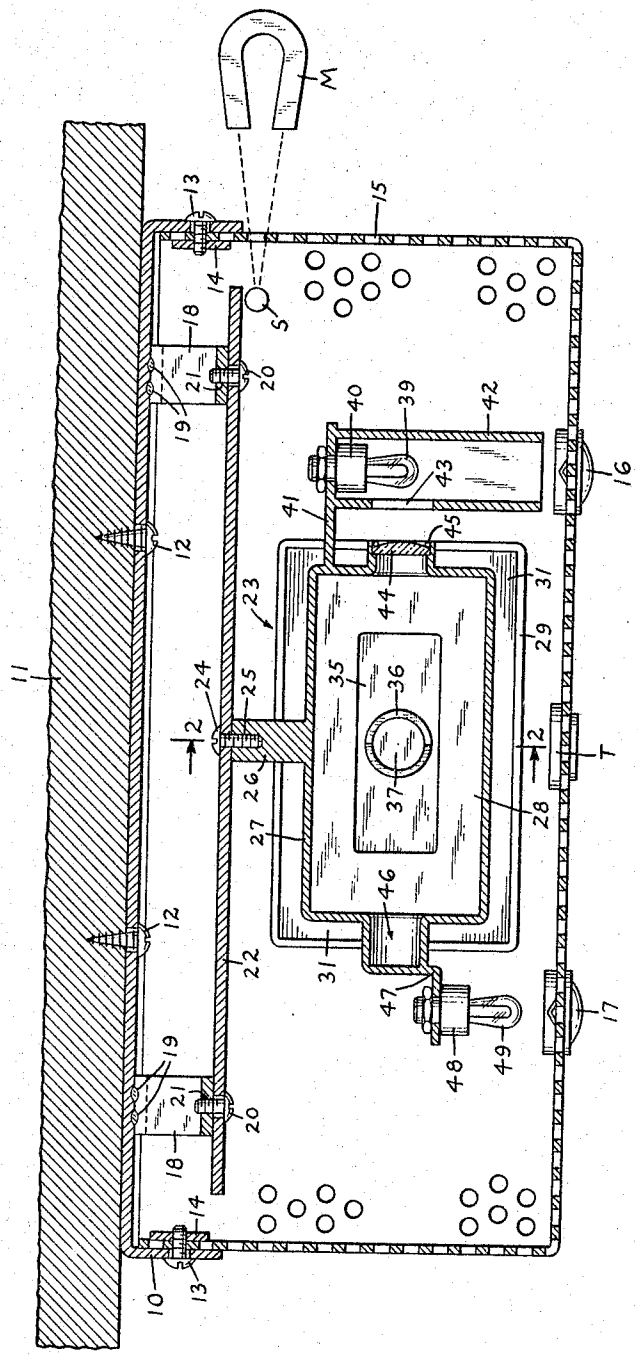
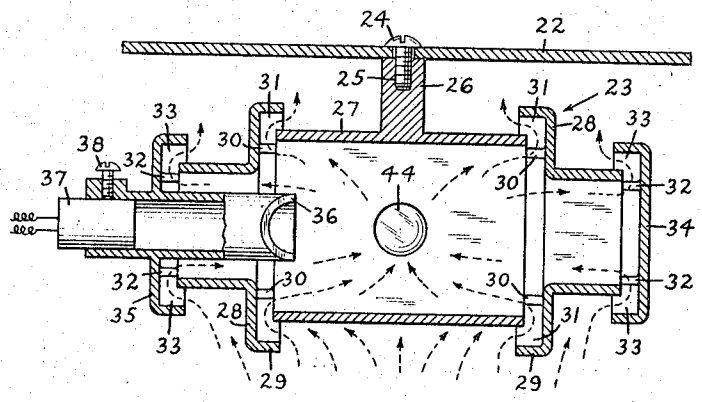


FIG. 1.

SMOKE DETECTING RADIATION SENSITIVE FIRE ALARM SYSTEM

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FIG.2.



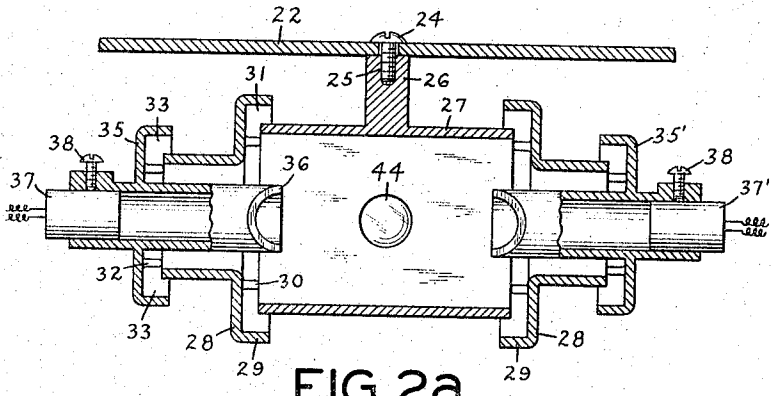


FIG.2a.

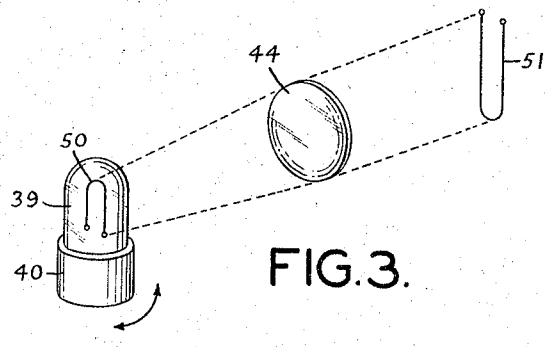


FIG.3.

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SMOKE DETECTING RADIATION SENSITIVE FIRE ALARM SYSTEM

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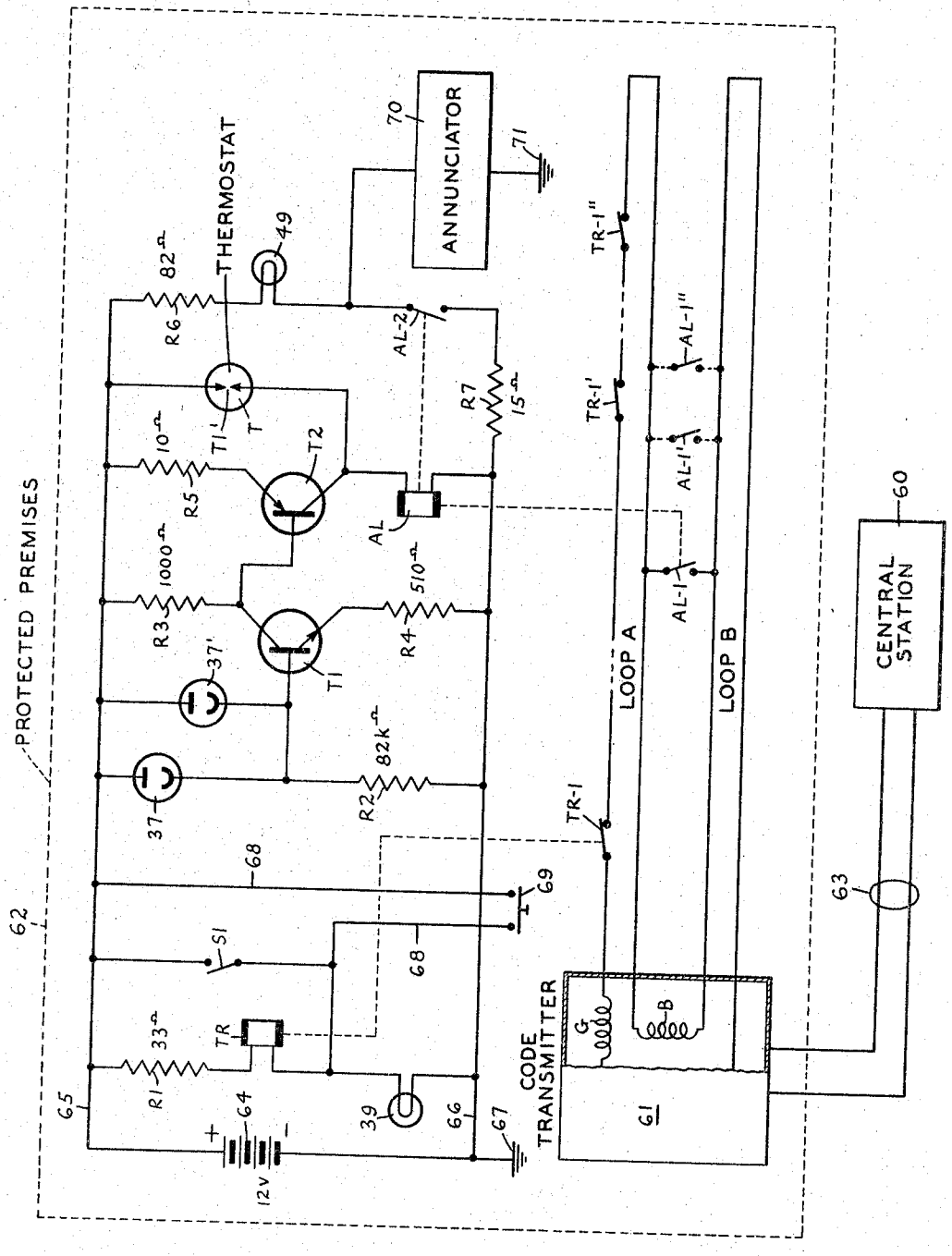


FIG. 4.

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SMOKE DETECTING RADIATION SENSITIVE FIRE ALARM SYSTEM

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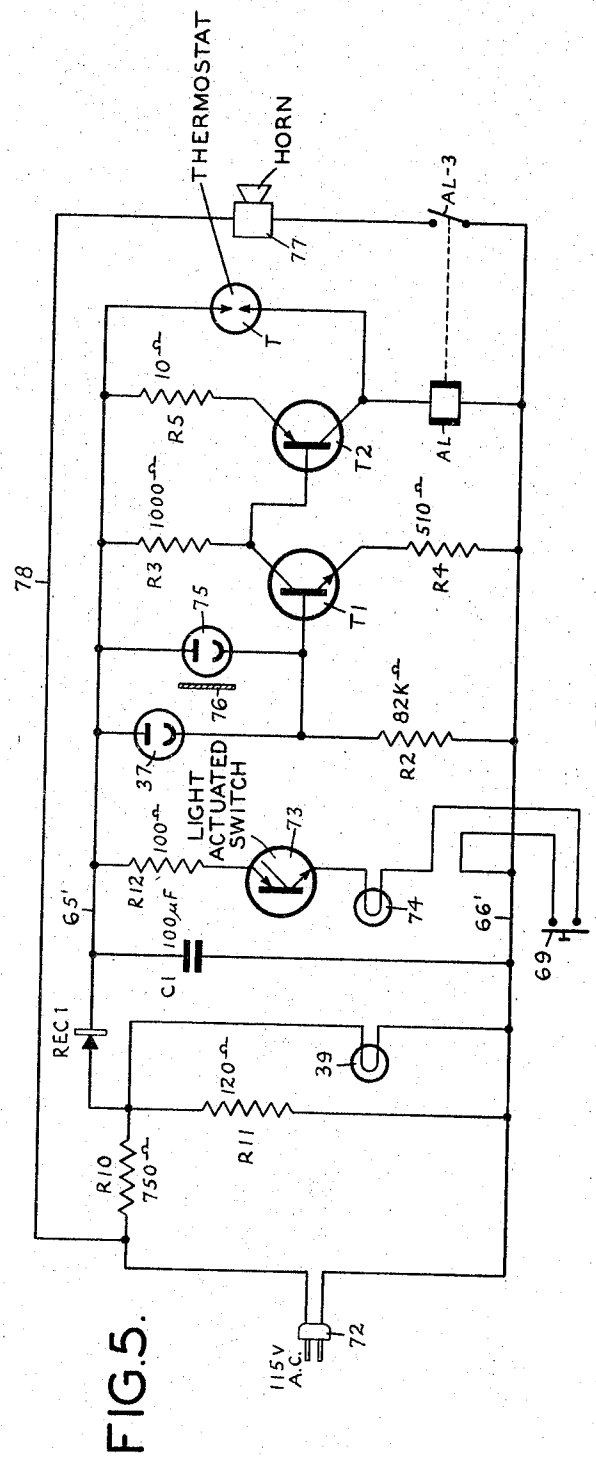


FIG.5.

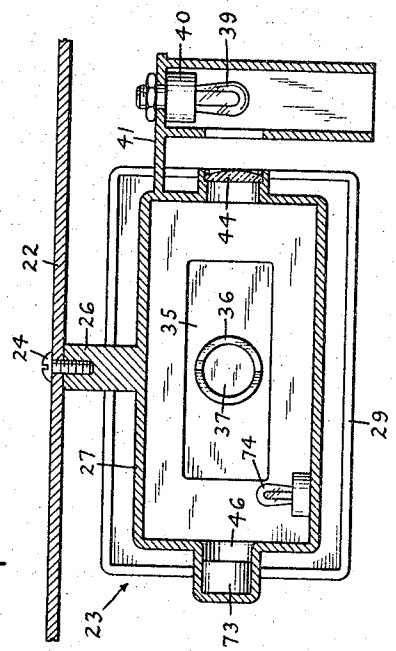


FIG.6.

United States Patent Office 3,319,069
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3,319,069

SMOKE DETECTING RADIATION SENSITIVE FIRE ALARM SYSTEM

Theo N. Vassil, Flushing, N.Y., assignor to American District Telegraph Company, Jersey City, N.J., a corporation of New Jersey

Filed Aug. 27, 1964, Ser. No. 392,449
14 Claims. (Cl. 250—218)

The present invention relates to systems for detecting and providing an alarm indication of the existence of a fire condition and more particularly to such systems wherein the fire condition is primarily detected by the presence of smoke.

The smoke detectors most commonly known and used in the past for the detection of fire conditions have been of two basic types. One type, exemplified by Evans et al. United States Patent 2,298,757, issued Oct. 13, 1942, consists of a light source, an optical system for projecting a beam across the space to be protected, and a photoelectric cell serving as a light receiver. The presence of smoke in the protected area partially obscures the beam of light, thereby causing a diminution in the light energy received by the cell. The resulting change in the electrical characteristics of the cell is detected by associated circuitry and is employed to initiate an alarm indication. Such systems have been employed successfully for many years and provide reliable protection with a high degree of sensitivity to the presence of small quantities of smoke.

Currently, however, a commercial demand exists for the more compact and economical form of smoke detector known as the "spot" type. Smoke detectors of the spot type have the operating elements combined in a single unit of relatively small size and depend upon the smoke spreading to the location (or "spot") in which the detector is mounted. There are thus obvious savings in equipment size and complexity over the beam type of detector in which the light beam is often projected from a light source on one side of a room to a receiver unit mounted on the opposite wall. An additional advantage of the spot type detector is freedom from false alarms caused by inadvertent interruption of the light beam by workmen transporting large objects such as ladders, building materials, etc.

It has been known for many years that smoke particles reflect light (the so-called Tyndall Effect), a phenomenon often observed in motion picture theatres as the light beam from the projector passes through clouds of tobacco smoke. The Tyndall Effect has been used in the past as the operating principle of smoke detectors such as, for instance, that disclosed in the Freygang United States Patent 1,828,894. The Tyndall Effect detector as shown by Freygang (and others) comprises a normally dark chamber traversed by a beam of light and a photoelectric cell arranged at an angle to the light beam so that the cell is not directly affected by the light. However, when smoke enters the chamber, light reflected from the smoke particles falls upon the cell and an alarm signal is initiated. The Tyndall Effect principle is obviously well suited to the construction of a detector of small physical size as opposed to the projected beam principle.

Difficulties, however, have been experienced in the construction of Tyndall Effect smoke detectors having a high degree of sensitivity to small amounts of smoke. A high degree of sensitivity may be obtained readily in the beam type of detector when the beam is of appreciable length due to the integrating effect of the beam length. For reasonably evenly distributed smoke of a given density, it is obvious that the longer the beam path through the smoke cloud the greater will be the reduction in the light arriving at the photocell. Consequently, the sensitivity of the system may be increased by simply extending

the length of the projected beam. The sensitivity of a small volume Tyndall Effect chamber may be increased somewhat by brightening the light source, since more light energy would then be reflected to the cell from smoke of a given density. But only small gains in sensitivity may be thus accomplished because the reflections from the inner walls of the chamber are also increased, thereby impairing the signal-to-noise ratio of the entire system. Increasing the cross-sectional size of the light beam is also ineffectual as the light reflected from smoke particles on the side of the beam away from the photocell is obscured by those particles nearer the cell.

The present invention provides a simple and effective smoke detector of the Tyndall Effect type in which a high level of sensitivity is obtained by controlling the shape of the light beam cross section in such manner that a maximum amount of light is reflected from the smoke particles to the cell. Furthermore, both the transmission of reflected light through the smoke filled chamber and the response of the photocell have been optimized by control of the wave lengths of the light constituting the beams.

The principal object of the present invention therefore has been to provide a novel and improved smoke detector of the Tyndall Effect type.

More particularly, it has been an object of the present invention to provide a Tyndall Effect smoke detector of high sensitivity characterized by simple construction.

The effectiveness of a smoke detector is also dependent on the provision of suitable means to permit a free flow of smoke through the device and, at the same time, to exclude ambient external light. An important feature of the present invention is the particular geometry of the smoke chamber which assures a dark interior, freedom from back pressures, and provides flow patterns to promote the entry of smoke into the chamber.

To provide assurance that a smoke detector is in proper operating condition, it is necessary that there be a means of testing the functioning of the entire detection system. Any smoke detector may, of course, be tested by simply applying smoke to the device. Yet so doing is not only an inconvenient means of test, but is also inadvisable in that repeated testing by such means may well result in an accumulation of smoke particles on the surfaces of the lens and photocells which will impair the future operation of the device. It has, therefore, been a common practice to simulate the presence of smoke in the chamber by introducing additional light as a substitute for light actually reflected from smoke particles. Such procedure, however, is deficient in that no assurance is provided that the normal light beam is in correct alignment and of the desired intensity. In the extreme case, it is possible that the normal light source may have failed completely, yet the device would test satisfactorily upon the introduction of a secondary source of light for test purposes. Accordingly, it has been another object of the present invention to provide a novel means of testing a smoke detector in such manner as to determine that the light beam is in correct alignment and of the desired intensity.

As a means of protection against fire conditions where there may be an accumulation of heat without appreciable smoke, smoke detectors are commonly equipped with a thermostat arranged to initiate the alarm signal when a predetermined temperature is attained in the protected area. It is also possible that a fire condition may occur in which visible flame is apparent prior to the arrival of appreciable heat or smoke at the detector. Accordingly, another feature of the present invention is the provision of means to detect independently either a predetermined increase in the ambient temperature and/or a "flash" of fire and initiate the alarm signal.

Fire protection services for commercial, industrial and ercantile establishments are usually rendered through e medium of a central station. Each of the premises be protected is connected to the central station through common transmission line and each of the premises is ovided with a transmitter capable of producing a disictive coded signal. When an alarm condition occurs a protected premises, the coded signal is automatically ansmitted to the central station where trained operators entify the source of the signal and initiate appropriate medial action, i.e., dispatch the fire department, notify e owner, etc.

Central station service, however, is not always appopriate for the requirements of the average home own-. Therefore, it has been yet another object of the presit invention to provide a modification of a Tyndall Effect noke detector especially suitable to the requirements of sidential fire protection service.

Other and further objects, features and advantages of e invention will appear more fully from the following escription taken in connection with the appended drawgs, in which:

FIG. 1 is a longitudinal cross-sectional view of a dector embodying the invention mounted on the ceiling f a protected area;

FIG. 2 is a cross-sectional view of the smoke detection hamber taken along the line 2–2 of FIG. 1 and showing e smoke entry passages (the protective cover is omitted om FIG. 2);

FIG. 2*a* is a transverse cross-sectional view of a smoke etection chamber illustrating a modified construction roviding increased sensitivity of response;

FIG. 3 is a schematic view illustrating the method of roperly aligning the light source filament with respect to he smoke detection chamber;

FIG. 4 is a schematic diagram of an electrical circuit or a form of the detector especially adapted for commercial premises;

FIG. 5 is a schematic diagram of an electrical circuit or a form of the detector especially adapted for residential premises; and

FIG. 6 is a longitudinal cross-sectional view of a smoke hamber showing the details of a modified testing arangement.

Referring now to FIG. 1, reference numeral **10** denotes a bracket or support element, which may be made of relatively heavy gauge sheet steel and is mounted on eiling **11** of the area to be protected by means of screws 2. Fastened to the element **10** by screws **13** and nuts 4 is a protective cover **15** which may be made of relaively light gauge perforated sheet steel. The purpose of he cover **15** is to provide a degree of protection against ccidental damage for the components contained therein. t is, however, important that the cover present little reistance to the passage of smoke and thus preferably hould be formed from perforated sheet stock having a otal opening area of at least fifty percent of the overall rea. A green transparent jewel **16** and a red transparnt jewel **17** are mounted on the cover **15** by conveniional fastening means. The function of jewels **16** and **17** will be made apparent hereinafter.

Two U-shaped brackets **18** are spot welded to the elenent **10** at points **19**. Screws **20**, which engage tapped oles **21** in brackets **18**, support a panel **22** on which are nounted all of the remaining components. Panel **22** nay conveniently be of a synthetic material having copper circuits printed thereon for the interconnection of the various resistors, relays and transistors which comprise he electrical circuit but have been omitted from FIG. 1 for clarity. A miniature, glass enclosed switch S of the magnetic type is mounted at one edge of panel **22** for circuit testing purposes, as will be described subsequently. A miniature thermostat T, which may be of the snap-disc type, is supported by the protective cover **15**.

A smoke detection chamber, indicated generally as **23**, is mounted centrally on panel **22** by screw **24**, which engages a tapped hole **25** in an extension member **26** formed as an integral part of central portion **27** of the smoke chamber **23**, whose basic construction is best seen in FIG. 2. The central portion **27** is primarily a rectangular box, two of whose opposing longer sides are open. Each of these open sides is provided with a cover unit **28** having a flange **29** whose periphery is substantially greater than the corresponding periphery of central portion **27**. Spacer projections **30** formed as an integral part of central portion **27** serve to space the cover units **28** apart from central portion **27** in such manner that two smoke entry ports **31** are established around the entire periphery of the chamber. The covers **28** may be fastened to central portion **27** in conventional manner by means of screws and tapped holes not shown in the drawings. The outermost sides of cover units **28** are open and are provided with spacer projections **32**.

Two additional smoke entry ports **33** are established in similar manner by cap units **34** and **35**, which cover the open sides of the cover units **28** and which may be fastened by screws and tapped holes not shown in the drawings. The cap unit **34** is blind and serves to seal off that side of the chamber from ambient light. Cap unit **35**, however, is provided with a central tubular portion **36** to serve as a holder for a photocell **37** which is locked in place by a set screw **38**.

The sensitivity of response of the unit may be varied to meet the requirements of special installations by loosening set screw **28** and moving the cell **37** back and forth in tube **36** as required. For ordinary service, the cell **37** will remain as assembled at the factory. One side (the left in FIG. 1) of the tip of tubular portion **36** protruding into the chamber is tapered at approximately 45° in the vertical plane. The untapered portion serves to shade the photocell **37** from direct exposure to the light beam from a midget lamp **39**. The tapered portion increases the exposure of the photocell to light reflected from smoke in the chamber. The chamber central portion **27**, cover units **28** and cap units **34** and **35** may all be fabricated conveniently from a light alloy metal by a die casting process.

The optical system is best shown in FIG. 1 and comprises midget lamp **39** with a suitable base **40** mounted on an extending projection **41** of the chamber central portion **27**. Surrounding lamp **39** is an open-ended shroud **42** serving to conduct light to the green jewel **16** which is thereby illuminated to provide an external indication that the detector is in service. An aperture **43** in shroud **42** permits light from lamp **39** to pass through a lens **44** which is secured in the end wall of the chamber central portion **27** by a snap ring **45**. Lens **44** focuses the light from lamp **39** into a beam which travels longitudinally through the chamber and is received in a light trap **46**. Trap **46** is a cylindrical recess in the end wall of chamber portion **47** and serves to suppress excessive reflections of the light beam within the chamber. A lug **47**, projecting externally from the light trap **46** supports a lamp base **48** and a midget lamp **49**. The lamp **49** is positioned adjacent the red jewel **17** which is thereby illuminated to serve as an alarm indication, as will be more fully described hereinafter.

As previously stated, the cross-sectional shape of the light beam is of great importance. The method of controlling the beam shape is illustrated by FIG. 3 wherein the basic components of the optical system are shown as the lamp **39**, the lamp base **40** and lens **44**. The lamp **39** has a filament **50**, essentially of U-shape, which, when incandescent, becomes the source of the light energy comprising the beam formed by lens **44**. If the plane of the filament **50** is parallel to the plane of the opposite wall of the chamber, the image **51** of the filament **50** will be projected as a normally proportioned U on the back wall of light trap **46**. However, if the lamp base **40** is ro-

tated in the horizontal plane, the legs of the U of the image will draw together as the plane of the filament **50** approaches a right angle to the back wall of the chamber. Under this condition, while there is some diffusion of the light by the lens **44**, the brightest and thus most effective portion of the light beam has a vertical dimension far greater than the horizontal width. The vertical dimension should be as large as possible so that the illuminated area of smoke particles seen by the photocell will be maximized and thereby permit the greatest possible amount of light energy to be reflected to the cell.

By thus transposing the normally circular cross section of the beam into a long, narrow rectangle, the present invention provides maximum brilliancy of the beam for a source of given intensity. The brilliancy is obtained without producing troublesome reflections in the chamber (as would result from merely brightening a circular beam) and thus results in an efficient, economical design of great sensitivity of response to the presence of small quantities of smoke.

As a practical matter, the lamp **39** should not be adjusted so that image **51** appears as the narrowest possible line because one leg of filament **50** would then be directly in front of the other leg and thus would block the emission of light energy from the first leg. Optimum efficiency is obtained by rotating the lamp base **40** until the legs of the image **51** just appear to touch. FIG. 3 has been distorted intentionally in this respect to illustrate more clearly the principle rather than to accurately depict the desired adjustment. Those skilled in the art will recognize that a rectangular beam could be formed by inserting a slotted diaphragm in the light path. However, so doing will not provide the concentrated brilliance that is obtained by adjustment of the lamp filament, as described.

The geometry of the chamber construction is also of importance to the performance of the detector. The chamber is made rectangular in shape with the entry ports extending around the longer perimeter, since so doing results in the most efficient design, i.e., the longest entry ports per unit volume of occupied space. The flat exterior bottom of the chamber is located above the horizontal portion of entry ports **31** to take advantage of natural smoke flow patterns. The wavy arrows shown in FIG. 2 represent smoke rising from a fire condition of some nature. After a virtually unimpeded passage through the perforated protective cover **15**, the smoke encounters the flat areas of the chamber and is deflected laterally into the entry ports **31** and **33**. Since the entry ports extend completely around the chamber, smoke which is spreading laterally from a source not directly under the detector finds ready access to the chamber through the vertical sections of entry ports **31** and **33**. Once in the chamber, the smoke, as it continues to rise, departs via the upper horizontal sections of the ports. It is important that the exit portions of ports **31** and **33** be kept a reasonable distance below the panel **22** to prevent the build-up of back pressures which might impede the passage of heated air and smoke through the chamber. The unique combination of flat, smoke deflecting surfaces, appropriately designed smoke entry ports, and freedom from back pressure make possible the construction of a particularly efficient and sensitive smoke detection chamber.

The electrical circuit

The electrical circuit of an embodiment of the present invention which is especially adapted for use in commercial establishments, e.g., factories, offices, stores, etc., is shown in FIG. 4. A central station **60** is connected to a code transmitter **61** at protected premises **62** by a telephone pair or similar wire connection **63**. Typically, the lines **63** may be as much as twenty miles in length and may pass through several telephone exchanges. As is well known in the art, a number of code transmitters may be connected in series by lines **63**. The code transmitter **61** contains two relays whose windings B and G are connected in series with wire loops A and B, which serve to connect individual smoke detector units to the code transmitter **61**. A source of potential (not shown) causes a supervisory current to flow through loops A and B, and the relays are so designed that relay B is normally energized and relay G is not energized by the supervisory current. A code originating mechanism, also not shown but which may be of well known construction, is arranged to be operated by the functioning of either of relays B or G to transmit a coded signal to the central station to identify the particular premises. The signals produced by operation of relays B and G will also be distinctive, as by the number of times the code signal is repeated, so that the central station operator may determine which of the two relays has operated. Those skilled in the art will recognize that the circuit thus far described is so conventional as to require no further exposition.

Only one smoke detector is illustrated in detail in FIG. 4, although contacts for three detectors are included in loops A and B, as will be described below. The internal circuitry of an individual smoke detector comprises a number of parallel circuits connected to a source of voltage **64** (which typically might be a 12 volt battery) by means of conductors **65** and **66** which are connected to the positive and negative battery terminals, respectively. The negative terminal of the battery **64** is grounded at **67**. One of the circuits comprises, in series connection, a resistor R1, winding TR of the trouble relay and the filament of the lamp **39**. Lamp **39** serves primarily as the light source for the smoke detection chamber; a portion of the light, however, is directed by the shroud **42** to the green jewel **16** (FIG. 1) which is illuminated thereby to serve as an indication that the unit is in service. Resistor R1 and winding TR are shunted by normally open contacts S1 of the magnetically operated switch S and, as will be further explained hereinafter, may also be shunted by a conductor **68** which includes a normally open push button switch **69**. Conductor **68** and switch **69** may be omitted. Typical values for certain circuit elements are shown in FIG. 4 (and also FIG. 5), but these are representative only and should not be taken as in any way limiting the scope of the invention.

Another series circuit connected between conductors **65** and **66** comprises a resistor R2 and the photocell **37**, which might conveniently be of the CL604L type manufactured by the Clairex Corporation. The function of photocell **37'**, in parallel with cell **37**, is explained below with regard to the species of FIGURE 2*a*. This photocell is omitted in the species of FIGURE 2. The cell is of the photoconductive type, i.e., the internal electrical resistance is varied by the incidence of light upon the cell and is characterized by having a peak response embracing the portion of the spectrum containing both visible light and infrared energy. The junction of resistor R2 and cell **37** is connected to the base of a transistor T1 which might be of the TI495 type manufactured by Texas Instruments, Incorporated. The collector of transistor T1 is coupled to conductor **65** through a resistor R3, while the emitter is coupled to conductor **66** through a resistor R4. The junction of resistor R3 and the collector of transistor T1 is coupled to the base of a transistor T2 which might be of the 2N1305 type. The emitter of transistor T2 is coupled to conductor **65** through a resistor R5, and the collector is coupled to conductor **66** through winding AL of the alarm relay. Resistor R5 and transistor T2 are shunted by normally open contacts T1' of the thermostat T. The final circuit between conductors **65** and **66** is formed by the series connection of a resistor R6, the lamp **49** (which illuminates the red jewel **17** under alarm conditions), normally open contacts AL–2 of the alarm relay, and a resistor R7.

Normally open contacts AL–1 of the alarm relay interconnects the transmitter loops A and B in such manner as to shunt the winding B of one of the transmitter

elays. Normally closed contact TR–1 of the trouble elay is included in loop A in such manner that the opening thereof will interrupt the flow of supervisory current through the circuit of transmitter 61. If desired, n annunciator 70, located at some remote point, may e connected between the junction of lamp 39 and contacts AL–2 and a convenient ground shown as 71.

Further smoke detector units may be connected to the ansmitter 61 by connecting the trouble relay contacts R–1', TR–1'', etc., in series with contact TR–1 in loop and the alarm contacts AL–1', AL–1'', etc., in parallel with contact AL–1 between loops A and B.

Operation

Under normal service conditions, current from battery 64 flows through resistor R1, winding TR of the trouble relay, which is thereby energized, and the filament of lamp 39, which is thereby illuminated. The light rom lamp 39 is projected as a narrow beam across he otherwise dark interior of the smoke chamber. While he lamp 39 will be of a type normally rated for service t the voltage of battery 64, e.g., 12 volts, the combined esistance of resistor R1 and the winding TR will reduce he potential at the lamp filament to approximately nine nd a half volts. The filament, therefore, does not chieve normal, full brilliancy and the output of energy n the infrared range is accordingly increased. The light eam is thus composed of a mixture of visible and infraed energy which corresponds to the peak response of he photocell 37, thereby providing maximum efficiency f energy transfer. Furthermore, under alarm conditions, infrared energy penetrates the smoke-filled chamber more readily than visible light and thus facilitates he transfer of energy to the photocell, a distinct advantage of the present invention over detectors relying primarily on visible light. An incidental advantage is that he service life of the lamp 39 is prolonged by operation at less than rated voltage.

When smoke, rising by means of natural convection currents or spreading laterally under the influence of air currents, enters the chamber, the smoke particles reflect a portion of the light from the beam onto the cell 37. The incidence of light upon the cell 37 reduces the electrical resistance thereof resulting in an increase in the current flowing through the branch of the circuit containing cell 37 and resistor R2. The corresponding increase in potential across resistor R2 causes the base-emitter bias of transistor T1 to become more positive and collector current flows through resistor R3. The potential thus appearing across resistor R3 causes a negative bias at the base of transistor T2 which then conducts through the emitter-collector circuit. The current is sufficient to energize the winding AL of the alarm relay located in the collector circuit of transistor T2. Contact AL–1 now closes to directly interconnect loops A and B of the transmitter 61. The resistance of winding B is thereby removed from the transmitter circuit and the resulting increase in the supervisory current causes the energization of winding G and the transmission of a coded alarm signal to the central station 60 in the conventional manner. Simultaneously, contact AL–2 closes to apply operating potential from conductors 65 and 66 to the lamp 49 thereby causing the red jewel 17 to become illuminated. The closure of contact AL–2 will also provide operating potential for an annunciator 70 as would usually be provided external to large premises having a number of detectors in service as an aid to the personnel investigating the alarm signal.

In the event of an abnormal heat condition occurring in the protected premises unaccompanied by smoke, the thermostat T will close its normally open contact when a predetermined temperature has been attained at the detector unit. The closing of the thermostat contact applies operating potential from conductor 65 directly to the winding AL of the alarm relay which is thus energized and closes contacts AL–1 and AL–2 to provide alarm indications in the manner previously described. The thermostat T would ordinarily be of the type operating at a temperature of 135° F. It is, however, obvious that a thermostat operating at any desired temperature could be substituted readily to meet the requirements of any unusual installation.

Regardless of whether the alarm was originated by the presence of smoke or heat, the system is restored automatically to the normal condition by the removal of the alarm producing factor. When the smoke is cleared from the chamber, light will no longer be reflected upon the cell 37 and the resistance thereof will return to the normal value. The biasing potentials are thus removed from transistors T1 and T2; therefore transistor T2 will no longer conduct through the emitter-collector circuit and winding AL of the alarm relay becomes de-energized, thereby returning contacts AL–1 and AL–2 to the normal open position. Similarly, a reduction in the ambient temperature will open the contact of the thermostat T to de-energize winding AL of the alarm relay. Manual reset of the alarm indicating devices at the annunciator 70 and at the central station 60 may be required depending upon whatever type of conventional apparatus has been provided at these locations.

The trouble relay, whose winding TR is connected in series with the filament of the light source lamp 39, provides continual supervision of the light source. Should the lamp 39 be extinguished by reason of a power failure, filament failure, or the failure of some related circuit component, the winding TR of the trouble relay will become de-energized and contact TR–1 will open. Supervisory current will therefore cease to flow in the transmitter circuit, causing the de-energization of winding B in the transmitter 61 and the transmission of an appropriate distinctive trouble signal to the central station 60, as is well known in the art. Local indication of the extinguishment of lamp 39 is provided by the consequent darkening of the green jewel 16. It will also be evident to those skilled in the art that the sensitivity of response of the trouble relay may be varied at will by the proper selection of resistor R1 so that a trouble signal may be obtained when the power supply voltage has decreased to a predetermined value rather than a complete outage.

As mentioned above, the sensitivity of response may be varied by shifting the photocell 37 longitudinally in the tube 36. Moving the cell toward the center of the smoke chamber increases the sensitivity because the angle of vision of the cell 37 is increased and thereby permits a greater amount of light energy to reach the cell. The change in sensitivity which may be thus accomplished is obviously somewhat limited.

FIG. 2*a*, however, illustrates a means whereby significantly large changes in sensitivity may be achieved. In FIG. 2*a* the blind cap unit 34 of FIG. 2 is replaced by a second cap unit 35'. A second photocell 37' is added to the device to view the light beam from the side opposite to the first cell. Cell 37' is connected in parallel with cell 37 between the base of transistor T1 and conductor 65. The addition of the second cell will approximately double the sensitivity of the response of the unit since twice as much light energy is being coupled into the response circuit. Further increases in sensitivity may be obtained by the addition of still further cells, connected in parallel, since more and more of the smoke particle reflected light may thus be utilized. It is, of course, necessary that all cells be shielded from direct exposure to the light emerging from lens 44.

Test procedure

While supervision of the light source lamp 39 is obtained by means of the trouble relay as described above, it is also desirable that means be provided to ascertain the operability of the detection circuit proper. The magnetic switch S, which might conveniently be of the

miniature, glass-enclosed, reed type, has therefore been provided in a shunt path around the resistor R1 and winding TR of the trouble relay. The switch is normally open, but may be closed by means of permanent magnet M held adjacent the protective cover 15 when a test is to be made. The resultant closure of the switch S shunts the resistor R1 and winding TR thereby applying the full potential of the source 64 to the lamp 39. The consequent brightening of lamp 39 produces random light reflections in the chamber simulating those produced by smoke particles, and these reflections falling upon the photocell 37 cause the device to generate an alarm signal in the manner hereinbefore described. When the detector is mounted on a high ceiling or other relatively inaccessible place, the magnet M may conveniently be affixed to a long pole. Alternatively, normally open push button switch 69 may be installed at some suitable remote location and connected to shunt the resistor R1 and winding TR by means of conductor 68. Manual operation of the switch 69 will accomplish the same result as magnetic operation of the switch S.

Modification for residential use

The design of a smoke detector according to the invention adapted primarily for residential use differs from the commercial design primarily in that there is no connection to a central station, a local sounding device being provided to annunciate alarm signals. Also, it is desirable that provision be made for operation from 115 volt alternating current, as is usually available in private homes. FIG. 5 is a schematic diagram of the electrical circuit of the residential design and differs from the commercial design of FIG. 4 in the above details. In addition, FIG. 5 also illustrates an alternative arrangement for testing the operability of the detector, and provision has been made for the incorporation of a "flash" detector. Those skilled in the art will recognize that the alternate test arrangement and the "flash" detector could readily be included in the commercial design of FIG. 4. The residential design does not include a trouble relay or visual alarm indicator, but does make use of all the basic hardware and principal features of the commercial design. Those components common to the two designs have been designated by like numerals in the figures.

The residential design comprises a base element 10, a protective cover 15 and a panel 22 which supports a smoke chamber 23, all as previously described in connection with FIG. 1. Referring now to FIG. 5, numeral 72 represents a male plug for connection to a conventional source of 115 volt alternating current. The majority of the components of the internal circuitry of the unit are connected between a pair of conductors 65′ and 66′. Conductor 66′ is connected directly to the plug 72, whereas conductor 65′ is connected to plug 72 through a rectifier REC1, which might be a diode of the IN2070 type, and a resistor R10. The junction of resistor R10 and rectifier REC1 is coupled to conductor 66′ through a resistor R11 and a parallel branch circuit containing the light source lamp 39. The other terminal of rectifier REC1 is coupled to conductor 66′ through a capacitor C1. Another branch circuit between conductors 65′ and 66′ is composed of the series connection of a resistor R12, a light actuated switch 73, a test lamp 74, and a remotely located test switch 69. The test lamp 74 may conveniently be a miniature size incandescant lamp of the same type used as the light source 39. The light actuated switch 73, which might be of the L7F type manufactured by the General Electric Company, is a combination of a photoelectric cell and a transistor so arranged that when light falls upon the cell the transistor will conduct and thus is employed as a switching element responsive to the presence of light.

As in the FIG. 4 form of the detector, the photocell 37 is connected in series with resistor R2 between the conductors 65′ and 66′. The junction of photocell 37 and resistor R2 is connected to the base of transistor T1, whose collector is coupled to conductor 65′ through resistor R3, and whose emitter is coupled to conductor 66′ through a resistor R4. Another photocell 75, which may be similar to photocell 37, is connected between conductor 65′ and the base of transistor T1. Photocell 75 serves to detect the flame of a smokeless fire and is thus mounted on the protective cover 15 in a manner similar to the mounting of thermostat 54 shown in FIG. 1, except that a red filter glass 76 is provided to shield the photocell 76 from ordinary ambient light and yet transmit the infrared energy of a flame.

The junction of the collector of transistor T1 and resistor R3 is connected to the base of transistor T2, whose emitter is coupled to conductor 65′ through the resistor R5 and whose collector is coupled to conductor 66′ through the winding AL of the alarm relay. The thermostat T is connected between conductor 65′ and the junction of the collector of transistor T2 and winding AL. An electrically operated horn 77 is connected on one side to conductor 66′ through the normally open contacts AL–3 of the alarm relay and to the plug 72 on the other side by means of a conductor 78.

Operation

When the device of FIG. 5 is connected to a source of 115 volt alternating current, resistors R10 and R11 act as a voltage divider to supply approximately nine volts A.C. to the light source lamp 39, which is thereby illuminated. Current flowing through conductor 65′ is rectified by the half wave rectifier REC1 and the resulting ripple is smoothed by the capacitor C1. The alarm relay winding AL is de-energized, since transistor T2 is not conducting.

When smoke enters the chamber 23, light is reflected onto the photocell 37 in the manner previously described. Also, as before, the resultant decrease in the resistance of cell 37 changes the bias on transistor T1, causing it to conduct through the emitter-collector circuit, which in turn causes transistor T2 to conduct through the emitter-collector circuit and energize winding AL of the alarm relay. The closure of contact AL–3 completes the circuit to horn 77 and the sounding thereof provides a warning of the presence of smoke in the protected area. The thermostat T also operates as previously described, closing its normally open contacts T1 when subjected to the rated temperature to energize the alarm relay and sound horn 77.

Should visible flame occur unaccompanied by smoke, infrared energy passing the filter 76 will fall on photocell 75, causing the resistance thereof to decrease. Transistors T1 and T2 will then function to sound horn 77 in the manner above described.

Test procedure

Referring now to FIG. 6, there is shown the light actuated switch 73 mounted in the light trap 46 in such manner as to receive the light beam projected from the light source 39 via the lens 44. Also located within the chamber 23 is the test lamp 74 which is situated so that its rays will fall directly on the photocell 37. The light actuated switch 73, test lamp 74 and the remotely located push button switch 69 are in series connection between the power conductors 65′ and 66′ (FIG. 5), and the light from the source 39 holds the light actuated switch 73 in the conducting condition. A test is made by momentarily closing the push button switch 69 to complete the circuit to the test lamp 74. Light from the lamp 74 falls directly on the photocell 37, resulting in the sounding of horn 77 in the manner hereinbefore described. However, should the light beam be misaligned, of low intensity or obscured in some way, the light actuated switch will not be in the conducting condition and the test will fail.

While the method of testing described in conjunction with the FIG. 4 form of the smoke detector assures the operability of the light source and the integrity of the electrical circuitry, the method described in connection

vith FIG. 5 also accomplishes these ends and further provides important information regarding the state of the ight beam. For instance, smoke and dust accumulations on the surfaces of the lens and photocell could render he unit insensitive under normal operating conditions yet capable of response to the brighter light used for testng. The same situation could also arise from beam misalignment caused by building vibrations, low voltage at the power supply, and mechanical interference caused by the nests of insects. The use of the light actuated switch in he test circuit guards against such contingencies and also provides a means of establishing sensitivity levels since switches of various operating points may be selected or the light falling upon the switch may be controlled by means of an interposed diaphragm having an aperture of desired size.

While the invention has been described in connection with specific embodiments thereof, various modifications will occur to those skilled in the art without departing from the spirit and scope of the invention as set forth in the appended claims.

What is claimed is:

1. A fire detecting device, comprising:

(1) a smoke detection chamber, comprising:

(a) a hollow generally rectangular box having closed opposing top and bottom walls and closed opposing end walls and having substantially open opposing side walls;

(b) a first pair of cover elements mounted on said box and each spaced from and covering a respective one of said side walls, each of said cover elements having inwardly extending flanges spaced from and overlying said top, end and bottom walls, respectively, to provide a first set of ports for the entry and exit of smoke from the interior of said box, the edges of said flanges of said first cover elements extending inwardly of the edges of said top and bottom walls to prevent the entry of ambient light into the interior of said box through the ports of said first set, said cover elements of said first pair having a second pair of spaced outwardly extending flanges forming sideward open-ended extensions of said box; and

(c) a second pair of cover elements mounted, respectively, on the cover elements of said first pair and each covering a respective one of said open-ended extensions and having inwardly extending flanges spaced from and overlying the respective flanges of said second pair of flanges of said first cover elements to provide a second set of ports for the entry and exit of smoke from the interior of said box, the edges of said flanges of said second cover elements extending inwardly of the edges of said respective flanges of said second pair of flanges of said first cover elements to prevent the entry of ambient light into the interior of said box through the ports of said second set;

(2) means to direct a narrow substantially rectangular cross-sectioned beam of light across the interior of said box;

(3) a photocell;

(4) means to mount said photocell in optical communication with the interior of said box but shielded from direct exposure to said light beam; and

(5) circuit means coupled to said photocell and arranged to produce an alarm signal indication when light from said beam is reflected from smoke particles in said box and onto said photocell.

2. A fire detecting device, comprising:

(1) a smoke detection chamber, comprising:

(a) a hollow generally rectangular box having closed opposing top and bottom walls and closed opposing end walls and having substantially open opposing side walls;

(b) a first pair of cover elements mounted on said box and each spaced from and covering a respective one of said side walls, each of said cover elements having inwardly extending flanges spaced from and overlying said top, end and bottom walls, respectively, to provide a first set of ports for the entry and exit of smoke from the interior of said box, the edges of said flanges of said first cover elements extending inwardly of the edges of said top and bottom walls to prevent the entry of ambient light into the interior of said box through the ports of said first set, said cover elements of said first pair having a second pair of spaced outwardly extending horizontal flanges forming sideward open-ended extensions of said box; and

(c) a second pair of cover elements mounted, respectively, on the cover elements of said first pair and each covering a respective one of said open-ended extensions and having inwardly extending horizontal flanges spaced from and overlying the respective flanges of said second pair of flanges of said first cover elements to provide a second set of ports for the entry and exit of smoke from the interior of said box, the edges of said flanges of said second cover elements extending inwardly of the edges of said respective flanges of said second pair of flanges of said first cover elements to prevent the entry of ambient light into the interior of said box through the ports of said second set;

(2) means to direct a narrow substantially rectangular beam of light across the interior of said box from a wall of one of said pairs to the opposing wall;

(3) a detecting element, comprising:

(a) a long narrow tube having an open end;

(b) means to mount said tube with said open end extending through one of the walls of another of said pairs of walls into said box and with said open end positioned to shield the interior of said tube from said beam of light; and

(c) a photocell mounted in said tube at a point spaced from said tip; and

(4) circuit means coupled to said photocell and arranged to produce an alarm signal indication when light from said beam is reflected from smoke particles in said box and onto said photocell.

3. A fire detecting device, comprising:

(1) a smoke detection chamber, comprising:

(a) a hollow generally rectangular box having closed opposing top and bottom walls and closed opposing end walls and having substantially open opposing side walls, said open side walls being longer than said end walls;

(b) a first pair of cover elements mounted on said box and each spaced from and covering a respective one of said side walls, each of said cover elements having inwardly extending flanges spaced from and overlying said top, end and bottom walls, respectively, to provide a first set of ports for the entry and exit of smoke from the interior of said box, the edges of said flanges of said first cover elements extending inwardly of the edges of said top and bottom walls to prevent the entry of ambient light into the interior of said box through the ports of said first set, said cover elements of said first pair having a second pair of spaced outwardly extending horizontal flanges forming sideward open-ended extensions of said box; and

(c) a second pair of cover elements mounted, respectively, on the cover elements of said first pair and each covering a respective one of said open-ended extensions and having inwardly ex-

tending horizontal flanges spaced from and overlying the respective flanges of said second pair of flanges of said first cover elements to provide a second set of ports for the entry and exit of smoke from the interior of said box, the edges of said flanges of said second cover elements extending inwardly of the edges of said respective flanges of said second pair of flanges of said first cover elements to prevent the entry of ambient light into the interior of said box through the ports of said second set;

(2) a lens mounted in one end wall of said box;

(3) a light trap in the opposite end wall of said box;

(4) an incandescent lamp having a U-shaped filament and means to mount said lamp outside of said box and adacent said lens so that said lens projects an image of said filament in said light trap, said filament being positioned so that the legs of the U of said projected image thereof nearly, but not exactly, overlap whereby the beam of light from said lamp passing through said box has a cross section of a long, narrow rectangle;

(5) a detecting element, comprising:

(a) a long narrow tube having an open end with a tip tapered in a vertical plane;

(b) means to mount said tube with said open end extending through one of said side walls into said box and with said tapered tip positioned to shield the interior of said tube from said beam of light; and a photocell mounted in said tube at a point spaced from said tip, said mounting of said photocell being adjustable to permit said photocell to be moved axially with respect to said tip; and

(6) circuit means coupled to said photocell and arranged to produce an alarm signal indication when light from said beam is reflected from smoke particles in said box and onto said photocell.

4. A fire detecting device as set forth in claim **3** in which said circuit means includes an energizing circuit for said lamp and means in said energizing circuit for decreasing the voltage supplied to said lamp substantially below the rated voltage of said lamp whereby a substantial proportion of the energy in said light beam is in the infrared range.

5. A fire detecting device as set forth in claim **3** in which said circuit means includes an energizing circuit for said lamp and means to produce a trouble signal upon failure of said lamp and upon failure of the energizing voltage for said lamp.

6. A fire detecting device, comprising:

(1) a hollow container having a multiplicity of openings affording free passage of smoke into said container;

(2) means to mount said container adjacent an upper surface of a space to be protected;

(3) a smoke detection chamber, comprising:

(a) a hollow generally rectangular box having closed opposing top and bottom walls and closed opposing end walls and having substantially open opposing side walls, said open side walls being longer than said end walls;

(b) a first pair of cover elements mounted on said box and each spaced from and covering a respective one of said side walls, each of said cover elements having a first pair of inwardly extending flanges spaced from and overlying said top, end and bottom walls, respectively, to provide a first set of ports for the entry and exit of smoke from the interior of said box, the edges of said flanges of said first cover elements extending inwardly of the edges of said top and bottom walls to prevent the entry of ambient light into the interior of said box through the ports of said first set, said cover elements of said first pair each having a second pair of spaced outwardly extending horizontal flanges forming sideward open-ended extensions of said box; and

(c) a second pair of cover elements mounted, respectively, on the cover elements of said first pair and each covering a respective one of said open-ended extensions and having inwardly extending horizontal flanges spaced from and overlying the respective flanges of said second pair of flanges of said first cover elements to provide a second set of ports for the entry and exit of smoke from the interior of said box, the edges of said flanges of said second cover elements extending inwardly of the edges of said respective flanges of said second pair of flanges of said first cover elements to prevent the entry of ambient light into the interior of said box through the ports of said second set;

(4) means to mount said box within said container and with said ports all spaced a substantial distance beneath any overlying horizontal surface to prevent back pressure from impeding the passage of smoke through said ports;

(5) a lens mounted in one end wall of said box;

(6) a recess in the opposite end wall of said box and forming a light trap;

(7) an incandescent lamp having a U-shaped filament and means to mount said lamp outside of said box and adjacent said lens so that said lens projects an image of said filament in said light trap, said filament being positioned so that the legs of the U of said projected image thereof nearly, but not exactly, coincide whereby the beam of light from said lamp passing through said box has a cross section of a long, narrow rectangle;

(8) a detecting element, comprising:

(a) a long narrow tube having an open end with a tip tapered in a vertical plane;

(b) means to mount said tube with said open end extending through one of said side walls into said box and with said tapered tip positioned to shield the interior of said tube from said beam of light; and a photocell mounted in said tube at a point spaced from said tip, said mounting of said photocell being adjustable to permit said photocell to be moved axially with respect to said tip; and

(9) circuit means coupled to said photocell and arranged to produce an alarm signal indication when light from said beam is reflected from smoke particles in said box and onto said photocell.

7. A fire detecting device, comprising:

(1) a smoke detection chamber formed as a hollow, generally rectangular box having opposing top and bottom walls, opposing side walls and opposing end walls, said side walls having labyrinth openings adjacent said top and bottom walls forming ports for the entry and exit of smoke from said box but arranged to exclude ambient light from entering said box through said ports, one end wall of said box having a recess forming a light trap;

(2) a lens mounted in the other end wall of said box;

(3) an incandescent lamp mounted outside of said box adjacent and in alignment with said lens and having an elongated U-shaped filament, said lamp being arranged so that a beam of light from said lamp passes successively through said lens and said box and into said light trap, said lens projecting an image of said filament on the wall of said light trap, said lamp being arranged so that the legs of the U of said projected image of said filament nearly, but not exactly, coincide whereby said beam of light passing through said box has a cross section consisting of a long, narrow rectangle;

(4) a detecting element comprising a photocell and means to mount said photocell so as to be shielded from direct exposure to said light beam but so as to be exposed to light reflected from smoke particles in said box; and

(5) circuit means coupled to said photocell and arranged to produce an alarm signal indication when light from said beam is reflected from smoke particles in said box and onto said photocell.

8. A fire detecting device, comprising:

(1) a smoke detection chamber formed as a hollow, generally rectangular box having opposing top and bottom walls, opposing side walls and opposing end walls, said side walls having labyrinth openings adjacent said top and bottom walls forming ports for the entry and exit of smoke from said box but arranged to exclude ambient light from entering said box through said ports, one end wall of said box having a recess forming a light trap;

(2) a lens mounted in the other end wall of said box;

(3) a shroud mounted externally of said other end wall of said box and having an opening aligned with said lens;

(4) an incandescent lamp having an elongated U-shaped filament mounted in said shroud so that a beam of light from said lamp passes successively through said opening, said lens and said box and into said light trap, said lens projecting an image of said filament on the wall of said light trap, said lamp being arranged so that the legs of the U of said projected image of said filament nearly, but not exactly, coincide, whereby said beam of light passing through said box has a cross section consisting of a long, narrow rectangle;

(5) a detecting element, comprising:

(a) a long narrow tube having an open end with a tip tapered in a vertical plane;

(b) means to mount said tube with said open end extending through one of said side walls into said box and with said tapered tip positioned to shield the interior of said tube from said beam of light; and a photocell mounted in said tube at a point spaced from said tip; and

(6) circuit means coupled to said photocell and arranged to produce an alarm signal indication when light from said beam is reflected from smoke particles in said box and onto said photocell.

9. A fire detecting device as set forth in claim 8, in which said circuit means includes a source of energizing potential for said lamp, a resistive element intercoupling said source and said lamp to reduce the voltage applied to said lamp below the voltage value of said source, and externally operable switch means for shunting said resistive element thereby to apply full source potential to said lamp, said full source potential being sufficient that the illumination provided by said lamp under said full source potential produces light reflections in said box substantially simulating light reflections from smoke particles.

10. A fire detecting device as set forth in claim 9 in which said switch means comprises contacts arranged to close when subjected to a magnetic field of at least a selected strength.

11. A fire detecting device as set forth in claim 8, comprising an additional light source mounted in said box and arranged, when energized, to illuminate said photocell, externally operable means for energizing said additional light source, and a light actuated switch positioned in said box in the path of said light beam from said incandescent lamp and intercoupling said switch and said additional light source, said light actuated switch being constructed and arranged to be open except when illuminated by light energy corresponding to proper operation of said lamp.

12. A fire detecting device as set forth in claim 8, comprising an additional photocell, means to mount said additional photocell on said device so as to be in optical communication with the space to be protected by said device, red filter means positioned adjacent said additional photocell and arranged to shield the latter from ordinary ambient illumination not characteristic of a fire, and means to couple said additional photocell to said circuit means so that illumination of said additional photocell by a fire will operate said circuit means to produce an alarm signal indication.

13. A fire detecting device as set forth in claim 8, comprising a fixed temperature thermostatic switch coupled to said circuit means and arranged to operate the latter to produce an alarm signal indication when said thermostatic switch is exposed to a temperature at least equal to said fixed temperature.

14. A fire detecting device, comprising:

(1) a smoke detection chamber formed as a hollow, generally rectangular box having opposing top and bottom walls, opposing side walls and opposing end walls, said side walls having labyrinth openings adjacent said top and bottom walls forming ports for the entry and exit of smoke from said box but arranged to exclude ambient light from entering said box through said ports, one end wall of said box having a circular recess forming a light trap;

(2) a lens mounted in the other end wall of said box;

(3) a shroud mounted externally of said other end wall of said box and having an opening aligned with said lens;

(4) an incandescent lamp having an elongated U-shaped filament mounted in said shroud so that a beam of light from said lamp passes successively through said opening, said lens and said box and into said light trap, said lens projecting an image of said filament on the wall of said light trap, said lamp being arranged so that the legs of the U of said projected image of said filament nearly, but not exactly, coincide, whereby said beam of light passing through said box has a cross section consisting of a long, narrow rectangle;

(5) a detecting element, comprising:

(a) a pair of long narrow tubes each having an open end with a tip tapered in a vertical plane;

(b) means to mount said tubes with said open ends extending through respective ones of said side walls into said box and with said tapered tips positioned to shield the interior of said tubes from said beam of light; and a pair of photocells each mounted in a respective one of said tubes at a point spaced from said tip thereof; and

(6) circuit means coupled to said photocells and arranged to produce an alarm signal indication when light from said beam is reflected from smoke particles in said box and onto either or both of said photocells.

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