July 4, 1950 C. N. CAHUSAC ET AL 2,513,283

PHOTOELECTRIC CONVECTION SMOKE DETECTOR

Filed Sept. 28, 1946 2 Sheets-Sheet 1

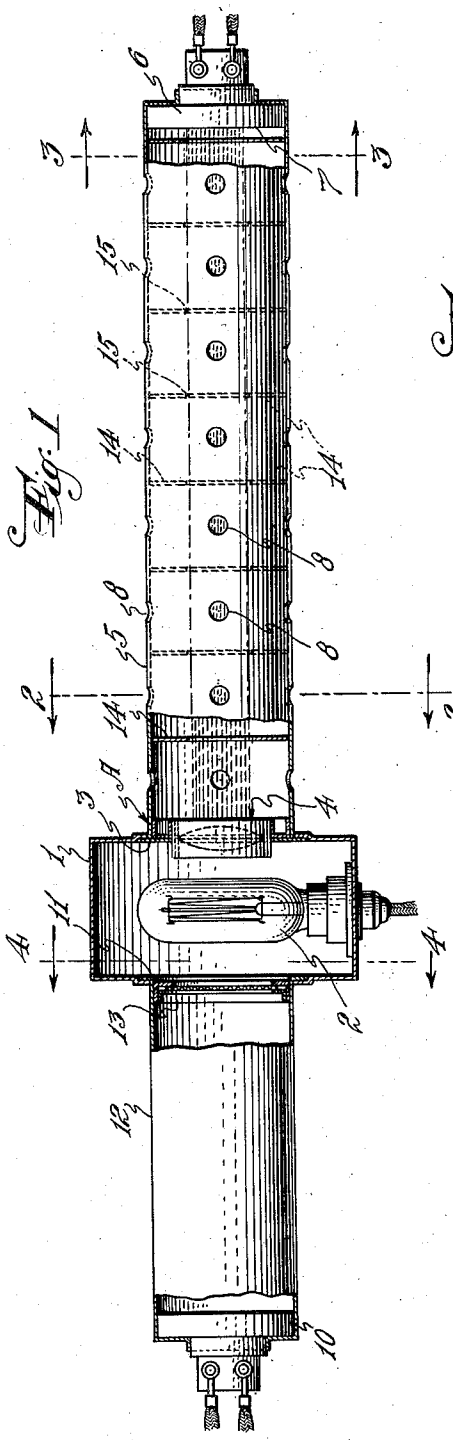


Fig. 1

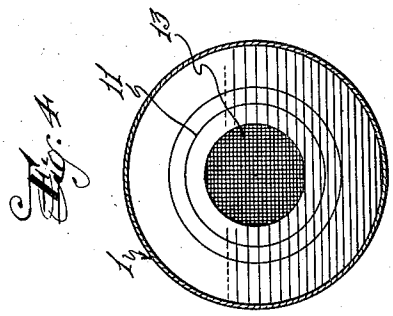


Fig. 4

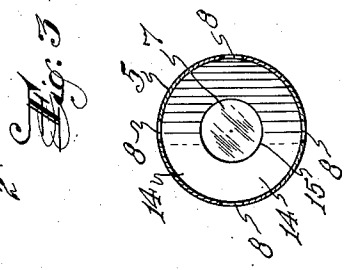


Fig. 3

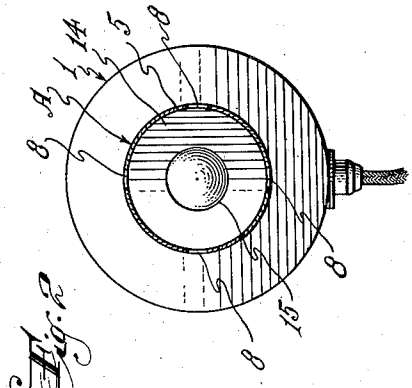


Fig. 2

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Fig. 5

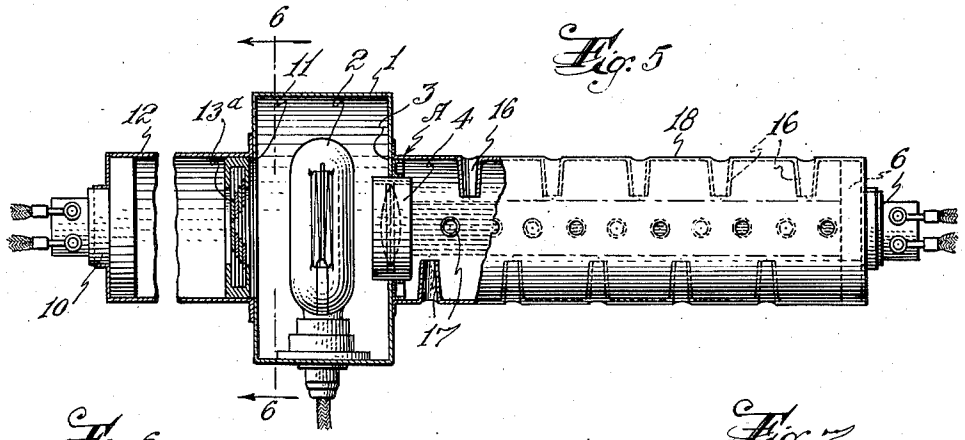


Fig. 6

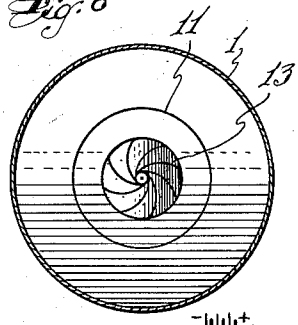


Fig. 7

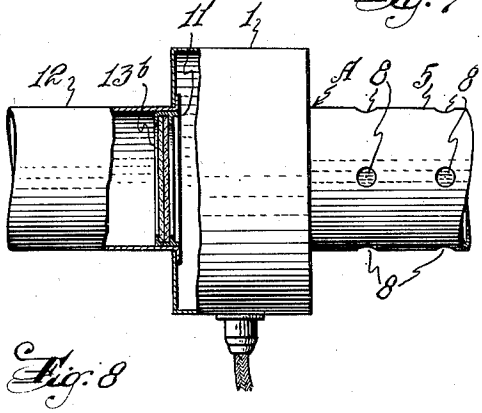
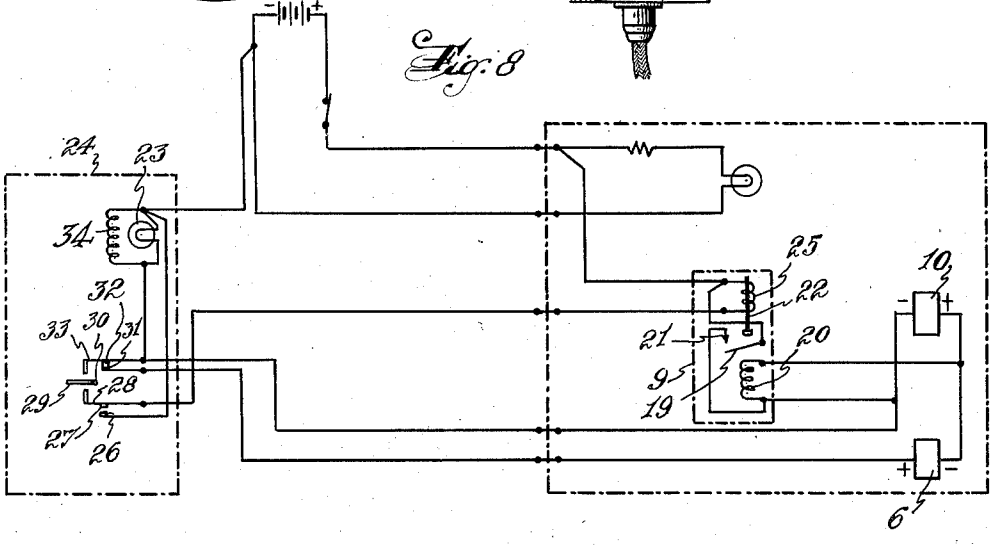


Fig. 8



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UNITED STATES PATENT OFFICE

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PHOTOELECTRIC CONVECTION SMOKE DETECTOR

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Application September 28, 1946, Serial No. 700,052

5 Claims. (Cl. 250—218)

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This invention relates in general to apparatus for detecting and announcing the existence at a point remote from the apparatus of a fluid having particles of matter suspended therein such as smoke; more particularly, the invention contemplates such apparatus which is especially adapted for detecting the presence of smoke in the various compartments or rooms of airplanes, ships, railway cars, and buildings, and producing a signal, for example, on the instrument board of an airplane, to ensure immediate warning of fires and prompt action to extinguish them.

The invention especially contemplates smoke detectors of the type wherein the detector unit is located in the space being protected and smoke from such space is conducted through the casing of the detector in which is located apparatus responsive to the presence of the smoke, for example, smoke detectors which include means for producing a beam of light, means for conducting a stream of smoke into said beam, and a photoelectric element located to be permanently illuminated by said light beam so that when fluid having particles of matter suspended therein passes through said light beam the illumination of the photoelectric element is weakened. The photoelectric element is connected in an electric circuit with another photoelectric element and an electrical responsive device whereby the photoelectric effects of the second-mentioned element opposes the photoelectric effects of the first-mentioned element so that said electrical responsive device is actuated, for example, to produce an audible or visible signal when smoke is present in the light beam.

A prime object of the present invention is to provide a smoke detector of the character described wherein the smoke shall be caused to flow directly from the protected space through the casing of the detector by thermal circulation, and the provision of a novel and improved means for permitting free flow of the smoke through the casing and at the same time preventing entry of light from outside the casing into the casing in such a manner as to affect the photoelectric elements.

The smoke detector embodying our present invention is of the light-blocking type, that is, the fluid containing the suspended matter, such as smoke, passes between the light source and the photoelectric element so as to partially block the projection of the light rays from the light source upon the photoelectric element, as contrasted with another type of smoke detector wherein the light is reflected from the source

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upon the photoelectric element from suspended particles of matter in the fluid.

Other objects are to provide in such a smoke-detecting apparatus a novel and improved construction, combination and arrangement of a casing, a light source, a photoelectric element and means for protecting the photoelectric element against the effects of light outside of the casing; and to obtain other advantages and results that will be brought out by the following description in conjunction with the accompanying drawings in which:

Figure 1 is a schematic view, with portions shown in side elevation and other portions shown in vertical longitudinal section, of the apparatus embodying our invention;

Figure 2 is a transverse vertical sectional view on the plane of the line 2—2 of Figure 1;

Figure 3 is a similar view on the plane of the line 3—3 of Figure 1;

Figure 4 is a transverse vertical sectional view on the line 4—4 of Figure 1;

Figure 5 is a view similar to Figure 1 showing a modification of the invention;

Figure 6 is a fragmentary view similar to Figure 4, showing a modification.

Figure 7 is a fragmentary vertical longitudinal sectional view showing a modification of the invention; and

Figure 8 is a wiring diagram of the detecting and signaling circuit.

Specifically describing the embodiment of the invention illustrated in Figures 1 to 4 inclusive, the reference character A generally designates the casing of the smoke-detecting unit which includes a compartment 1 in which is mounted a light source 2 such as an incandescent lamp. One wall of the compartment 1 has an opening 3 in which is arranged with a smoke-tight fit a suitable lens system 4 through which the light rays from the lamp 2 are directed through a tubular and preferably cylindrical testing compartment 5, so that said rays (represented by broken lines) are projected in a parallel beam through said compartment.

At the end of the compartment 5, opposite the lens system 4 and in alignment therewith, is mounted a photoelectric element 6, upon the light-sensitive surface of which the beam of light is permanently directed during operation of the apparatus. This photoelectric element may be of any suitable type, such as the current generating barrier layer type, and preferably has a large flat light-sensitive surface 7 and is capable of generating sufficient current to operate an elec-

trical responsive device without amplification of the electrical output of the element.

In use, the casing 1 and compartment 5 are mounted in any suitable manner in the space to be protected, and the compartment 5 is provided with a plurality of apertures 8 spaced longitudinally thereof to permit fluid, containing suspended matter such as smoke, to pass through the compartment by thermal circulation. The heat produced by the radiant energy of the light beam as well as the heat transmitted through the walls of the smoke detecting compartment from the light source heats the fluid in the detecting compartment causing the thermal circulation therethrough. It will be observed that as smoke passes through the compartment, it will cross the path of the light rays that are projected from the source 2 to the photoelectric element and thereby partially block the light rays and weaken the illumination of the photoelectric element.

The photoelectric element 6 is connected in an electrical circuit with an electric responsive device 9 and another photoelectric element 10 which is subject to rays from the light source 2, said photoelectric elements being connected in the the circuit in what is known as an "opposed parallel" arrangement, or so that the photoelectric effects of said elements are caused to operate in compensating differential or opposed relation; in other words, the electrodes of the element 7 are connected respectively to the opposite electrodes of the element 10 as best shown in Figure 8.

The photoelectric element 10 may be mounted in any suitable manner, but as shown, the light compartment 1 has an aperture 11 in its wall which is disposed at one end of a light-conducting tube 12 that projects from said wall of the compartment 1 and in which the photoelectric element 10 is mounted in spaced and aligned relation to the aperture 11. The tube 12 being preferably positioned on the opposite side of the compartment 1 from the lens system 2.

Within the aperture 11 is mounted suitable means for varying the effect of the light rays upon the photoelectric element 10. Such means may comprise, alternatively, an adjustable iris diaphragm 13*a*, (Figure 6), or light-diffusing media such as wire gauze 13, (Figure 4), frosted glass or "Polaroid" glass 13*b* (Figure 7).

With this construction, initially the photoelectric cell circuit is so adjusted that the relay or other device 9 will assume a normal condition, for example, to open the signal circuit when no smoke is present in the compartment 6, and when smoke is caused to flow through the compartment 5 into the beam of light, some of the light rays will be blocked and the illumination of the photoelectric element 6 will be weakened, whereupon the relay or other electrical responsive device 9 will be actuated into the closed position by the current in the photoelectric cell circuit so as to close the signal circuit.

To protect the photoelectric element 6 against the effects of stray light rays from outside the compartment 5, in other words, to prevent the passage of light rays through the apertures 8 in such a manner as to energize the photoelectric element 6, we provide a plurality of baffles or partitions 14 which extend transversely of the compartment 5 between the apertures 8, and have aligned central openings 15 through which the light beam may freely pass.

With this construction, it will be observed that it is impossible for light rays to enter the compartment 5 through any of the apertures 8 in such a direction as to impinge upon or affect the light-sensitive surface 7 of the photoelectric element 6.

The invention thus provides in one and the same unit, simple and inexpensive means for permitting the smoke to freely flow by thermal circulation through the light beam and for preventing light rays from outside the compartment in any way affecting the operation of the photoelectric system.

A modification of the invention is shown in Figure 5, where instead of the baffles or partitions 14, we utilize inwardly projecting tubes 16, one for each of the apertures 17 corresponding to the apertures 8, said tubes projecting into the testing compartment 18 which corresponds to the compartment 5, a sufficient distance to prevent exterior light rays from entering the compartment in such a way as to vary or otherwise affect the operation of the photoelectric element.

The various electrical responsive devices may be utilized and they may be connected in circuit in any suitable manner with various devices such as signal lamps, bells and the like, but one preferred circuit is shown in Figure 8 where the electrical responsive device 9 includes a pointer or swingable contact arm 19 which is actuated by a coil 20 connected in circuit with the photoelectric elements so that said pointer is normally spaced from a fixed contact 21, but is actuated into engagement with said contact when the output of the photoelectric cells 10 and 11 become unbalanced, such as by the partial or total de-energizing of either of the cells while the other is energized. Generally, the pointer tends to remain in such contact, yet it is customary to provide means for resetting this contact arm from any desired remote point. For the purpose of illustration, we have shown a resetting rod 22 having one end normally in spaced relation to the contact arm 19 when the latter engages the contact 21 as shown in Figure 6. The resetting rod 22 may be electrically operated as hereinafter described. The electrical responsive device 9 controls the signal circuit through contact of said contact arm 19 and contact member 21 in order to complete the circuit 2 any desired electrically operated device, such as a signal lamp 23 which may be mounted in any suitable location, for example on a remote control board 24 as shown in Figure 8.

In accordance with one feature of the invention, we provide a switch mechanism operated by the same finger piece for resetting the contact arm 19 of the electrical responsive device and testing the apparatus to ascertain whether or not the photoelectric elements and the circuit are in operative condition. As shown, an electromagnetic coil 25 is provided for actuating the resetting rod 22 and is connected in circuit with a normally open switch which includes a fixed contact member 26 and a movable contact member 27 that is mounted on a spring arm 28 which in turn is actuated into switch-closing position by an operating lever or finger piece 29 that is pivotally mounted at one end as indicated at 30 and will bear against the free end of the spring arm 28 when swung in one direction, so as to force the movable contact 27 into engagement with the fixed contact 26 and close the circuit through the electromagnetic coil 25. This will result in actuation of the resetting rod 22 so as to push the latter, with a snap action, against

the contact arm 19 which thereby will be pushed back to its normal position.

The same switch-operating lever or finger piece 29 is utilized for operating the switch for testing the photoelectric elements and the circuit generally. This switch is shown as comprising a fixed contact element 31 which cooperates with a movable contact element 32 that is mounted on a spring arm 33 so that the contacts 31 and 32 are normally engaged in circuit-closing position. These two contacts are connected in the circuit so that when they are disengaged to open the circuit, the operating photoelectric element 6 is thrown out of the circuit, while the balancing photoelectric element 10 remains operatively connected in circuit with the operating coil 20 of the electrical responsive device 9. When the main operating cell is thrown out of the circuit, the opposing effect thereof on the balancing cell is eliminated and, consequently, said balancing cell will be actuated by the light rays passing through the aperture 11 and light tube 12. When the balancing cell so operates, it is indicative that the whole system is in operative condition. Should the cell not operate in this manner, it would be apparent that something is wrong in the circuit.

It will be evident that the contact 32 may be moved away from the contact 31 by movement of the operating lever or finger piece 29 against the spring arm 33 in the direction opposite to that in which the finger piece is moved to operate the spring arm 28 of the resetting switch. As shown, the finger piece may conveniently be located between the two spring arms 28 and 33, but other arrangements will occur to those skilled in the art.

It is desirable in some instances to connect a coil 34 of a relay in circuit with the lamp 23 for operating other devices or signals, e. g. electric gong.

The smoke detector is claimed broadly in copending applications, Serial Number 619,744, filed October 2, 1945, Serial Number 74,342, filed February 3, 1949 as a division of Serial Number 604,892, now Patent No. 2,464,211 filed July 13, 1945 and owned by a common assignee.

While we have shown our invention as embodied in certain specific details of construction, it should be understood that the construction of the means for permitting smoke to pass through the testing compartment and for preventing light from entering said compartment may be provided within the spirit and scope of the invention.

What we claim is:

1. A smoke detector comprising a casing having a smoke detecting compartment, means for projecting a beam of light through at least a portion of the detecting compartment, light responsive means adapted to be actuated by variations in the light in the detecting compartment, the detecting compartment having a plurality of pairs of apertures in its side walls for admission of fluid to be tested for smoke directly from the ambient space around the compartment, each pair of apertures having one aperture positioned above the other so that the circulation of the fluid through the compartment is produced by thermal action, the beam of light producing heat in the detecting compartment for the thermal circulation, and a light obstructing barrier extending transversely of the detecting compartment inwardly from its side walls between each pair of apertures and the light responsive means

to prevent practically any rays of exterior light from entering through the apertures and impinging upon the light responsive means, the light obstructing barriers terminating short of the light beam.

2. A smoke detector comprising a casing having a smoke detecting compartment, means for projecting a beam of light through at least a portion of the detecting compartment, light responsive means adapted to be actuated by variations in the light in the detecting compartment, the detecting compartment having a plurality of pairs of apertures in its side walls for admission of fluid to be tested for smoke directly from the ambient space around the compartment, each pair of apertures having one aperture positioned above the other so that the circulation of the fluid through the compartment is produced by thermal action, the beam of light producing heat in the detecting compartment for the thermal circulation, and a light obstructing apertured partition extending transversely of the detecting compartment inwardly from its side walls between each pair of apertures and the light responsive means to prevent practically any rays of exterior light from entering through the apertures and impinging upon the light responsive means, the apertures in the partitions aligned and having a diameter sufficient to pass the beam of light.

3. A smoke detector comprising a casing having a smoke detecting compartment, means for projecting a beam of light through at least a portion of the detecting compartment, light responsive means adapted to be actuated by variations in the light in the detecting compartment, the detecting compartment having a plurality of pairs of apertures in its side walls for admission of the fluid to be tested for smoke directly from the ambient space around the compartment, each pair of apertures having one aperture positioned above the other so that the circulation of the fluid through the compartment is produced by thermal action, the beam of light producing heat in the detecting compartment for the thermal circulation, and a light obstructing tube extending inwardly from the side wall of the detecting compartment about each of the apertures to prevent practically any rays of light from entering through the apertures and impinging upon the light responsive means, the tubes having a length terminating short of the light beam.

4. Apparatus for detecting suspended light obstructing matter in a fluid comprising a housing having an elongated compartment formed therein, the compartment having a plurality of pairs of longitudinally spaced apertures in its wall for the passage of fluid through the compartment, a light source adapted to project light rays longitudinally through the compartment, light-responsive means positioned to receive the light rays, and a plurality of tubes extending inwardly about each of the apertures, each tube extending into the compartment a distance sufficient to block practically all exterior light which may enter through the apertures.

5. Apparatus for detecting suspended light obstructing matter in a fluid comprising a housing having an elongated compartment formed therein, the compartment having a plurality of pairs of longitudinally spaced apertures in its wall for the passage of fluid through the compartment, a light source adapted to project light rays longitudinally through the compartment, light-

responsive means positioned to receive the light rays, and a plurality of tubes extending inwardly about each of the apertures, each tube extending into the compartment a distance sufficient to block practically all exterior light which may enter through the apertures, the inner ends of each of the tubes terminating substantially in alignment to permit the passage of light rays from the light source to the light-responsive means.

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