Sept. 24, 1946. K. O. DONELIAN 2,408,051

FIRE AND SMOKE DETECTOR AND THE LIKE

Filed April 4, 1942

FIG. 3

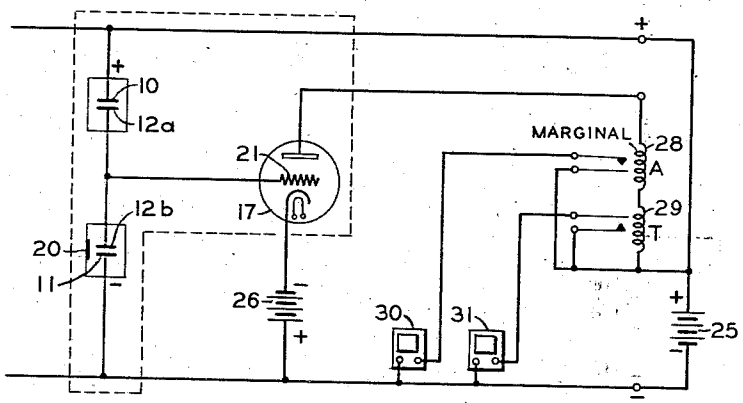


FIG. 1

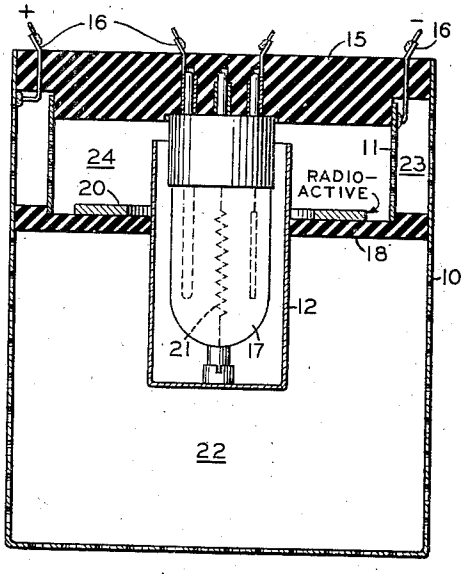
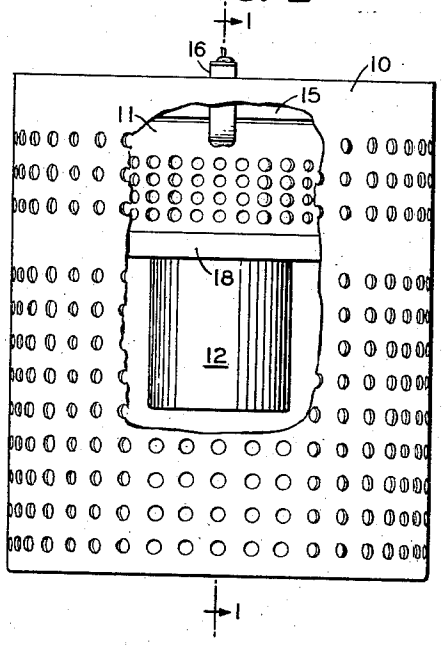


FIG. 2



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Patented Sept. 24, 1946

2,408,051

UNITED STATES PATENT OFFICE

2,408,051

FIRE AND SMOKE DETECTOR AND THE LIKE

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Application April 4, 1942, Serial No. 437,615

13 Claims. (Cl. 177—311)

1

This invention relates to fire detecting and alarm apparatus, and more particularly to an electrical detecting unit and system responsive to the presence of combustion products and/or smoke in the atmosphere adjacent the detector unit.

The object of the invention is to provide an improved and highly sensitive fire detecting unit which responds to minute traces of either ionized combustion gases or suspended solid particles having no electrical charge, generally referred to as smoke particles.

Another object of the invention is to provide a combined fire and smoke detector of the ionization type which will respond either to fires that produce little or no smoke, such as those involving organic combustibles like alcohol or gasoline, or to fires that produce only smoke with little or no perceptible heat or flame.

A still further object of the invention is to simplify and improve the construction of an electrical detector unit and alarm system of the class described.

Hitherto fire detecting apparatus which depend upon detection of the by-products of combustion have included smoke detectors embodying optical measuring apparatus or gas detectors employing chemicals to detect specific gases, such as carbon monoxide or carbon dioxide, usually formed in the combustion process. These prior devices have been relatively complicated, as well as unsuitable or unreliable for many applications, and have required considerable supervision and maintenance, such as the periodic replacement of exhausted chemicals or parts.

The present invention is based upon the well-known fact that the by-products of combustion may contain ionized molecules or particles, as well as solid smoke particles which have no electrical charge. It is also known that the ionized molecules or particles may retain for several minutes or more their ionized characteristics so that the conductivity of the gas containing said molecules for a considerable period of time is substantially different than that of air at the same temperature. Accordingly, the detector unit in its preferred form includes means such as spaced electrodes upon which a predetermined potential difference is maintained in order to detect the presence of the ionized molecules or particles. However, this would not provide for detecting the presence of suspended smoke particles in the atmosphere, which sometimes occur without the ionized air particles or molecules. Accordingly, the preferred form of the detector

2

unit comprises also a second chamber containing spaced electrodes which is shielded against the admission of ionized air particles and contains a quantity of a radioactive material to impart a normal conductivity characteristic to the space between the electrodes. It is found that the presence of smoke particles in the air in said space impedes the progress of the alpha radiation from the radioactive material and thereby reduces the amount of ionization of the air produced by said radioactive material. The effect of the smoke particles is therefore the opposite of the ionized air particles, and the shielding means is employed to prevent ionized air particles, if present, from masking the effect produced by the smoke particles.

In accordance with a further feature of the invention, the electrodes and source of potential are connected in the input circuit of a vacuum tube amplifier or other electrical relaying means in such a manner that the electroconductive effects of the two elements of the detector are combined additively so that, if both ionized air particles and smoke particles are present in the atmosphere adjacent the detector unit, the effect is somewhat greater than if only the ionized particles or only the uncharged particles are present.

For a better understanding of the invention reference may be had to the accompanying drawing showing a preferred embodiment thereof, and in which:

Fig. 1 is a sectional view of the detector unit taken on the line 1—1 of Fig. 2;

Fig. 2 is a side elevational view of the detector unit with a portion of the outer shell broken away; and

Fig. 3 is a circuit diagram of the detector unit connected in a typical alarm circuit.

Referring to Figs. 1 and 2 of the drawing, a preferred form of the detector unit, drawn to about three-quarter scale, comprises an outer perforated metallic shell or electrode 10 partially or completely enclosing two spaced inner electrodes 11 and 12, and acting as an electrostatic shield for the elements enclosed therein. The top of the hollow or cup-shaped electrode 10 may be closed by an insulating cover or cap 15 serving as a support for lead-in conductors 16 and the vacuum tube amplifier 17, as shown. The vacuum tube 17 is substantially enclosed by the electrode 12 which also acts in conjunction with an intermediate partition 18 to divide the spaces bounded by the electrodes 10, 11 and 12 into the three chambers 22, 23 and 24, all of

which are open for circulation of combustion gases and smoke from a fire in the vicinity of the detector unit.

Chamber 22 is employed for the detection of ionized air particles since the presence of such particles in the space between electrodes 10 and 12 causes a variation in the conductivity characteristic of said space. On the other hand, chamber 24 bounded by the electrodes 11 and 12 is completely enveloped by chamber 23 and by the imperforate insulating members 15 and 18 so that all of the air and gases circulating through chamber 24 must first pass through the outer chamber 23, for reasons which will be explained below. The inner chamber 24 contains a quantity of radioactive material 20 which normally ionizes the air in said chamber to a fixed degree. However, the presence of solid smoke particles in suspension in said air impedes the alpha emanations from the radioactive material 20 and thus reduces the conductivity of the space between electrodes 11 and 12 so long as smoke is present. In order to prevent ionized air particles and the like, which may be contained in the air currents around the detector unit, from nullifying the effect of smoke particles in reducing the conductivity of the air or gases in the inner chamber 24, the electrodes 10 and 11 are maintained at a sufficiently high difference of potential to de-ionize the circulating gases entering chambers 23 and 24. The voltage impressed between electrode 10 and electrode 11, for example, may be 100 volts, since a potential gradient of the order of 40 or 50 volts per centimeter is sufficiently high to neutralize the charges on any charged particles in a slowly moving air current. In this manner, the charged particles are filtered out of the air currents entering chamber 24, while the smoke particles suspended in the air will enter chamber 24 and reduce the ionization in said chamber as described above.

It will be apparent from the foregoing description that either the ionized-particle detecting element or the smoke detecting element of the detector unit shown in Figs. 1 and 2 may be used independently, although the arrangement shown in which the two elements are combined in a simple and effective manner is the preferred construction. It will also be apparent that the configuration and arrangement of the electrodes may be widely varied without departing from the operating requirements outlined above, which require—first, that the ionized-particle detecting chamber and the smoke detecting chamber be open to the air for circulation of the by-products of combustion from the fire therethrough; and, second, that the chamber containing the radioactive material must be shielded against the ionized air particles. The radioactive substance 20 may be a ceramic film containing radium or some radioactive salt. Reference is made to this material because it may be purchased in this form in the open market but other forms may be substituted. For the preferred arrangement shown in Fig. 1, approximately one microgram of radium in ceramic film form described above is used.

In accordance with a further feature of the invention, the electrodes and the source of current are so connected to the input circuit of a vacuum tube amplifier 17 or other relaying means that the opposite electroconductive effects in the two detecting chambers are additively combined. In this manner, if the by-products of combustion from the fire include both ionized air particles and solid smoke particles in suspension, although the ionized air particles increase the conductivity of chamber 22 and the smoke particles decrease the conductivity of chamber 24, the change in potential of the grid 21 of the vacuum tube is in the same direction in each case so that there is no tendency for one effect to compensate or cancel out the other but rather the combined effect results in quicker response to a fire. As shown in Fig. 1, the inner electrode 12 of the detector unit connected to the control electrode or grid 21 of the vacuum tube amplifier extends into both chambers 22 and 24 of the detector unit, and the electrodes 10 and 11 are connected to the positive and negative terminals, respectively, of the source of potential. This is represented diagrammatically in Fig. 3, in which 12*a* and 12*b* represent the two parts of the electrode 12, and the spaces between said electrodes and electrodes 10 and 11 represent the chambers through which combustion gases and smoke particles circulate in the event of a fire. A source of potential impressed upon the electrodes of the unit is represented by the battery 25. In order to secure the proper cathode-grid bias, depending upon the characteristics of the tube 17, a second source of potential 26 may be connected, for example, in the cathode circuit of said amplifier. A normally deenergized alarm relay 28 and a normally energized trouble relay 29 are shown by way of illustration as connected in the plate circuit of the vacuum tube amplifier 17. The contacts of relay 28 are arranged to control a buzzer or alarm device 30, whereas the contacts of the relay 29 are arranged to operate a similar trouble signal 31 in the event that the plate current of the amplifier 17 drops below its normal value, as would be caused by failure of the battery, breaking of the connecting conductors or failure of the vacuum tube itself.

Under normal conditions, the potential of the grid 21 of the vacuum tube amplifier 17 is maintained at a predetermined potential by reason of the connection of said grid to the terminals of the battery 25 through the resistances represented by the spaces between the electrodes 10 and 12*a*, and 11 and 12*b*, respectively. This potential is preferably so chosen with respect to that of the cathode that the amplifier 17 is conductive and the plate current thereof is sufficient to maintain the contacts of the trouble relay 29 open but insufficient to operate the marginal alarm relay 28. If, however, the conductivity of the space between the electrodes 10 and 12*a* is increased, owing to the presence of ionized air particles to which the detector unit is responsive, the potential of the grid 21 of the amplifier 17 becomes more positive, and the increased plate current of the amplifier actuates the contacts of relay 28 to sound the alarm 30. Similarly, if the conductivity of the space between the electrodes 11 and 12*b* decreases upon the occurrence of smoke in said space, the grid 21 of the amplifier 17 likewise becomes more positive than before, and thus the alarm relay 28 is operated either upon the occurrence of ionized air particles or of smoke particles in the combustion gases from the fire, and the electroconductive effects are additive when both conditions occur simultaneously. Therefore, it will be seen that the detector unit will respond to either so-called smokeless fires or to fires which produce smoke with no perceptible flame or heat, as well as to fires in which considerable flame and smoke are both produced.

While the vacuum tube amplifier 17 shown in

Fig. 3 is a triode, any high gain pentode amplifier of the 38, 6C6 or other type may be used, providing its input or grid resistance is very high. It has generally been found desirable to reduce the filament voltage impressed to approximately 60% of the rated normal value to reduce positive ion emission to a negligible value in order to obtain this high grid resistance. It is also to be noted that, although only one stage of amplification is shown, additional stages may be provided if desired, depending upon the operating current requirements of the control relays.

While no special mounting arrangement or positioning of the detector unit is required in many installations, conventional means, such as sampling pipes, may be employed to direct combustion gases and smoke from distant fires to the detector unit. Various other modifications and auxiliary arrangements will occur to those skilled in the art and may be employed without departing from the scope of the invention as defined in the appended claims.

I claim:

1. A detector unit for detecting either fire or smoke comprising spaced electrodes defining two separate chambers through which pass the combustion products from a fire in the space to be protected, means to maintain a difference of potential between said electrodes, and detection means having as parts thereof a pair of said electrodes to detect a change in the conductivity of the gases in one of said chambers resulting from ionized air particles or molecules reaching said chamber from a fire, said detection means having as part thereof a third electrode cooperating with one of said pair of electrodes to shield the other of said chambers from ionized molecules, said third electrode cooperating with the other of said pair of electrodes to detect smoke particles in suspension in the air or gases in said other chamber.

2. A detector unit for detecting smoke comprising at least three nested electrodes defining two chambers or cavities open to the atmosphere, one of said chambers being enveloped by the other, a quantity of radioactive material in said one chamber, means having two of said electrodes as parts thereof for neutralizing charged or ionized particles from the air or gas in the other chamber whereby the air or gas circulating through the chamber containing radioactive material is free from charged particles except as produced by such material and means having two of said electrodes as parts thereof for detecting changes in conductivity of the air or gas in said one chamber upon the occurrence of smoke particles suspended in the air or gas therein.

3. A detector unit for fire alarm systems comprising a plurality of spaced electrodes defining at least two spaces in inner and outer relation and open to the atmosphere for the circulation of combustion products from a fire therethrough, an inner one of said spaces defined by two of said electrodes being completely enveloped by a space between two of said electrodes, said inner space containing means to ionize the gas therein to a predetermined degree, means to deionize gaseous combustion products prior to entering said inner space, and means having the electrodes defining the inner space as parts thereof for detecting smoke particles in said inner space.

4. A detector unit for fire alarm systems comprising spaced electrodes defining a plurality of spaces open to the atmosphere for circulation of combustion products from a fire therethrough,

one of said electrodes being common to two of said spaces, a vacuum tube having the control electrode thereof connected to said last-mentioned electrode and means having said vacuum tube and said electrodes as parts thereof for detecting the presence of ionized air particles in one of said two spaces and smoke particles in the other.

5. A detector unit for fire alarm systems comprising a plurality of spaced electrodes defining spaces open to the atmosphere for circulation of combustion products from a fire therethrough, a vacuum tube connected in a manner to be controlled by variations in the electroconductive characteristic of one of said spaces, means for normally ionizing said one of said spaces to a predetermined degree and means for shielding the same against entry of ionized air particles whereby the conductivity of said space is varied by the presence of smoke particles therein, said vacuum tube also being connected in a manner to be controlled in the same manner by the electroconductive characteristics of another space caused by the presence of ionized particles therein with an additive control effect upon the presence simultaneously of smoke particles and ionized particles in the respective spaces.

6. A detector unit for fire alarm systems comprising at least three spaced electrodes defining adjacent spaces exposed to combustion products from a fire in the space to be protected, the said product including either ionized molecules or solid particles in suspension in the form of smoke, or both ionized molecules and smoke particles, a source of potential connected to said electrodes, means for ionizing the air in the space between two of said electrodes, and means so co-acting with said electrodes as to detect jointly and severally by electroconductive effects smoke particles in suspension in the ionized air between two of said electrodes and ionized molecules in the air in another of said adjacent spaces between two of said electrodes.

7. A detector unit for fire alarm systems comprising at least three spaced electrodes defining adjacent spaces exposed to combustion products from a fire in the space to be protected, the said products including either ionized molecules or solid particles in suspension in the form of smoke, or both ionized molecules and smoke particles, a source of potential connected to said electrodes, means for ionizing the air in the space between two of said electrodes, and means so co-acting with all of said electrodes as to detect by electroconductive effects smoke particles in suspension in the ionized air between two of said electrodes and ionized molecules in the air in another of said adjacent spaces between two of said electrodes.

8. A detector unit for fire alarm systems comprising spaced electrodes exposed to combustion products from a fire in the space to be protected, the said products including either ionized molecules or solid particles in suspension in the form of smoke, or both ionized molecules and smoke particles, a source of potential connected to said electrodes, means so co-acting with all of said electrodes as to detect ionized molecules between a pair of said spaced electrodes and uncharged smoke particles in suspension between a third electrode and one of said pair of electrodes and a common biasing control circuit included in said means and so connected to one of said electrodes that said means is affected by both ionized molecules and smoke particles in suspension from fire producing combustion products containing both.

9. A detector unit for detecting either fire or smoke comprising at least three spaced electrodes defining two separate chambers through which pass the combustion products from a fire in the space to be protected, means to maintain a difference of potential between said electrodes and means co-acting with all of said electrodes to detect ionized air particles or molecules in one of said chambers and uncharged smoke particles in the other chamber by electroconductive effects, said electrodes being so associated each to the other and to said means as to additively combine said effects when both ionized molecules and uncharged particles are present.

10. A detector unit for fire alarm systems comprising at least three electrodes defining chambers open to the atmosphere for circulation of combustion products from a fire therethrough, a vacuum tube having its control element connected to one of said electrodes, a source of potential so connected to said electrodes and to said vacuum tube that each electrode is at a different potential from that of each of the other electrodes, means for ionizing the air in one of said chambers, and means including said electrodes, vacuum tube, and source of potential for detecting variations in the conductivity of the space paths of the respective chambers resulting from different types of combustion products in the respective chambers.

11. A detector unit for fire alarm systems comprising a cup-shaped perforated shell electrode, a second hollow electrode inside of the first-mentioned electrode and spaced therefrom, a vacuum tube supported inside of said second electrode and having the control element thereof connected to the second electrode, a source of potential connected to the two electrodes and to the anode of

the vacuum tube, and means having said electrodes and said tube as parts thereof for detecting variations in the conductivity path between said electrodes.

12. A detector unit for fire alarm systems comprising spaced electrodes defining a plurality of adjacent spaces open to the atmosphere for circulation of combustion products from a fire therethrough, means for ionizing the atmosphere in one of said spaces, a source of potential connected to said electrodes, and a vacuum tube amplifier connected to said electrodes to be controlled in the same manner by the variations in the conductivity of said spaces resulting either from smoke particles to the substantial exclusion of transient ionized air particles in a space of ionized atmosphere or from ionized air particles to the substantial exclusion of smoke particles in another of said spaces, with an additive control effect upon simultaneous changes in the conductivity of said spaces.

13. In a fire alarm system, a vacuum tube amplifier provided with a control electrode, a detector unit connected to said control electrode, means for ionizing the atmosphere in a part of said unit, and means in said unit to vary the potential of said electrode in the same direction upon the occurrence of either smoke to the substantial exclusion of transient ionized air particles in a part of said unit having ionized atmosphere or of ionized air particles to the substantial exclusion of smoke in another part of said unit, and to vary the potential of said electrode upon the occurrence simultaneously of both ionized air particles and smoke in said unit, said last-mentioned potential variation being an additive function of the separate variations.

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