Sept. 30, 1969 A. A. JAFFE ET AL 3,470,551

FIRE AND SMOKE DETECTOR

Filed Dec. 2, 1965 2 Sheets-Sheet 1

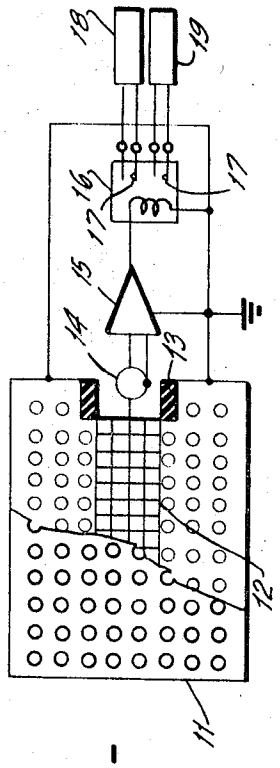



FIG. 1.

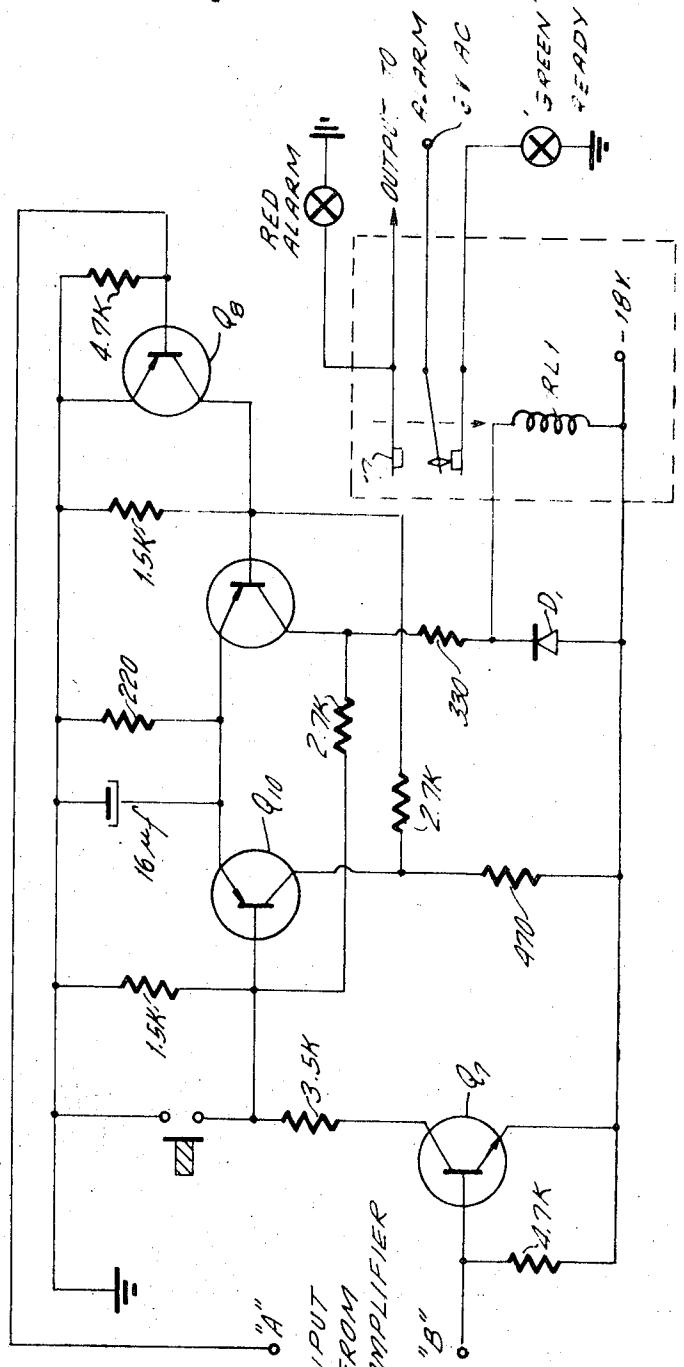



FIG. 2.

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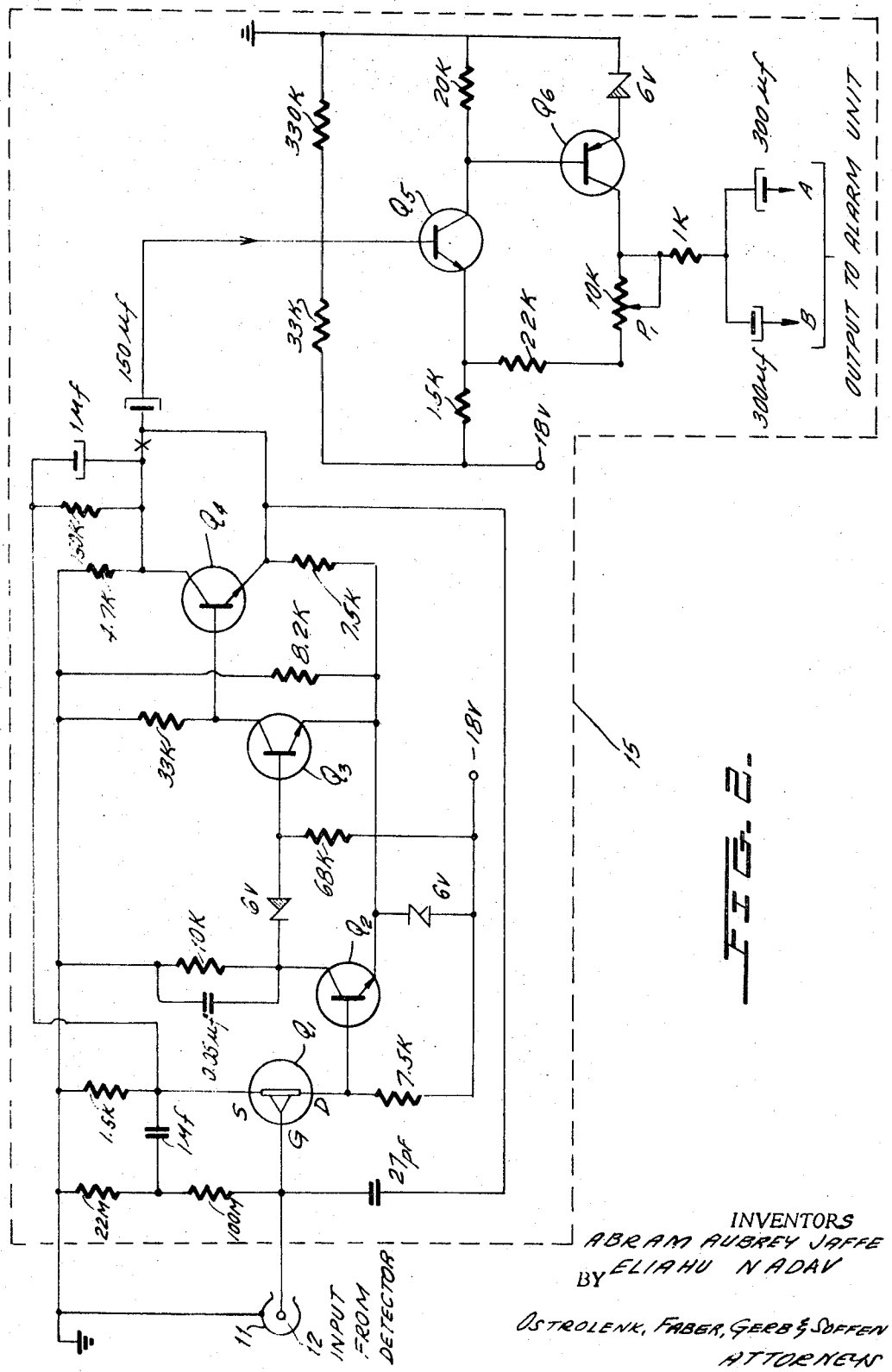



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# FIRE AND SMOKE DETECTOR

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U.S. Cl. 340—237 4 Claims

## ABSTRACT OF THE DISCLOSURE

A fire and smoke detector including an electrical conductor which has induced thereon an electrical charge when approached by the net electrical charge carried by smoke and combustion by-products. A perforated shield surrounds the electrical conductor to screen the conductor from external charges and external electrical fields while at the same time permits the flow of smoke and combustion by-products therethrough. Amplifying and alarm apparatus are provided responsive to the establishment of the induced charge on the conductor signifying the presence of smoke and combustion products.

This invention relates to a fire and smoke detector and more particularly to a fire and smoke detector the operation of which is dependent upon the detection of the net electrical charge carried by smoke and combustion products from fires.

Heretofore, 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 device 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.

More recent fire and smoke detectors which depend upon detection of the by-products of combustion have included ionization chambers having at least one pair of electrodes spaced therein. Such electrodes have been impressed with a relatively high potential therebetween to establish predetermined conductivity characteristics of the air between the electrodes. Recognizing that the by-products of combustion may contain ionized molecules or particles, the presence of such ionized particles within the ionization chamber increases the conductivity within the chamber, which increase of conductivity may be detected, amplified and utilized to activate suitable alarm and/or fire fighting equipment. Recognizing also that smoke particles may sometimes occur without ionized air particles or molecules, these more recent fire and smoke detectors have provided a second ionization chamber which includes a second pair of voltage impressed spaced electrodes to shield the interior of the second chamber against the admission of extraneous ionized air particles. Provided within the second chamber is a quantity of radioactive material the radiation of which imparts normal conductivity characteristics to the space between the electrodes. The presence of smoke particles in the chamber impedes the progress of the alpha-radiation from the radioactive material and thereby reduces the amount of ionization of the air produced by such radioactive material. The reduction of conductivity characteristics within the second chamber may be electrically sensed, amplified and utilized to activate suitable alarm and/or fire fighting apparatus.



An example of the ionization chamber technique of detecting smoke and combustion by-products may be seen in United States Patent 2,4008,051 issued to K. O. Donelian on Sept. 24, 1946.

The above described prior art fire and smoke detectors, as illustrated by the Donelian patent, suffer from several disadvantages which the instant invention effectively eliminates. Specifically, a device such as that shown in the Donelian patent requires at least two ionization chambers, one of which detects an increase in conductivity between spaced electrodes due to the presence of ionized combustion products therebetween, and the second of which detects the influence of smoke particles on the normal conductivity characteristics established between a pair of spaced electrodes by a radioactive material. Secondly, both ionization chambers require that a relatively high voltage be impressed upon the spaced electrodes located therein; and thirdly, as is well known, the utilization of a radioactive material, especially those which emit alpha-particles, are a potential health hazard.

In contradistinction thereto, the instant invention is based on an effect which is quite different from the two effects utilized by such prior art devices as the Donelian patent. It is based on the fact that smoke and combustion products from fires carry a net electrical charge. Recognizing the fact that if a net electrical charge approaches an electrical conductor, an induced charge will be established on the surface of such conductor; the presence of smoke and combustion products from fire may be simply detected by the eletcrical observation of such induced charge on a single electrical conductor. Thus, where the prior art detectors, illustrative by the Donelian patent, require separate ionization chambers to detect (1) the presence of ionized combustion products, and (2) the presence of non-ionized smoke particles, the instant invention materially simplifies fire detection by electrically detecting the presence of an induced charge on a single conductor.

The advantages derived from the detection of net electrical charge of combustion products may be summarized as follows. A single detector consisting of a single electrode is possible and neither an ionization nor de-ionization chamber is required. Similarly, where the ionization and the de-ionization chambers of the prior art devices require that relatively high voltages (for example, 100 volts) be impressed upon the spaced apart electrodes located therein, the instant invention requires neither the pairs of electrodes nor the potential impressed thereon. Furthermore, the instant invention completely eliminates the necessity for a radioactive source which, as noted before, presents a potential health hazard in the detectors of the prior art.

As a further advantage, it may be appreciated that the single electrode of the instant invention may be made of any shape to provide protection for large and/or irregular areas while the double ionization chambered device of the prior art is relatively complex and, therefore, does not lend itself to various shapes and sizes.

Accordingly, it is an object of the instant invention to provide a fire and smoke detector, the operation of which is dependent upon the fact that smoke and combustion products from fire carry a net electrical charge which may be sensed and amplified to activate suitable alarm and/or fire fighting apparatus.

It is another object of the instant invention to provide apparatus for detecting smoke and combustion products from fires comprising sensing means for producing a signal indicative of the presence of a net electrical charge carried by smoke and combustion products from fires; and amplifier means connected to said sensing means for amplifiying said signal.

It is another object of the instant invention to provide a fire and smoke detector which eliminates the relatively complex arrangements prevalent in the prior art.

Still another object of the instant invention is to provide a fire and smoke detector which electrically detects the presence of an induced charge on an electrode, which induced charge has been established by the approach of the net electrical charge carried by smoke and combustion products from fires.

Yet another object of the instant invention is to provide a fire and smoke detector the simplicity of which permits great flexibility with respect to size and shape.

Other objects and a fuller understanding of the instant invention may be had by referring to the following specification and drawings, in which:

FIGURE 1 is a somewhat schematic diagram of a fire and smoke detector constructed in accordance with the teachings of the instant invention;

FIGURE 2 is an electrical circuit diagram of an amplifier which may operate in conjunction with the fire and smoke detector of the instant invention; and

FIGURE 3 is an electrical circuit diagram of an alarm device which may be utilized in conjunction with the amplifier of FIGURE 2.

Referring to FIGURE 1, there is shown an illustrative embodiment of the instant invention. The detector comprises a sensing element **12**, which may be any metal electrode (i.e., electrically conducting material), preferably mesh or perforated, and hollow inside. The sensing element **12** may be virtually of any shape, for example, a long cylinder extending over a number of yards, or alternatively, may comprise a large, flat box or sheet to give protection over a large area, such as a ceiling or roof. It is to be understood that the flexibility of shape which the simplicity of the instant invention facilitates represents an important feature of the instant invention in that the invention may be suitably adapted to provide adequate fire protection in various sized and/or irregularly shaped rooms or areas.

Sensing element **12** is supported by an insulator **13** of good electrical insulating properties, for example, polytetrafluoroethylene, and is enclosed by a grounded shield **11**, the purpose of which is to screen the sensing element **12** from any external charges or fields while simultaneously allowing the flow of smoke or combustion products from fires to flow readily therethrough. The shield **11** consists of electrically conducting material preferably in the form of wire mesh or perforated sheet. Although grounded shield **11** is shown as a single layer of metal in FIGURE 1, it is to be understood that more effective electrical screening may be obtained by using several layers of such material.

The shape of the grounded shield **11** should conform to, but be larger than, the shape of the sensing element **12**. Thus, if the sensing element **12** were chosen as a long cylinder, the grounded shield **11** would consist of a coaxial cylinder, or series of cylinders, which enclose the sensing element.

An electrical connection is made by an insulated lead through **14** which may consist of a coaxial connector of conventional type, to an electronic amplifier **15**. As will be explained in greater detail, amplifier **15** may be of either a voltage sensitive or charge sensitive type. If a charge sensitive amplifier is used the sensing element may be extended up to a limit such that its electrical capacity is approximately equal to the effective input capacity of the amplifier, without serious loss of sensitivity. Alternatively a number of smaller sensing elements may be connected to a single amplifier. The output of amplifier **15** energizes a relay **16** with one or more pairs of electrical contacts **17** therein being controlled by energization of the relay **16** to operate any desirable alarm device **18** and/or automatic fire extinguishing apparatus **19**.

It is to be understood that the instant invention may be combined with a sampling system, for example, consisting of a fan and air ducts, to sample over a large area.

The operation of the fire and smoke detector of the instant invention will now be described with respect to FIGURE 1.

Recognizing that smoke and combustion products from fire carry a net electrical charge, the entrance of such combustion products through the perforated, grounded shield **11** and the approach of such products to the immediate vicinity of the sensing element **12**, will induce a charge on the surface of sensing element **12**. As noted previously, the creation of the induced charge on the surface of sensing element **12** may be observed in changes of electrical potential of the sensing element or by detecting currents flowing from or into such conductor if it is connected to a fixed potential, such as ground. Assuming that amplifier **15** is of a charge sensitive type, (an example of such amplifier being illustrated in FIGURE 2), it will be apparent that the flow of current between the sensing element **12** and ground, will be amplified by amplifier **15** to energize the coil of relay **16** to close one or more pairs of contacts **17** and activate alarm and/or fire fighting apparatus **18** and **19**.

Referring to FIGURES 2 and 3, there is shown a schematic diagram of an amplifier and alarm circuit which may be used in conjunction with the sensing apparatus described above. It is to be understood, however, that the particular amplifier and alarm unit shown and described is merely presented as an illustrative embodiment of the instant invention and that the instant invention is in no way intended to be limited to such circuitry.

Without going into the details of the circuit presented in FIGURE 2 (since all circuit elements have been appropriately identified), it is noted that sensing element **12** which is surrounded by a grounded shield **11** represents the input to the field effect transistor Q1 of the first stage of the charge sensitive amplifier **15**. The output from amplifier **15** represents the input to the alarm unit, the output coil RL1 of which is energized to close multiple contacts **17** to activate the alarm and/or fire fighting equipment.

Thus, there has been described a fire and smoke detector, the operation of which is dependent upon the induction of change on a single electrode, which induced charge has been established by the presence of the net electrical charge carried by smoke and combustion products from fires. It is seen that the instant invention represents a significant advancement in terms of simplicity of consturction and operation over prior art devices while at the same time the flexibility inherent in the instant invention lends itself to the maximum protection of large and/or odd-shaped areas.

What is claimed is:

**1.** Apparatus for detecting smoke and combustion products comprising

an electrical conductor, a surface of which has an induced charge established thereon when approached by the net electrical charge carried by smoke and combustion products;

detection means for detecting the creation of said induced charge on said conductor; and

shield means surrounding said electrical conductor for screening said electrical conductor from external charges and electric fields while at the same time permitting the flow of smoke and combustion products therethrough.

**2.** The apparatus of claim **1**, wherein said detecting means includes:

an amplifier for amplifying a signal which represents the establishment of said induced charge on said electrical conductor; and

alarm means responsive to said amplifier for signifying the presence of smoke and combustion products within said shield means.

**3.** The apparatus of claim **1**, wherein said shield means

comprises at least one layer of perforated conducting material.

4. The apparatus of claim 3, wherein said perforated conducting material is electrically grounded.


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317—148.5, 262