United States Patent

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[54] **COMBUSTION PRODUCTS DETECTOR USING A RADIOACTIVE SOURCE AND DETECTOR**
11 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** **250/43.5,** 250/44, 250/83.6; 313/54
[51] **Int. Cl.** **G01n 23/12**
[50] **Field of Search** ..... 250/43.5D, R, 44, 83.6FT; 313/54

[56] **References Cited**

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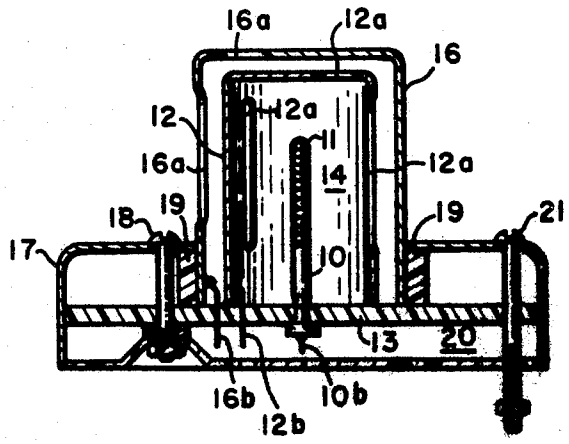
ABSTRACT: A combustion detector of the ionization chamber type having a pair of spaced anode and cathode electrodes wherein the anode carries a radioactive source of beta particles for causing an ionization current in the interelectrode space. The electrodes are supported and positioned to provide an interelectrode space large enough to prevent most of the beta particles, emitted at the one electrode, from traversing the interelectrode space and reaching the other electrode while allowing some of the particles to do so. An electrostatic shield is provided by means of a third electrode surrounding the first two electrodes.



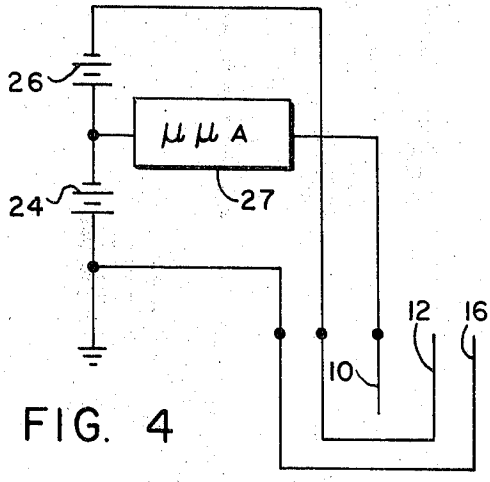


FIG. 4

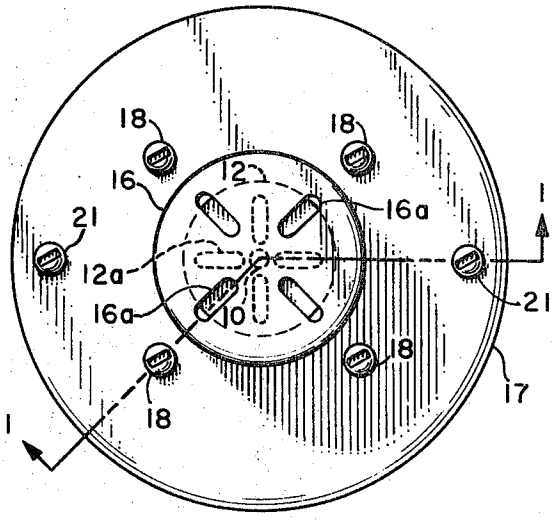


FIG. 2

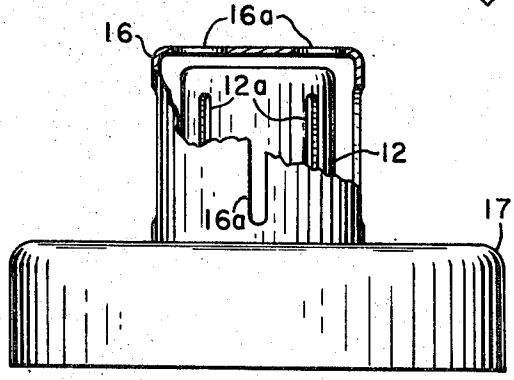


FIG. 3

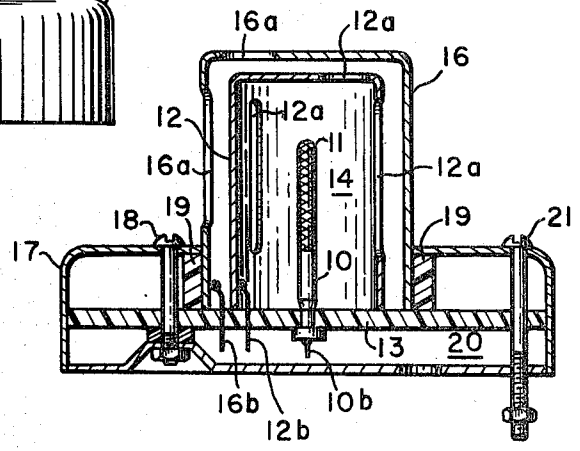


FIG. 1

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COMBUSTION PRODUCTS DETECTOR USING A RADIOACTIVE SOURCE AND DETECTOR

BACKGROUND OF THE INVENTION

This invention relates to apparatus for determining the presence of products of combustion in the ambient environment. More particularly, this invention relates to an improved ionization chamber type of combustion products detector wherein an electric current is established between a pair of electrodes in an ionization chamber, the magnitude of which depends on whether the ions transmitting the current are formed in pure gases, such as air, or in gases that are mixed with products of combustion such as air mixed with smoke and the various gases given off as a result of combustion. The ions are produced in the space between the electrodes by means of a radioactive source. Typical prior art apparatus of this type is shown in U.S. Pat. No. 2,702,898.

In the devices of the aforementioned type, it has been typical to provide two series-connected ionization chambers, each provided with a radioactive source, wherein one chamber is largely enclosed while the other is open to the atmosphere so that a relatively slow change in the composition of the air, due to normal variations in ambient pressure, temperature or humidity, will not cause instability or false alarms.

Devices of this type are satisfactory to a degree in that they have established the fact that ionization type detectors for detecting the presence of combustion products detect combustion during its earliest stages or during what is known as the "incipient period" when combustion products in very minute amounts are being produced. However, it is an established common practice to use the aforementioned double chamber arrangement in order to overcome the inherent sensitivity of such detectors to normal changes in ambient pressure, temperature, humidity and rate of flow of the gaseous sample entering the chambers. Such arrangements are electronically complicated and costly. Furthermore, these detectors tend to respond with false alarms to unexpectedly rapid variations in normal ambient conditions.

SUMMARY

Although the use of ionization chambers for the electrical detection of combustion products has long been known and the present invention makes use of an ionization chamber generally, this invention is distinguished from the known detectors since a fundamentally different arrangement is employed. Owing to the different arrangement, the operation of the present invention is improved over conventional ionization detectors.

This invention is characterized by the fact that a single chamber device including a single radioactive source is used for bringing about the ionization wherein the radioactive source is particularly characterized in that it provides substantially only beta particles. Furthermore, the source is carried by one of the electrodes, preferably the anode, and the electrodes are critically positioned to provide an interelectrode space or distance therebetween which is slightly less than the maximum range of the higher energy beta particles but in excess of the range of the lower energy beta particles. Since there are relatively few higher energy beta particles, a minor number of the beta particles emitted traverse the interelectrode space to contact the opposing electrode whereas most of the beta particles do not. This arrangement has been found to provide a detector possessing improved sensitivity to combustion products and relative insensitivity to ambient variations in pressure, temperature, and humidity, which improvements have not been available with such simplicity of structure heretofore in the art. Of course, the ultimate sensitivity or insensitivity of any detector of this type is also dependent on the electrical components and circuitry used. The improved characteristics referred to herein are related to the detector per se and should be distinguished from characteristics attributable to any electronics as such.

BRIEF DESCRIPTION OF THE DRAWING

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 along the line 1–1 of FIG. 2;

FIG. 2 is a plan view of the detector unit;

FIG. 3 is a side elevational view of the detector unit with a portion of the outer shielding electrode broken away; and

FIG. 4 is a schematic circuit diagram of preferred electrical connections which may be made to the detector unit.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIGS. 1, 2 and 3 of the drawing, the invention consists in the preferred embodiment essentially of an anode **10** carrying a beta source **11**, such as Nithu **63**, and a cathode **12**. Radioactive beta sources other than Ni^{63}, such as tritium and the like, may also be used. However, Ni^{63} is preferred and may be conveniently electroplated on anode **10** in the form of a thin coating as shown. Preferably, anode **10** takes the form of a pin as shown and cathode **12** takes the form of a cylinder which may be cup-shaped as shown. Both electrodes are carried by an insulating board **13** and may be connected thereto by various standard means. The electrodes are spaced to provide a critical interelectrode space **14** wherein combustion products may be detected as they diffuse through openings **12***a* provided in cathode **12**.

To attain the improvements contemplated by this invention, it is critical that radioactive sources which emit substantially only beta particles be used and the spacing between the electrodes be such that the majority of the beta particles emitted from the source carried by one of the electrodes, such as anode **10** fail to traverse the interelectrode space **14** while a minority of the beta particles actually traverse space **14** and reach the other electrode, such as cathode **12**. Such an arrangement is not practical with other radioactive sources such as alpha and gamma sources. Experimentally, the critical interelectrode spacing in accordance with this invention has been determined for radioactive beta sources generally. The interelectrode spacing must correspond to less than about the maximum range of the higher energy beta particles emitted by the source in air at standard conditions and greater than about one and one-half times the half-thickness range of the beta particles emitted by the source in air at standard conditions. In the case of Ni^{63}, the spacing limitation is one which is greater than about 1 cm. but less than about 5.3 cm. with about 3 cm. being more preferred. Such limitations for other radioactive beta sources which provide suitable interelectrode spacings in accordance with this invention will now be obvious to those familiar with the art.

In the preferred embodiment of the detector shown in FIGS. **1**, **2** and **3**, the geometry is cylindrical having the pin-shaped anode **10** carrying the beta source axially aligned within the cylindrical cup-shaped cathode **12**. This configuration is used to provide a strong field near the anode for affecting ionized negative charge carriers and a weak field near the cathode for affecting positive charge carriers whereby recombination effects are minimized in air in the absence of combustion products and a stable current is attained during operation. In the presence of combustion products, this configuration provides field effects which are insufficient to collect charge carriers before recombination occurs and the current decreases. In addition, this configuration provides a compact symmetrical detector.

In the case of detectors having the preferred cylindrical configuration including the radioactive source of Ni^{63}, the following design parameters provide an improved detector capable of operating in or near current saturation with low voltages (below about 30 volts) applied between the anode and cathode ambient air without the presence of combustion products:

about 2 mm. < annode anode radius < about 5.3 cm.

about 0.05 mc. < source strength (Ni^{63})< 1.6mc.

To provide stable electrical operation of the detector at the low voltages contemplated for the preferred embodiment, anode **10**, cathode **12** and interelectrode space **14** may be electrically shielded from stray field effects. To this end, the detector shown in FIGS. **1**, **2** and **3** includes a second cylindrical cup-shaped electrode **16** within which anode **10** and cathode **12** are axially aligned. Electrode **16** includes a plurality of openings **16***a* on its sides and bottom as shown to allow access of combustion products, ambient air and the like which diffuse therethrough and through the cathode openings **12***a* into the sensitive interelectrode space. Cylindrical electrode **16** is positioned close to cathode **12** in order to provide a strong field between electrode **16** and cathode **12**. For the preferred cylindrical configuration shown, a practical spacing has been found to correspond to the one established when the radius of the cylindrical electrode **16** is greater than the radius of cathode **12** but less than double the radius of cathode **12**.

For practical purposes, electrode **16** may be carried by insulating board **13** in the same manner as cathode **12**. Board **13** is enclosed in a housing **17** and held together by bolts **18**. Insulating ring **19** is included in housing **17**. However, it should be noted that housing **17** is in electrical contact with electrode **16** and is therefore maintained at the same potential. Such an arrangement provides space **20** which may be used to house the electronic circuitry for the detector. Electrically shielded circuitry is important for stable operation at the preferred low current involved. The circuitry may take the form of solid state components (not shown) mounted directly on the insulating board **13**. Electrode contacts **10***b*, **12***b* and **16***b* are shown extending through board **13** for connection to the electrical circuitry. Additional bolts **21** may be used for mounting the detector on the wall or ceiling of a building.

In FIG. **4**, the detector electrodes, which are shown schematically, are connected into an illustrative circuit. Although the basic device consisting of anode **10** and cathode **12** may be used in any of the many typical circuits known in the art for this type of detector, the type of arrangement shown as been found to be desirable in that preferred operating potentials may be conveniently applied to electrodes **10**, **12** and **16**. The circuit includes potential source means such as series-connected batteries **24** and **26**. The positive side of battery **24** is connected to a suitable reference potential, such as ground, and to electrode **16** while the negative side of battery **26** is connected to cathode **12**. Anode **10** is connected through the micromicroammeter **27** to a point intermediate batteries **24** and **26** resulting in an applied potential at anode **10** which is positive with respect to cathode **12** but slightly negative with respect to the reference potential and electrode **16**. A micromicroammeter is shown for convenience in the FIG. but other current sensing means including various arrangements for amplification may be utilized as will be obvious to those familiar with this art.

In operation during exposure to an ambient environment such as air, a selected current is set up between anode **10** and cathode **12**, which may be at or near current saturation. For the preferred embodiment shown, voltages of less than **30** volts have been found to be adequate and are in fact desired in practice. Current flows between the anode and cathode due to the ionization of the air in the interelectrode space by the beta particles emitted from the source carried by anode **10**. Upon the entrance of combustion products into the interelectrode space, the current decreases in accordance with principles already known in the art.

I claim:

1. An apparatus for detecting products of combustion of the type where unidirectional potential is impressed across the electrodes comprising:

a spaced anode and cathode electrode defining an interelectrode space and arranged to provide access into said interelectrode space for products of combustion, said anode and cathode adapted to be connected to a source of unidirectional potential;

a radioactive source of substantially only beta particles below about 1.6 mC carried by one of said electrodes for emitting beta particles into said interelectrode space to produce current carriers between said electrodes; and

means supporting said electrodes such that said interelectrode space dimensionally corresponds to less than the maximum range of the higher energy beta particles emitted from said source at said one electrode and greater than one and one-half times the half-thickness range of the beta particles emitted from said source at said one electrode.

2. Apparatus as in claim **1** wherein said radioactive source is Ni^{63}.

3. Apparatus as in claim **1** wherein: said anode is in the form of a pin, said radioactive source is a coating on said anode, said cathode is in the form of a cylinder, and said supporting means supports said pin substantially coaxially inside said cylinder.

4. Apparatus as in claim **3** wherein:

said radioactive source is Ni^{63}; and

said interelectrode space is greater than about 1 cm and less than about 5.3 cm.

5. Apparatus as in claim **4** wherein said interelectrode space is about 3 cm.

6. Apparatus as in claim **3**:

including a shielding electrode means; and

wherein said support means supports said pin anode and said cylindrical cathode substantially coaxially within said shielding electrode.

7. Apparatus as in claim **6** and further including an electrical conductive housing for enclosing electrical circuitry to be operatively connected to said electrodes, said housing being electrically connected to said shielding electrode whereby the interior of said housing is substantially shielded electrically.

8. Apparatus as in claim **5** and further including voltage source means and interconnecting circuit means for operatively applying a voltage to said three electrodes whereby said shielding electrode is maintained at a reference potential, said anode is maintained negative with respect to said reference and positive with respect to said cathode, and said cathode is maintained substantially negative with respect to said reference.

9. Apparatus as in claim **5** wherein:

the radius of said pin anode is greater than about 2 mm. and less than about 4.5 mm.;

the radius of said cylindrical cathode is greater than about 1 cm. and less than about 5.3 cm.;

said radioactive source is between about 0.05 mC and about 1.5 mC of Ni^{63};

said shielding electrode is in the form of a cylinder having a radius greater than the radius of said cylindrical cathode and less than double the radius of said cylindrical cathode; and

whereby said apparatus is adapted for substantially stable operation at about current saturation in air with an applied voltage between said anode and cathode of less than about 30 volts.

10. Apparatus as in claim **7** wherein the radius of said cylindrical cathode is about 3 cm.

11. An apparatus for detecting products of combustion of the type where unidirectional potential is impressed across the electrodes comprising:

an anode in pin shape having a radius from about 2 mm to about 4.5 mm, said anode having a coating of Ni^{63} for a radioactive source of a strength of 0.05 mC to 1.6 mC;

a cathode in generally cylindrical form having a radius of from about 1 cm. up to about 5.3 cm.;

means supporting said anode substantially coaxially inside said cathode; and

said anode and said cathode adapted to be connected to a unidirectional potential whereby said apparatus is adapted to operate substantially at an applied voltage between the anode and cathode of less than about 30 volts.