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(54) Low profile detector with multi-sided source.

(57) A low profile ionization type smoke sensor (50) is formed with a cylindrical housing (62) having a diameter on the order of 50.8 mm with a height on the order of 25.4 mm or less. A common electrode (66) is centrally located within the housing (62). A single sided ion source (74) is carried on the common electrode (66) and centrally located thereon. The ion source (74) extends into a first or reference region (68b) and into a second or active region (68a). First and second target electrodes (70, 72) are provided , attached to the housing (66), in each region (68a, 68b). The ion source (74) emits particles on paths that are substantially parallel to the common electrode (66). A 25.4 mm path, substantially parallel to the common electrode (66), is provided between the ion source (74) and each target electrode (70, 72).

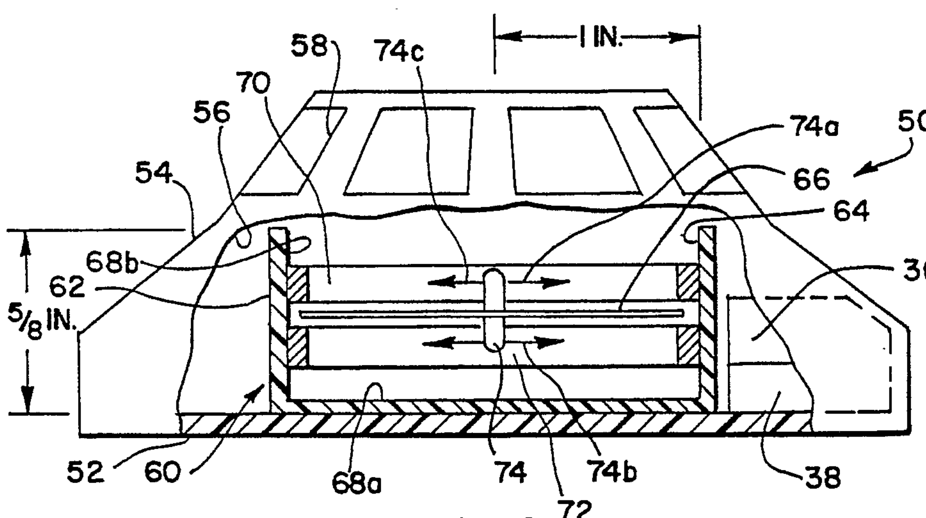


FIG. 2

EP 0 405 473 A2

LOW PROFILE DETECTOR WITH MULTI-SIDED SOURCE

This is a continuation-in-part of U.S. Patent Application Serial No. 373,156 filed June 28, 1989.

Field of the Invention

The invention pertains to ionization type smoke detectors. More particularly, the invention pertains to ionization-type smoke detectors having an extra low profile.

Background of the Invention

Ionization type smoke detectors are well-known and are particularly useful safety devices. One such detector is disclosed and illustrated in U.S. Patent No. 4,595,914 entitled Self-Testing Combustion Products Detector which is assigned to the assignee of the present invention. The disclosure of that patent is incorporated herein by reference.

Known ionization-type smoke detectors have been formed with a sensor that includes an active or detecting chamber and a reference chamber. An ion source is conventionally centrally located at or adjacent to a common or center electrode between the two chambers. Additional electrodes are located in each of the active and the reference chambers. These electrodes are conventionally spaced on the order of one inch from the center or common electrode. Such ionization chambers are often referred to as uni-polar.

A reference chamber is provided to compensate for environmental changes such as temperature, humidity or atmospheric pressure. Compensation is achieved by having the reference chamber sealed or essentially sealed. In order to achieve the best possible compensation, it is necessary to have the reference chamber reflect the environment of the active chamber as closely as possible.

Known ionization sources have been formed using a material named Americium 241 which emits alpha particles. These particles create ions throughout their pathway in accordance with the so-called "Bragg" curve. In accordance with the characteristics of this curve, known sensors have been formed with the reference chamber and the active chamber each having a height on the order of one inch. This type of sensor has a central electrode and two target electrodes. Each target electrode is spaced one inch from the common electrode. The overall height of the sensor is on the order of two inches.

In addition, the structure of the two chambers, namely the reference chamber and the active chamber, requires that the ion source extend into both chambers and emit substantially equal numbers of particles of equal energy. Hence, it is necessary to balance the two sides of the source in known prior art detectors.

In view of the utilitarian characteristics of smoke detectors, from the point of view of an interior designer, it is desirable that the detector be as inconspicuous as possible. Hence there, continues to be a need for low profile detectors. In addition, preferably a low profile detector could be constructed without having to utilize a carefully balanced two-sided ion source.

Summary of the Invention

In accordance with the invention, a low profile, horizontal ionization-type sensor is provided which is usable to detect a predetermined level of smoke in the ambient atmosphere. The smoke sensor includes a hollow housing formed of an insulating material such as a non-conducting plastic. The housing defines an interior volume or chamber. The chamber has a first dimension, or height and a second dimension or width. The height of the chamber is on the order of one-half or less of the width thereof.

A center or common electrode which has a length on the order of the width dimension is centrally positioned within the housing. The electrode divides the chamber into first and second regions having substantially equal volumes.

A first electrode is attached to and carried by the housing within the first region. A second electrode is attached to and carried by the housing in the second region.

A cylindrical or multi-faceted ion source is centrally located with respect to the center electrode and extends into each of the regions. The ion source can include a group of single sided sources which emit substantially equal quantities and energies of charged particles to each region in a plane which is parallel to the central electrode.

In order to obtain essentially a 360° radiation pattern, a four sided core or base structure that has a rectangular cross-section is centrally located and extends into both chambers of a dual chamber unit. The core is also centrally located in a single chamber unit.

A plurality of separate ion sources is carried on the core. One member of the plurality is attached to each face of the core. A four sided core requires four separate ion sources. Each source is formed of Americium 241.

A four sided multi-faceted ion source provides a reasonable approximation to a 360° radiation pattern. Where the chamber or chambers are cylindrical, the individual sources are oriented to emit radiation radially.

A core having a larger number of sides, such as six or eight, can also be used. Such a core would carry a corresponding number of ion sources and provide a more uniform ionization field. Alternately, a cylindrical source can be used.

The first and the second electrodes are displaced from the source a distance which is substantially equal to 1/2 of the width dimension.

In a preferred embodiment, the housing is cylindrically shaped with a diameter on the order of two inches. The height of the cylindrically shaped housing is one inch or less.

The first and second electrodes can be formed as cylindrical metal bands. In an embodiment wherein the housing is formed in the shape of a cylinder, the central or common electrode is formed as a planar disc shaped member. The diameter of this disc shaped member is a selected amount less than the diameter of the chamber within the housing.

The relationship between the first and second electrodes and the center electrode is such that a generally laterally or radially directed electric field can be established between the first electrode and the common electrode as well as between the second electrode and the common electrode.

The smoke sensor can be incorporated into a smoke detector unit which has a base and a cover. The smoke sensor is located on the base substantially surrounded by the cover.

Electrical circuitry is provided for biasing the sensor. In addition, circuitry is provided for generating an electrical signal indicative of smoke having been sensed in the ionization type sensor. Finally, a horn or other device is provided for generating an audible alarm in response to the presence of the smoke indicating electrical signal. Alternately, any other appropriate means could be used to indicate an alarm condition.

In yet another embodiment, a combustion products detector is provided which includes an ionization type sensing chamber which has a single region. This region is formed so as to be substantially open with respect to the ambient atmosphere. A multi-faceted or cylindrical ionization source is located within the region. First and second electrodes are provided spaced apart from one another adjacent the ionization source.

Control circuitry is provided for repetitively sensing, at spaced-apart time intervals, a potential value at one of the electrodes. As the conductivity between the two electrodes changes, in response to ambient smoke, variations in this potential value are tracked by the control circuitry. When the variations exceed a predetermined threshold, an electrical signal is generated in response thereto which can be used to initiate an audible or other alarm indicating the presence of a predetermined level of smoke in the ambient atmosphere.

Numerous other advantages and features of the present invention will become readily apparent from the following detailed description of the invention and the embodiments thereof, from the claims and from the accompanying drawings in which the details of the invention are fully and completely disclosed as a part of this specification.

Brief Description of the Drawings

Figure 1 is a schematic view, in section of a prior art ionization-type smoke detector,

Figure 2 is a schematic side elevational view, partly broken away and partly in section of an ionization-type smoke detector in accordance with the present invention;

Figure 3 is an alternate embodiment of a single chamber, low profile smoke detector;

Figure 4 is an overall flow diagram illustrating a method of operating the detector of Figure 3;

Figure 5 is an enlarged perspective view of an alternate ionization source in accordance with the present invention;

Figure 6 is a top plan view of a portion of a detector incorporating the source of Figure 5;

Figure 7 is an enlarged, fragmentary view, partly in section, of the source of Figure 5 incorporated into a dual chamber type detector; and

Figure 8 is an enlarged, fragmentary view, partly in section, of the source of Figure 5 incorporated into a single chamber type detector.

Figure 9 is a side plan view of a multi-sided detector in accordance with the present invention; and

Figure 10 is a perspective view of an alternate source multi-sided source.

Detailed Description of the Preferred Embodiments

While this invention is susceptible of embodiment in many different forms, there is shown in the drawing and will be described herein in detail specific embodiments thereof with the understanding that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the invention to the specific embodiments illustrated.

A known prior art smoke detector 10 is illustrated schematically in section in Figure 1. The detector 10 includes a base 12 and a cover 14 which can be lockably engaged with the base 12. When the cover is engaged with the base 12, an interior region 16 is defined by those two members. The detector 10 carries within the region 16 an ionization type smoke sensor 20.

The sensor 20 includes a housing 22. The housing 22 is generally cylindrically shaped and defines an interior chamber 24.

The chamber 24 is divided into two regions by a center electrode 26. A first region 28a is formed as an essentially closed reference chamber bounded by the center electrode 26 and a portion of the housing 22.

A second region 28b forms an active chamber which is open to the ambient atmosphere. Smoke in the ambient atmosphere can readily drift into the active chamber 28b via openings 14a and screens 14b in the sidewall of the housing 22 adjacent the chamber 28b.

A dual sided ionization source 30 is centrally located on and carried by the center electrode 26. The dual sided ionization source 30, formed for example of Americium 241, emits approximately equal numbers of alpha particles of approximately equal energy into each of the regions 28a and 28b.

As is known from the prior art, the alpha particles create ions throughout the regions 28a and 28b along their path length in accordance with the so-called "Bragg" curve. This curve plots ion pairs created versus distance from a source.

In the sensor 20, the optimal distance based on the "Bragg" curve results in target electrodes 32 and 34 being located approximately 25.4 mm from the ion source 30. This results in the sensor 20 having an overall height on the order of 50.8 mm. As a result, the detector 10 has an overall height on the order of (63.5 mm inches).

The detector 10 also includes electronic circuitry 36, which could be of the type disclosed in the above-mentioned Siegel issued U.S. Patent incorporated herein by reference. The circuitry 36 biases the electrodes 26, 32 and 34. In addition, the circuitry 36 monitors the output voltage at the center electrode 26. In response to an increase therein, indicating that a sufficient level of smoke has been detected in the active region 28b, the circuitry 36 can initiate an audible alarm signal via an alarm 38.

Because of the need to space the target electrodes 32 and 34, on the order of (25.4 mm) from the center electrode 26, the sensor 20 imposes a lower limit on the height of the detector 10. From the point of view of aesthetics, and overall appearance, it would be desirable to be able to reduce the overall height of the detector 10. Further, it would be desirable to be able to eliminate the need for the double sided ion source 30.

Figure 2 illustrates a smoke detector 50 in accordance with the present invention which has an overall profile substantially less than the profile of the detector 10 of Figure 1. The low profile of the detector 50 is achieved by reorienting the path length of the ionized particles from a substantially vertical direction, as in the detector 10, to a substantially horizontal direction.

As illustrated in Figure 2, the detector 50 includes a base 52 which could be mounted, for example, on a ceiling surface. Removably affixed to the base 52 is a cover 54.

The base 52 and the cover 54 together define an interior region 56. The region 56 is open to the ambient atmosphere as a result of a plurality of openings 58 defined in the cover 54.

A horizontally oriented ionization type smoke detector 60 is positioned in the region 56. The sensor 60 is formed with a housing 62. The housing 62 can be molded of a variety of non-conducting plastics such as polyester.

The housing 62 defines a chamber 64 therein. The chamber 64 is subdivided into two essentially equal volume regions by a center electrode member 66.

The center electrode member 66 in combination with a portion of the housing 62 defines an essentially closed reference region 68a. An essentially open or sensing region 68b is defined in part by the housing 62 in combination with the center electrode 66. The ambient atmosphere can readily flow into the region 68b via the openings 58 in the cover 54.

The sensor 60 includes an active electrode 70 and a reference electrode 72. Each of the electrodes 70, 72 is formed as a cylindrical stainless steel member. The center electrode 66 is formed as a planar disc shaped stainless steel member.

Centrally located on the center electrode 66 is an ion source 74. The source 74 emits alpha alpha particles in a horizontal plane perpendicular thereto preferably informly in a 360° surrounding region.

The source 74 is formed as an elongated tubular member and is attached at its center to the central electrode 66. The length of the source 74 is on the order of (12.7 mm) with a diameter in a range between (1.27 to 2.54 mm).

The source 74 which emits the alpha particles in the directions 74a-74c which in general are substantially parallel to the center electrode 66 is not a dual sided source as is the source 30. The altered structure of the sensor 60 thereby eliminates the need for the dual sided source 30.

The source 74 preferably is formed of Americium 241. Other sources which emit charged particles with the desired orientation can also be used. The type of material used for the source is not a limitation of the present invention.

The distance between the source 74 and the target electrodes 70 and 72 is on the order of (25.4 mm) for a uni-polar chamber. This distance could be less if the uni-polar regions within the chambers were to be eliminated in which case the chambers would operate in the so-called bi-polar mode. As a result, the diameter of the chamber could be substantially reduced to be on the order of (25.4 mm).

When the detector 50 is mounted on a ceiling for example, with the base 52 generally horizontal, the reference chamber 68a and the active chamber 68b assume a generally horizontal orientation as opposed to the generally vertical orientation illustrated in the detector 10.

The detector 50 can also include the electronic circuitry 36 and audio alarm 38 discussed previously.

The overall height of the sensor 60 can vary in a range between (15.88 mm to 38.1 mm) in height. The diameter of the sensor 60 is on the order of (50.8 mm).

For symmetrical operation, the sensor 60 is formed with a cylindrical housing 62. It will be understood however that the housing 62 need not be cylindrical. It can assume a variety of shapes without departing from the spirit and scope of the present invention. For example, the housing 62 could have a cross-section which is generally square, as opposed to circular, or if desired, could be formed with a half moon cross-section. In this instance, the source 74 would be located adjacent a planar edge of the housing and the target electrodes would extend in a 180° arc around the source 74 and would be located radially about (25.4 mm) therefrom.

In an alternate embodiment, the active chamber and the reference chamber could each be formed of a plurality of pie shaped regions within a circular cross-section. In this embodiment the source 74 would be centrally located and alternate regions would be formed as either portions of the reference chamber or portions of the active chamber. Such an implementation could result in a sensor on the order of (6.35 mm) high with a diameter on the order of (50.8 mm). It will be understood that none of these alternates depart from the spirit and scope of the present invention.

Figures 3 and 4 illustrate an alternate embodiment of the present invention. In the embodiment of Figures 3 and 4, a single sensing region is used simultaneously for providing a reference function as well as providing a sensing function. In addition, the sensor of the embodiment of Figures 4 and 5 can be implemented as a horizontally oriented sensor in accordance with the sensor 60 of Figure 2 thereby resulting in another form of ultra low profile detector.

With respect to Figure 3, a smoke detecting system 100 is illustrated schematically. The system 100 includes a single chamber sensor 102 which in turn is coupled to an electronic system 104.

The single chamber system 102 is formed with a plastic housing 108 with supports a center electrode 110. The center electrode 110 can be formed as a planar disk shaped member similar to the member 66 previously discussed. The center electrode 110 carries a centrally located source of ions 112. The source 112 emits charged particles on a plurality of paths 112a and 112b essentially parallel to the planar electrode 110.

The sensor 102 also includes a cylindrical target electrode 114 carried within the housing 108. The distance between the centrally located source 112 and the target electrode 114 is on the order of (25.4 mm).

The electronic system 104 includes interface circuitry 120 which is in turn coupled to microprocessor 122. The microprocessor 122 is in bidirectional communication with random access memory 124 and can receive control information as well as instructions from a read-only memory 126.

Interface circuits 120 can be used to bias the target electrode 114 and to sense voltage variations from the center electrode 110. These voltage variations can be due to atmospheric changes in temperature, humidity or ambient air pressure. They can also result from smoke or combustion products being present in the sensor 102. The sensed voltage or output signal from the electrode 110 is digitized in the interface circuits 120 before being transferred to the processor 122.

In view of the absence of a reference chamber, the sensor 102 utilizes a single chamber 108a for both the reference and active or sensing function. The processor 122 repetitively samples the voltage from the center electrode 110 and compares it to previous voltages to determine whether or not an alarm condition exists.

Figure 4 illustrates, in block diagram form, the steps of a method which can be implemented by the electronic system 104 for the purpose of repetitively sensing the output of the sensor 102.

In a step 150, the output voltage of the center electrode 110 is measured and digitized. In a step 152, the present digitized measurement is compared to a predetermined number of previous digitized measurements.

In a step 154, a determination is made as to whether or not the present measurement from the center electrode 110 varies from the prior recorded measurements by an amount which exceeds a predetermined allowable threshold. If not in a step 156, the present value is stored and the list of stored measurements can be adjusted for any variation in ambient condition such as temperature, humidity or atmospheric pressure.

On the other hand, if the measured value of voltage from the center electrode 110 has a variation from prior recorded values which exceeds a predetermined allowable threshold, a determination can be made in a step 160 as to whether or not an alarm flag had been previously set within a predetermined period of time. If so, an alarm condition has been detected and the audible alarm 38 can be energized. If not, the alarm flag can be set and the window timer can be initialized to zero in a step 162. Subsequently, a new measurement can be made in the step 150.

As a result of carrying out the method of Figure 4, the system 100 can repetitively monitor the smoke condition of the ambient atmosphere utilizing only the single chamber 108a. The steps of the method of Figure 4 can be stored in the read-only memory 126 in the form of a program executable by the microprocessor 122.

Figure 5 illustrates an alternate source 140 useable with the detector 50 or the detector 100. The source 140 is a multi-faceted, four-sided source with a core or base structure 142 that is four-sided with a rectangular cross-section. It may be formed of stainless steel.

Affixed to the core 142 is a plurality of ion producing, planar, radioactive sources 144a-144d. A material known as Americium 241 can be used for this purpose. The members 144a-144d can be affixed to the core or base 142 using conventionally available adhesives.

Figure 6 illustrates the multi-faceted source 140 installed in a cylindrical housing 60a comparable to the housing 60 of Figure 2. In this instance, the radiation pattern, generally indicated by arrows 146 emanating from the various sources is substantially radial and provides a 360° radiation pattern throughout the cylindrical chamber illustrated in Figure 6. The source 140 differs from the source 74 which is tubular or cylindrical and which carries a single planar radioactive member such as the member 144a which has been curved to assume a cylindrical shape and which is carried on a cylindrical base member.

It will be understood that six or eight sided base members could be used as an alternate to the four sided base member 142. In such instances, six or eight planar ionization sources could be used corresponding to the sources of Figure 1, 144a-144d. A larger number of sources of course has the advantage that it provides a more uniform field over the 360° range.

Source 140 of Figure 5 can be used in a dual chamber detector, such as the detector 50 of Figure 2 or a single chamber detector such as the detector 100 of Figure 3. Figure 7 is an enlarged fragmentary view partly in section of the source 140 installed on a common electrode, such as electrode 66a in a dual chamber detector. In this instance, a portion of each of the ionization sources 144a-144d extends into the reference chamber 68a and into the active chamber 68b. In this instance, the source 140 thus generates a 360° ionization pattern which is uniform for both chambers. The source 140 is held in an opening in the center electrode 66a with a press fit.

Figure 8 illustrates the .source 140 used in a single chamber detector such as a detector 100 of Figure 3. In this instance, the source 140 is positioned at the center of the circular center electrode 110 and can be affixed thereto in any conventional fashion. In this embodiment, the source 140 generates a uniform 360° ionization field throughout the single chamber 108a.

It will also be understood that the way in which the source 140 is affixed to the electrode 110 is not a limitation of the present invention.

Figure 9 illustrates as an alternate implementation, a multi-sided source 150. The source 150 is formed of stainless steel with top and bottom disks 152a and 152b. A plurality of four elongated stainless steel members 154a-154d is positioned between the disks 152a and 152b. Carried on each of the members of the plurality of stainless steel members is an elongated ion producing radioactive member 156a-156d.

The ion producing radioactive members 156a-156d can be attached to the corresponding stainless steel members by adhesive or any other conventional means. The source 150 is illustrated in Figure 9b positioned in a centrally located opening on the center electrode 66a, so as to extend equally into both the adjacent reference chamber and active chamber. Hence, the source 150 will be effective to emit charged particles uniformly throughout a 360° range in both chambers. The radioactive material can be Americium 241.

Figure 10 illustrates an alternate four sided source 160. The source 160 has a top and a bottom disk 162a and 162b. It has four elongated, spaced apart supporting members 164a-164d. Each of the members 164a-164d carries an elongated, slightly curved radioactive members 166a-166d. The source 160 can be used instead of the source 140.

From the foregoing, it will be observed that numerous variations and modifications may be effected without departing from the spirit and scope of the novel concept of the invention. It is to be understood that no limitation with respect to the specific apparatus illustrated herein is intended or should be inferred. It is, of course, intended to cover by the appended claims all such modifications as fall within the scope of the claims.

Claims

1. A low profile ionization-type sensor usable to detect a predetermined level of smoke in the ambient atmosphere comprising:
a housing (60a; 62, 108;) defining a chamber (64), said chamber (64) having a length dimension and a width dimension with said length dimension on the order of one-quarter of said width dimension,
a center electrode (66; 110) having a length dimension on the order of said width dimension and carried within said housing,
a first electrode (70; 114), carried by said housing, oriented substantialy perpendicular to said center electrode (66),
means (74; 112), centrally located with respect to said center electrode (66), for emitting charged particles on paths substantially parallel to said center electrode (66) substantially uniformly throughout a surround 360 degree region,
said first electrode (70; 114) displaced from said source (74; 114) a distance substantially equal to one-half of said width dimension.

2. An ionization-type sensor as in claim 1 wherein said center electrode (66) devides said chamber (64) into first and second regions (68a, 68b).

3. An ionization-type sensor as in claim 2 wherein said first region (68b) is substantially open to ambient atmospheric flow.

4. An ionization-type sensor as in claim 2 with a second electrode (72) carried by said housing (62) in said second region (68a).

5. An ionization-type sensor as in claim 2 with said emitting means including an ion source (74) formed as a multi-sided member extending into both of said regions (68a, 68b).

6. An ionization-type sensor as in claim 2 with said emitting means including a cylindrical ion source (112).

7. An ionization-type sensor as in claim 1 with said emitting means (140) including a multi-faceted ion source for injecting substantially equal quantities of charged particles into said chamber (108a).

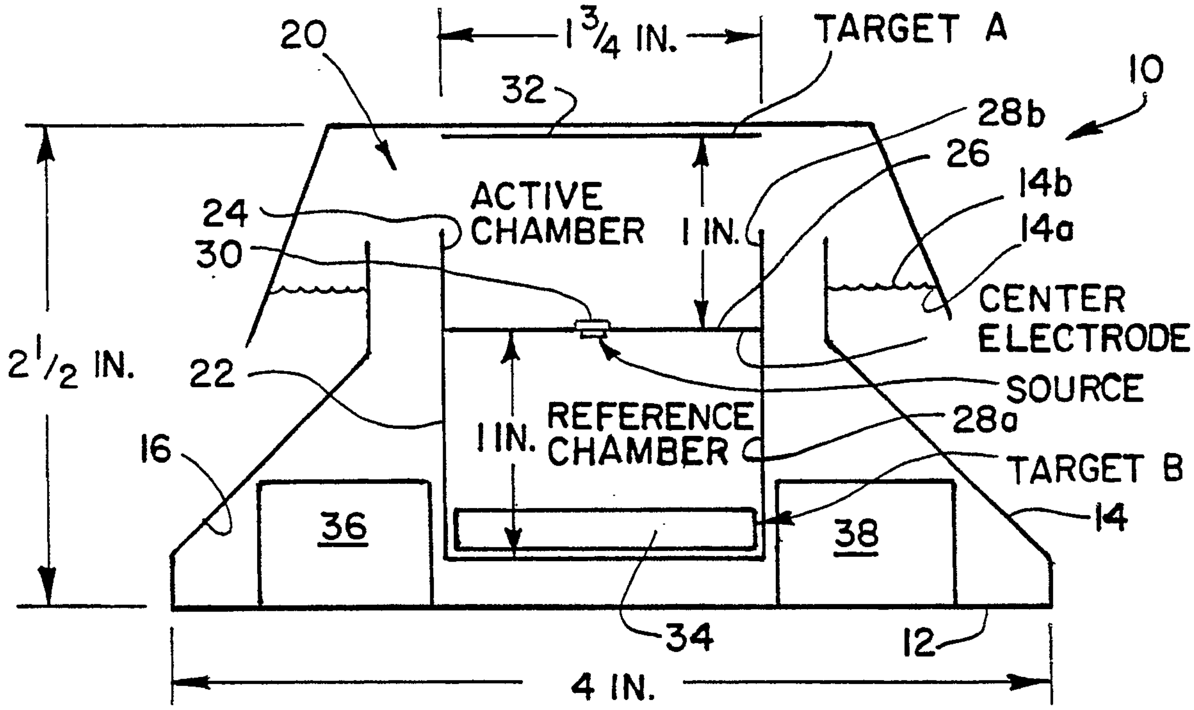
8. An ionization-type sensor as in claim 1 including:
means (100) for repetitively measuring an output signal from said chamber (108a) including means for compensating for relatively long term, non-smoke induced variations; and
means (120) for detecting a smoke induced variation in said output signal.

9. An ionization-type sensor as in claim 8 with said compensating means including means (108a) for intermittently establishing a reference condition.

10. An ionization-type sensor as in claim 1 wherein establishment of said reference condition provides compensation for changes in ambient atmospheric temperature and pressure.

11. An ionization-type sensor as in claim 8 with said measuring means including a computer.

12. An ionization-type sensor as in claim 5 with said multi-sided source (140) including a plurality of planar ion emitting elements (144a - 144d).



PRIOR ART
DUAL UNI-POLAR
FIG. 1

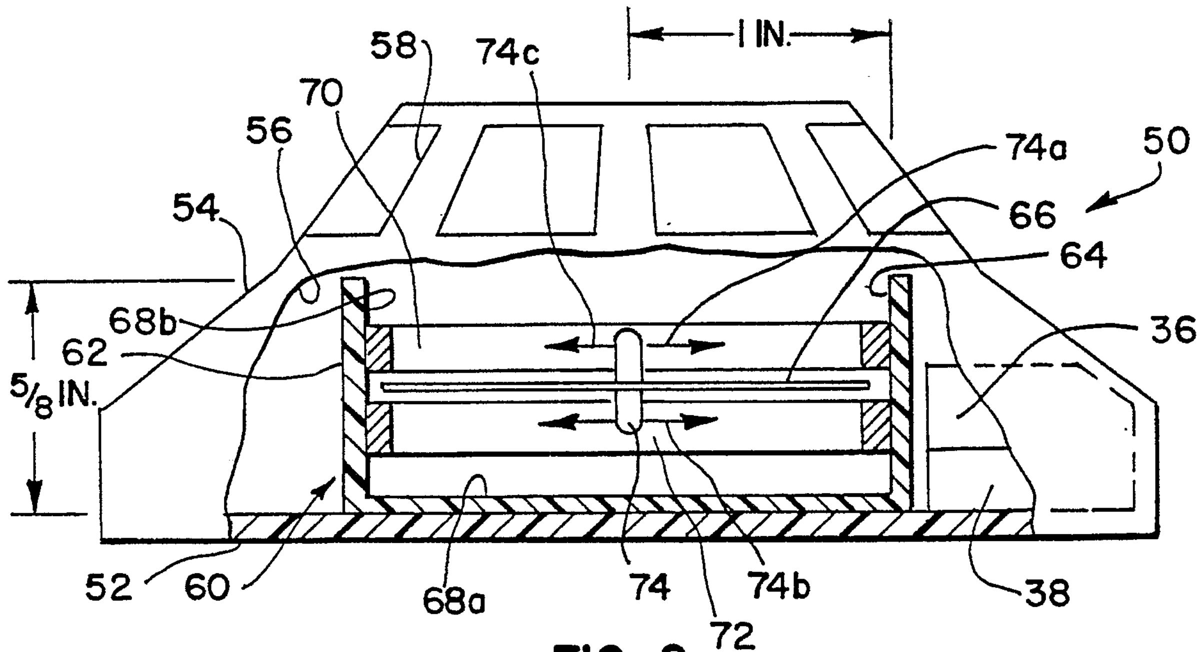
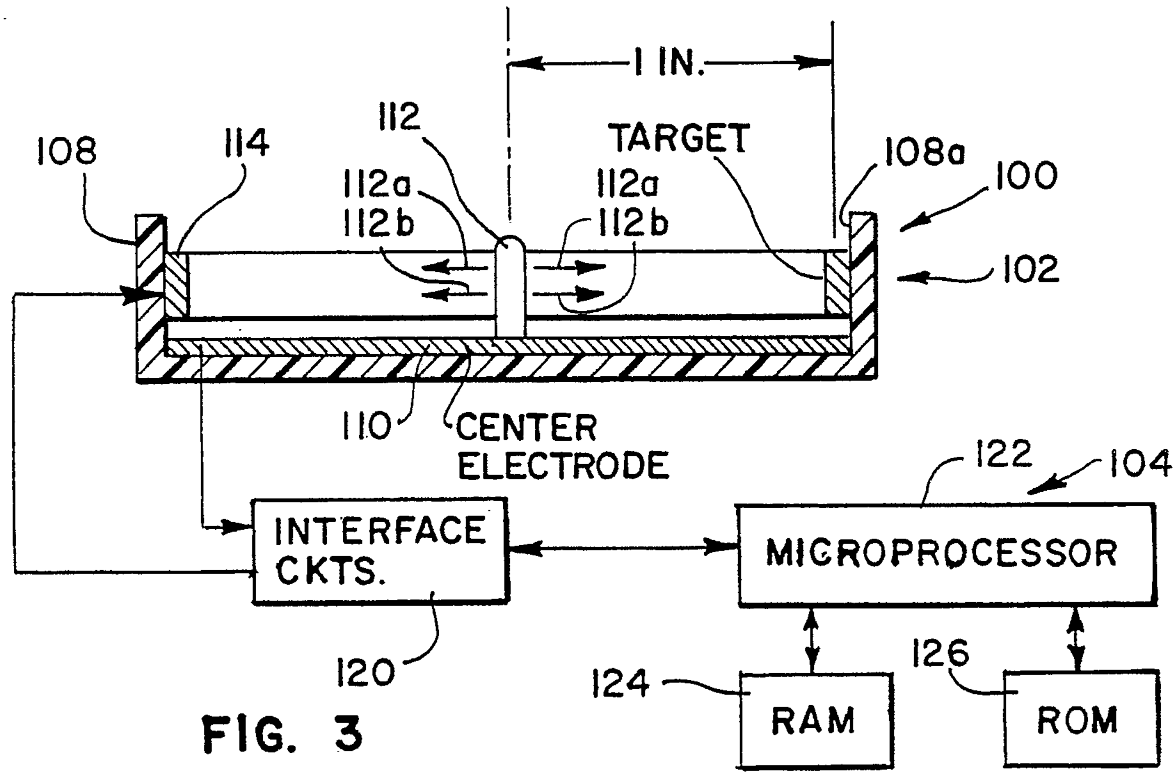


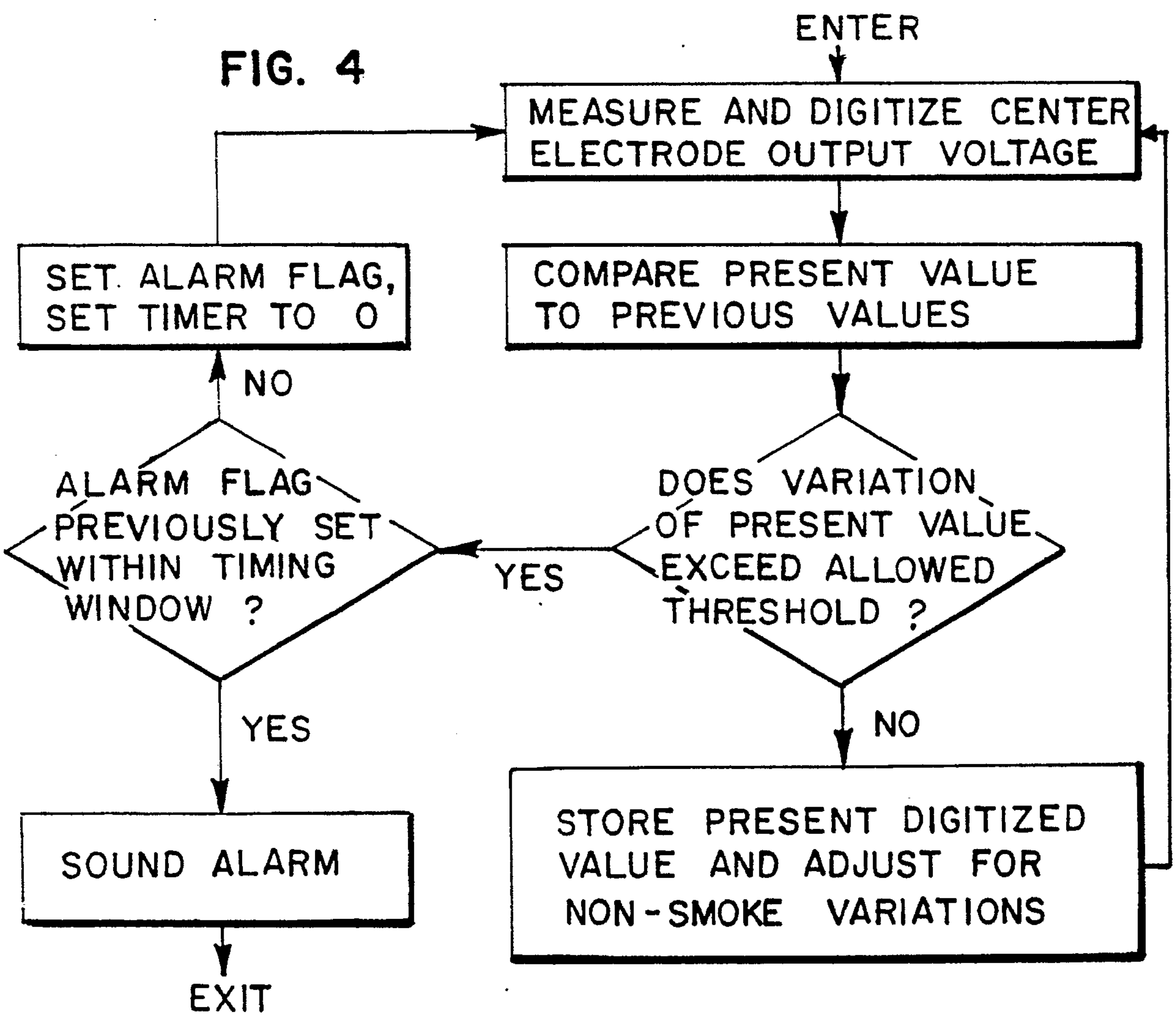
FIG. 2



1 IN.
112
108
114
TARGET
108a
100
112a
112b
112a
112b
102
110
CENTER
ELECTRODE
122
104
INTERFACE
CKTS.
MICROPROCESSOR
120
126
124
RAM
ROM

FIG. 3

FIG. 4



ENTER
MEASURE AND DIGITIZE CENTER ELECTRODE OUTPUT VOLTAGE
COMPARE PRESENT VALUE TO PREVIOUS VALUES
DOES VARIATION OF PRESENT VALUE EXCEED ALLOWED THRESHOLD ?
YES
NO
STORE PRESENT DIGITIZED VALUE AND ADJUST FOR NON-SMOKE VARIATIONS
ALARM FLAG PREVIOUSLY SET WITHIN TIMING WINDOW ?
NO
SET ALARM FLAG, SET TIMER TO 0
YES
SOUND ALARM
EXIT

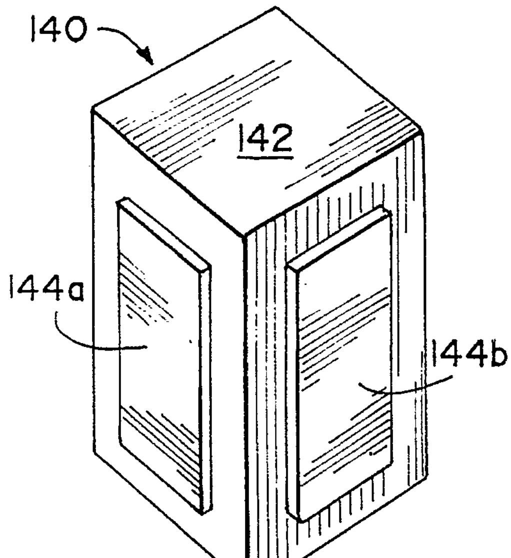


FIG. 5

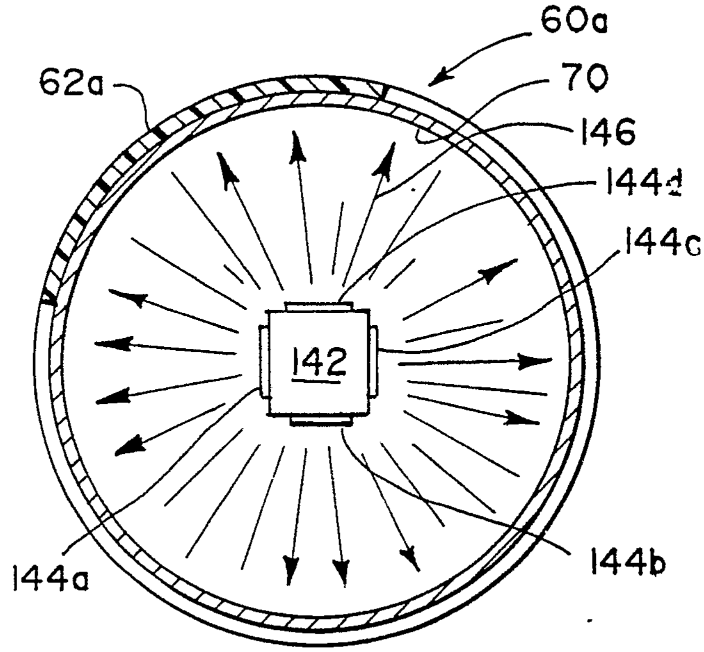


FIG. 6

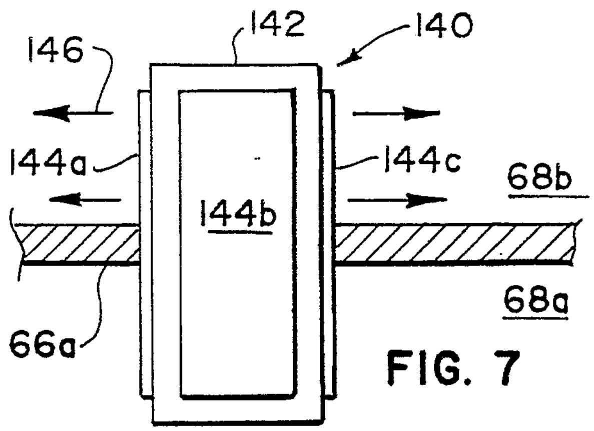


FIG. 7

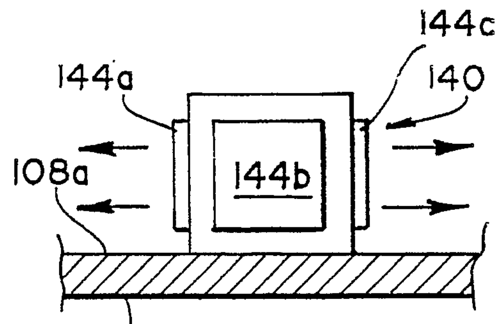


FIG. 8

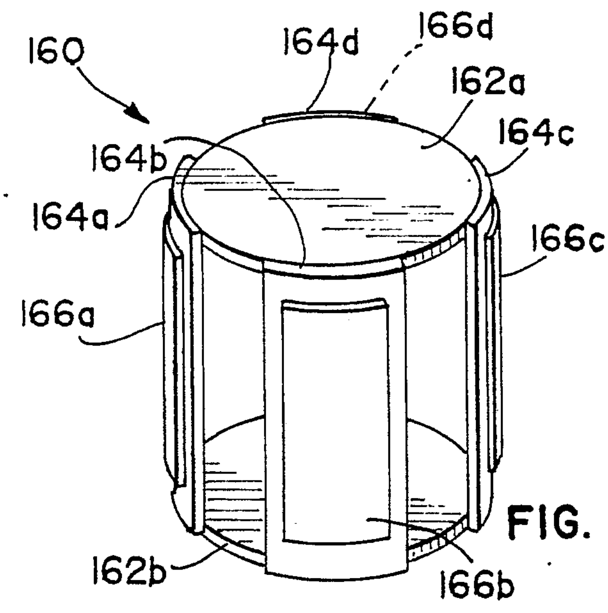


FIG. 10

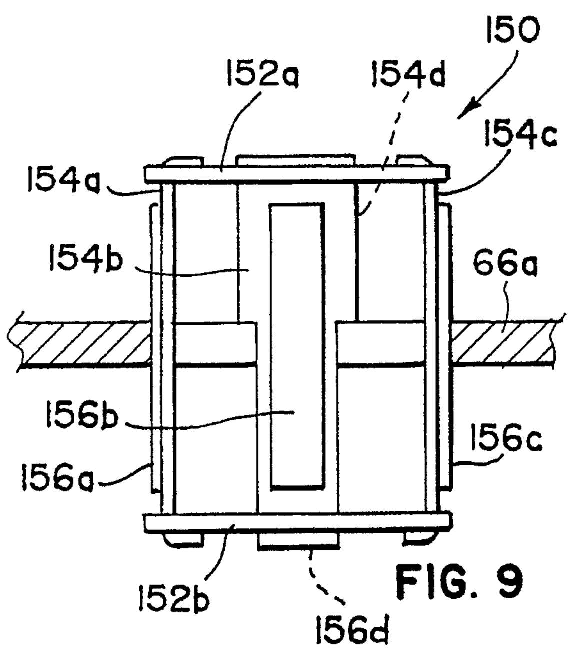


FIG. 9