

[54] **HIGH IMPEDANCE GASEOUS ION SENSING AND DETECTION SYSTEM**[75] Inventor: **Carl F. Klein**, Milwaukee, Wis.[73] Assignee: **Johnson Service Company**, Milwaukee, Wis.[22] Filed: **Jan. 3, 1972**[21] Appl. No.: **214,884**[52] U.S. Cl. **340/237 R**, 250/83.6 R, 340/237 S, 340/258 D[51] Int. Cl. **G08b 21/00**

[58] Field of Search 340/237 R, 237 S, 340/258 D, 258 R, 258 C; 250/83.6 R

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Primary Examiner—David L. Trafton
Attorney—Andrus et al.

[57] **ABSTRACT**

An air pollutant or fire combustion sensing capacitor includes a sensing electrode mounted in insulated relationship within a perforated outer grounded shield which permits the free entrance of air borne ions. The sensing electrode is connected to an amplifying and alarm circuit to respond to the accumulation of either negative or positive charge on the sensing electrode. The circuit includes a thermally stabilized field effect transistor buffer amplifier having the input terminal connected to the sensing electrode and the output connected to a high gain dual DC operational amplifier having a feedback compensation network to compensate for thermal and low frequency drift charge. A pair of transistors are connected in a differential configuration with a common input connected to the output of the operational amplifier. The alarm is connected through steering diodes to the two transistors. Either an increase or a decrease in charge thereby actuates the alarm.

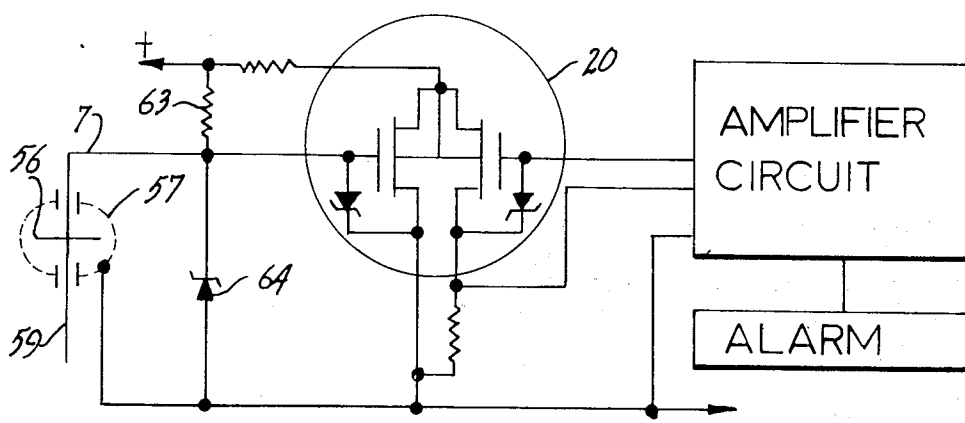
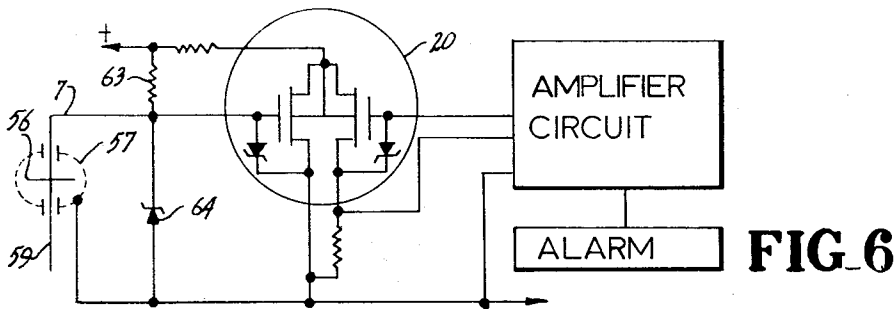
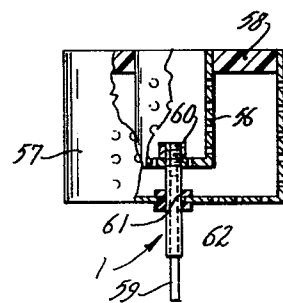
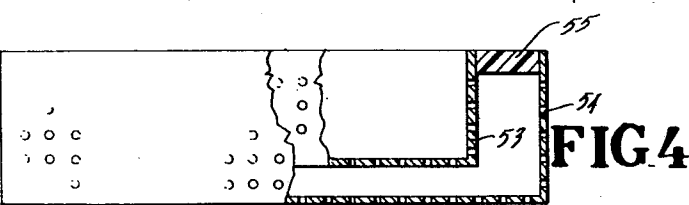
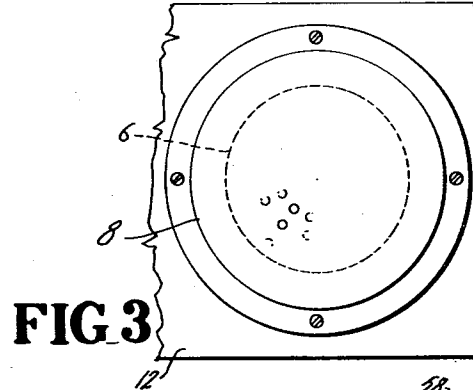
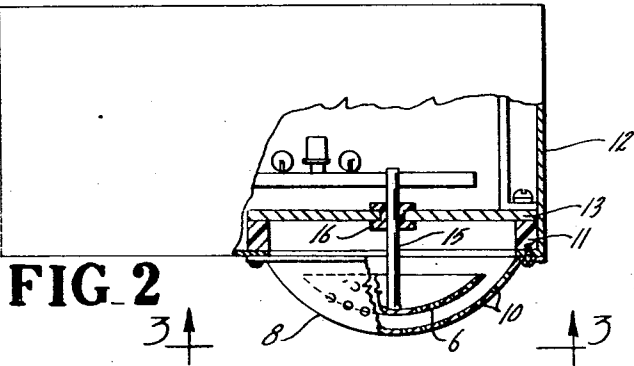
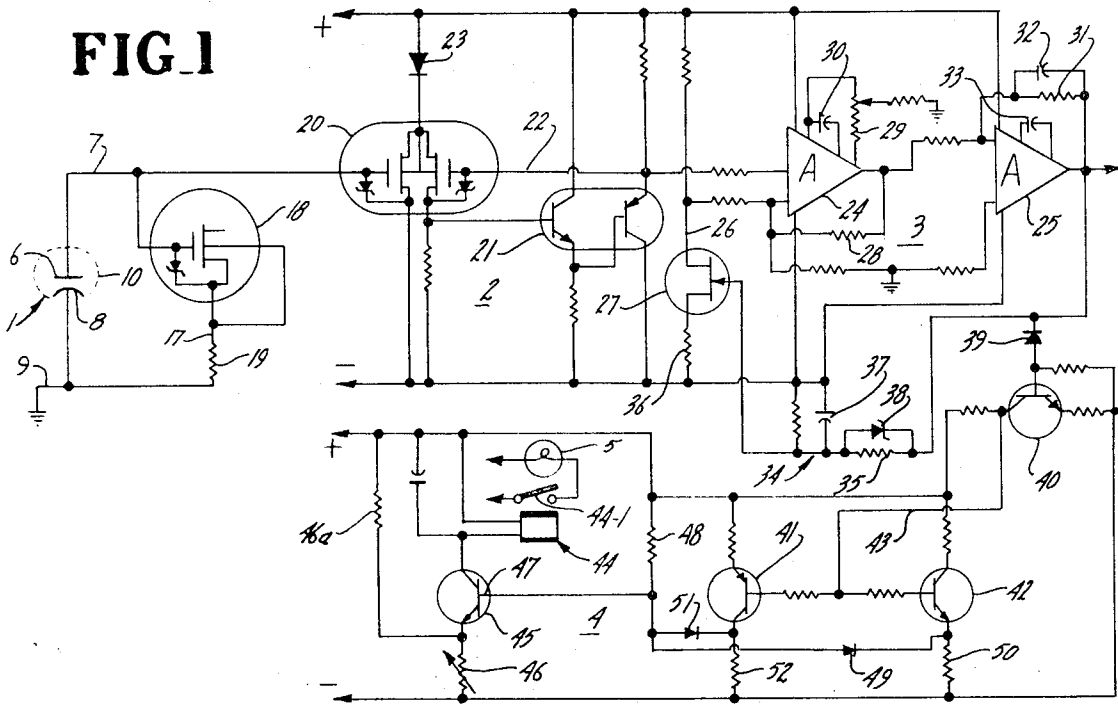
14 Claims, 6 Drawing Figures

FIG. 1



HIGH IMPEDANCE GASEOUS ION SENSING AND DETECTION SYSTEM

BACKGROUND OF THE INVENTION

This invention relates to a gaseous ion detection system and particularly to such a system for detecting ions and charged particles such as generated, for example, as a result of air pollution, combustion or the like.

High input impedance devices have been employed in intrusion detection and fire detection systems and the like. The vacuum tubes presented certain problems from the standpoint of voltages and associated circuitry. The development of high input impedance solid state devices and particularly field effect transistors has permitted substantial simplification in the circuits for such sensing devices and has also permitted more reliable designs. An unusually satisfactory intrusion detection system is disclosed in Applicant's U.S. Pat. No. 3,543,056 which issued Nov. 24, 1970. That patent particularly discloses an intrusion detection system including a wire-like antenna mounted in a space to be protected against unwarranted entry by unauthorized personnel. An induced charge on the antenna in response to the entrance of unauthorized personnel or engagement of the antenna by unauthorized personnel provides a control signal. The antenna is connected to a pair of field effect transistors to selectively trigger a pair of alarms. The field effect transistors are selected to be of opposite types thereby responding to positive and negative charge. As noted in such patent, the field effect transistor circuit may also be advantageously applied to the conventional fire detection system employing series connected ionization chambers. In the latter system, a pair of chambers are series connected to a suitable voltage source and define a voltage dividing network with the center junction interconnected to the input gate of the field effect transistors. Generally, the one chamber is freely open to the atmosphere while the other chamber is shielded against the rapid admission of particulate matter. Each chamber is provided with a separate radioactive source producing ion pairs within the chamber to establish a selective conductivity. In the absence of combustion particles and the like, the resistance levels are such that the voltage division across the two chambers maintains a non-triggering output voltage on the gate. Particles of combustion which enter the freely open chamber impede the flow of current through the corresponding chamber and effectively increase its resistance. This results in a variation in the voltage division across the two detection chambers which is detected by the field effect transistor and actuates the alarm.

Although such systems have provided very significant advantages over the more conventional vacuum tube fire alarm systems, they have relied on the use of the special ionization chambers with the separate radioactive sources. Such constructions contribute to the expense of the apparatus and of course the use of radioactive material can present unique problems.

SUMMARY OF THE PRESENT INVENTION

The present invention is particularly directed to a novel and improved sensor for detecting the presence of gaseous borne ions in a given space or volume and is particularly useful for sensing or detecting of air pollution levels and the ions generated in the incipient shape of combustion. Generally, in accordance with

the present invention, a charge sensing capacitance means includes a sensing electrode element mounted within a chamber defined at least in part by a referenced electrostatic shield means. The shield means permits movement of the surrounding environment such as the atmosphere freely into the chamber within which the sensing electrode is disposed. When the charge gradient on the sensing electrode changes, either due to direct or induced charge transfer, the voltage across the capacitance element changes in accordance with the usual formula of a change in charge divided by the capacitance of the unit. This provides a voltage which can be detected by high impedance devices such as the field effect transistors or any other similar high impedance device. A particularly satisfactory unit is a dual MOS-FET transistor operating in its active region.

As applied to a fire detection unit, the sensing unit would be mounted in the area to be protected. During the incipient stage of combustion invisible charged particles are released as the result of the initiating of the burning process. Although they are of a very small charge, Applicant has found combining of the sensing capacitance means with a high impedance sensing and amplifying means provides reliable detection of the presence of the products of combustion during the incipient stage.

In addition to detection of combustion ions, pollution ions and particulate matter charge change in the surrounding volume, the apparatus may also detect unauthorized intrusion in the system. Thus, a separate sensing antenna such as disclosed to the previously referred to issued U.S. Pat. No. 3,543,056 may be connected to the input element in common with the fire detection chamber.

In accordance with a particular and novel construction of the present invention, a sensing electrode is mounted within a dome shaped perforated ground shield. The sensing electrode is mounted with a high bulk and surface resistivity insulator to prevent charge leakage. The sensing electrode is connected as the input to a dual MOS-FET transistor which is coupled to a pair of complementary transistors to establish a thermally stable high input impedance transformer circuit. The sensing electrode is either connected to a bias network or allowed to float with respect to ground. In either event it is preferably shunted to ground with a large value resistance means to prevent gradual accumulation of charge on the sensing capacitor means and to thereby improve the stability and reliability of operation. The resistance means is preferably a zener diode or other type of a high resistance semi-conductor device because of the low noise properties of such devices. The output of the transistor amplifier is connected to a high gain DC operational amplifier to establish an amplified output signal which is applied to a level detection and alarm circuit. Feedback means are provided to suppress transient signals and to compensate for charge drift or thermal effects. The change in the sensor's charge gradient can be either positive or negative and, consequently, the sensing circuitry for optimum results, must respond to both the positive and negative changes in the quiescent charge condition.

The level detection circuit can advantageously be constructed with a pair of opposite type transistors having their inputs connected through suitable coupling resistors directly to the output of the DC amplifier. In the quiescent state both of the transistors are biased on.

A change in either positive or negative potential results in a corresponding change at the input to the two transistors driving the one transistor off and the other transistor further on. The alarm circuit is connected through control diodes to both of the transistors such that conduction of either actuates the alarm circuit.

The present invention thus provides a simplified and improved means of sensing and determining changes in the charge concentration of air ions, pollution ions and particulate matter carried in a surrounding atmosphere or environment.

BRIEF DESCRIPTION OF THE DRAWING

The drawing furnished herewith illustrates the preferred constructions of the present invention in which the above advantages and features are clearly disclosed as well as others which will be clear from the following description of such embodiments.

In the drawing:

FIG. 1 is a schematic circuit diagram of a fire detection apparatus incorporating the sensing means of the present invention;

FIG. 2 is a top elevational unit of a sensing unit such as diagrammatically shown in FIG. 1 with parts broken away and sectioned to show details of construction;

FIG. 3 is a fragmentary front elevational view taken generally on line 3—3 of FIG. 2;

FIG. 4 is a diagrammatic view of an alternative construction of a sensing unit or head constructed in accordance with the present invention;

FIG. 5 is a view similar to FIG. 4 showing a further modification in a construction of a sensing chamber or unit and the incorporation of an electrostatic intrusion detection device; and

FIG. 6 is a schematic circuit diagram showing a modification to the bias network of the sensing chamber head and also showing the dual sensing of charged particulate matter and intrusion of unauthorized personnel.

DESCRIPTION OF THE ILLUSTRATED EMBODIMENT

Referring to the drawing and in particular to FIG. 1, an ion detection system constructed in accordance with the teaching of the present invention is shown generally including a capacitive charge sensing head 1 mounted within a given area within which any combustion is to be detected. The output of the head 1 is interconnected in the embodiment of FIG. 1 to a buffer amplifying stage 2 which provides high input impedance isolation to a high gain amplifying stage 3, the output of which is connected to a level detection and alarm circuit 4. The system shown in FIG. 1 will respond to either a positive or a negative potential variation in the environment adjacent the sensing head 1 to actuate the alarm circuit 4 and provide an indication of a selected changed condition. The alarm 4 may take any desired form either visual, audible or a combination thereof, and is shown for purposes of subsequent description as a lamp 5.

The charge sensing head 1 is a capacitance charge sensitive means and includes a sensing electrode or plate 6 connected via a connecting lead 7 directly to the input of the buffer amplifier 3. The opposite plate 8 of the sensing head 1 is connected to a reference potential, shown as a ground line 9. The plate 8 is in the form of an enclosure surrounding the plate 6 with

openings 10 to permit free movement of the surrounding environment into the enclosure.

A physical construction of the head 1 with a supporting housing assembly is illustrated in FIGS. 2 and 3. The enclosure electrode 8 is shown as a dished perforated semi-cylindrical member having a mounting flange 11 connected to an outer enclosure 12. A mounting plate 13 is mounted within the enclosure 12 within which the circuit components can be mounted. The electrode 8 includes a plurality of openings or perforations 10 permitting an essentially free access of the surrounding environment into the interior of the dome-shaped enclosure defined by the capacitance electrode 8. The opposed electrode 6 is shown as a somewhat smaller dome-shaped member disposed within the electrode 8 and with a mounting terminal or connector rod 15 suitably secured within an opening with an insulating support 16 to support the electrode 6 in spaced relationship to the plate 8. The insulator 16 is preferably a high bulk and surface resistivity insulator which isolates the capacitance sensing probe 6 from ground. The terminal 15 extends through the plate and is connected into the circuitry within the housing 12 in accordance with well-known circuit design constructions.

The housing 12 is mounted within the environmental space or area within which the air ion variations are to be detected, with the openings 10 allowing relatively free movement of the surrounding environment around the electrodes and in particular between the electrodes 6 and 8. In the event of combustion, the process of combustion results in the generation of invisible incipient charged particles which will be rapidly dispersed within the enclosed area such as a room. Entry within the chamber defined by capacitance electrode 8 will change the capacitance of the sensing head 1 and provide a related signal to the circuitry for detection of the incipient stages of combustion. Thus, the charge gradient of the sensing electrode 6 is responsive, either by direct or induced charge transfer to the environmental charge state, with a resulting conversion to a voltage signal developed across the plates or electrodes 6 - 8. The corresponding voltage signal appears across the signal lead 7 and the reference lead 9. When this signal is applied to a high input impedance circuit such as presently described, Applicant has found that the charge variation associated with phenomena such as incipient combustion is sufficiently significant to provide an operative detection circuit. It should be noted that the device might respond to other charged gaseous or air ion conditions in the surrounding environment.

Referring again to FIG. 1, the lead 7 is connected as the input to the buffer amplifying stage 2 with a high value resistance branch 17 connected in parallel with the head 1. The branch 17 acts as a bleed resistance which prevents the gradual accumulation of charge on the capacitor of head 1 with time and thereby maintains reliable detection. The illustrated branch 17 includes a field effect transistor 18 having a Zener gate input connected in series with a resistor 19. The transistor 18 provides a very high impedance with essentially no noise generated signals and with good thermal stability. This is in contrast to employing of a carbon resistor or the like which are electrically noisy and have poor thermal stability. The resistor 19 provides low noise change bias stabilization.

The input stage of the buffer amplifying stage 2 is shown as a dual field effect transistor 20 connected in a differential amplifier configuration and coupled to a complementary pair of transistors 21. Although any suitable high impedance device or circuit can be employed, a MOS-FET transistor is particularly adapted to this application because of its very high input impedance, of the order of 10×10^{14} , and its ability to detect a very small voltage variation. The dual field effect transistor 20 is shown having a first gate connected to lead 7 and a second gate connected via a feedback lead 22 to the output of the complementary pair of transistors 21. The source electrodes of the dual transistor 20 are connected to the bias supply via a current limiting diode 23 to establish a constant current supply.

The output of the transistor 20 is connected to the complementary transistors 21 which are emitter follower connected transistors establishing further thermal stability by prevention of thermal drift.

The output of transistors 21 is connected as the input to the high gain amplifying stage 3, which is shown in the preferred construction including a pair of high gain operational amplifiers 24 and 25 with compensating feedback networks. The amplifier 24 has the one input connected to the output of the complementary transistors 21. The second input of amplifier 24 is connected to a stabilizing feedback branch 26 which includes a field effect transistor 27 establishing a feedback controlled high impedance input to the amplifier 24. The amplifier 24, in addition to a gain controlling feedback resistor 28 includes a zero offset adjustment potentiometer 29 connected in a feedback network for offset adjustment. A high frequency shaping capacitor 30 is also connected in a feedback branch to reduce high frequency transient signals such as signals above 10 Hz .

The output of amplifier 24 is connected as one input to the second stage operational amplifier 25. The amplifier 25 includes a gain controlling feedback resistor 31 having a gain shaping paralleled capacitor 32. A high frequency roll-off capacitor 33 is also provided to further increase the signal to noise ratio by suppressing transient signals.

The output of the amplifier 25 is fed back to the transistor 27 through a stabilizing network 34 to provide further thermal stability and to prevent low frequency charge drift. The network 34 includes a series resistor 35 connecting the output to the gate of the transistor 27 which is connected to negative bias supply in series with a resistor 36. A capacitor 37 is connected across the input to the transistor 27.

The resistance values of the resistors 35 and 36, the input impedance of the transistor 27 and the capacitance value of the capacitor 37 determined the time constant of the network and the amplitude of the signal. A Zener diode 38 is connected in parallel with the series resistor 35 to permit rapid charging of the capacitor 37 and thereby prevent oscillations. The feedback provides compensation for ambient thermal charges and low frequency charge drift over long time periods. Although such signals may be very small, the exceptional high gain provided by the cascaded amplifiers 24 and 25 could result in significant error if signal compensation is not provided.

The cascaded operational amplifiers 24 and 25 provide low noise, high gain amplification which permits accurate and reliable detection of the small voltage changes in the ion concentration such as that caused by

combustion, air pollution and the like. The gain shaping, particularly with the roll-off above 10 Hz , eliminates a further source of transient signals while transmitting the low frequency ion detected signals.

The output of the operational amplifier stage 3 is thus an amplified signal directly related to the small input voltage signal to the dual field effect transistor 20. The stabilized and amplified output signal is connected by a D.C. coupling diode 39 to a further amplifier 40, with the output connected to drive the alarm circuitry 4 in accordance with variations in the signal in either direction from the normal quiescent operating point, as follows.

The alarm circuitry includes a pair of complementing transistors 41 and 42 having their inputs connected in common to the output lead 43 of the amplifier 40. Thus as the signal moves from the quiescent operating point, it will tend to drive one transistor on and the other transistor off depending upon direction of movement.

More particularly, the transistor 42 is shown as an NPN transistor suitably connected to the bias supply. As the output of the amplifier 40 rises in a relatively positive direction it will tend to drive the base to emitter junction in a forward direction thereby biasing the transistor 42 on. The transistor 41 is a PNP transistor suitably connected to the bias supply. The same positive increase in the signal at line 43 therefor further biases transistor 41 to a lesser conductivity. An opposite movement of the quiescent operating point at line 43 will, of course, oppositely bias the transistors 41 and 42, and particularly biases the transistor 41 on and biases transistor 42 off.

The alarm output lamp 5 is connected to the output circuits of the transistors 41 and 42 to respond to the input of either transistor. A relay 44 is connected into the output circuit of a transistor 45 and includes contacts 44-1 connected to control the power supply to the lamp 5. Thus when the relay 44 is energized, the contacts 44-1 close and deenergize the lamp. Any other suitable connected alarm, visual, audible or the like, can also, of course, be connected into the circuit in a similar manner.

The relay 44 is coupled to the transistors 41 and 42 through the output driving transistor 45, the conductivity of which is controlled by conduction of either one of the transistors 41 and 42. Thus, the transistor 45 is shown as an NPN transistor connected to the bias supply, with the relay 44 connected in the collector circuit and an adjustable potentiometer 46 connected in the emitter circuit which is also connected directly to the positive bias supply via a resistor 46a. The base 47 of the transistor 45 is connected via a resistor 48 to the positive bias supply line. The transistor 45 is thus biased to conduct as the result of power supplied through the resistor 48 to the base.

The transistor 45 is driven off as the result of selective conduction of either one of the transistors 41 or 42. Thus, the base 47 of transistor 45 is also connected to the emitter circuit of the transistor 42 via a diode 49 and thus to the negative side of the bias supply in series with the emitter resistor 50 of transistor 42. A diode 51 similarly connects the base 47 of the transistor 45 to the emitter of the transistors 41, which, in turn, is connected in series with the resistor 52 to the negative supply.

With the transistors 41 and 42 in the quiescent normally on condition, the diodes 49 and 51 are biased off

and prevented from conducting current via the associated resistors 50 and 52. When either transistor 41 or 42 is driven off, the associated diode 49 or 47 is biased on, thereby permitting conduction through a low impedance path of the corresponding resistors 50 or 52. The conduction through a single one of the two paths provided by diodes 49 and 51 diverts sufficient turn-on current from transistor 45 to hold the transistor 45 off. The result of the decreased current flow through the base to emitter circuit of transistor 45 results in the turn off of the transistor and the deenergization of the relay 44. Contacts 44-1 then close and energize the warning lamp 5; thereby indicating the detection of a dangerous or undesired ion level at the head 1, such as caused by air pollutants, the incipient stage of combustion or the like.

Thus, regardless of whether there is a negative or a positive charge detection with a corresponding opposite polarity varied movement of the potential at lead 43, one of the transistors 41 and 42 is driven off thereby providing for detection of both positive and negative variation from the normal environmental conditions.

In summary, the charge sensitive capacitance chamber or head 1 is mounted to be subjected to the surrounding environment and with a normal environmental condition the output of the operational amplifier is in a quiescent condition as determined by the setting of potentiometer 46. Transistors 41 and 42 are in a normal standby condition. Charge particles or ions such as generated within the surrounding atmosphere or environment in the incipient stage of combustion will rapidly move into the vicinity of the capacitance sensing electrode 6. As a result, the charge gradient on the surface of this electrode 6 will change with a resulting change in the voltage or potential applied to the one gate of the dual field effect transistor 20. As the result of the very high input impedance, very slight voltage changes can be reliably detected.

Depending upon whether or not the charge gradient change is positive or negative, a corresponding voltage change will be applied to the transistor 20. In either event, a related polarity change in conductivity of the transistor 20 is established with the resulting change in the signal via the coupling transistor 21 to the dependent input of the operational amplifier 24. A corresponding amplified change in the output of the amplifier 25 appears at the output line 43. As previously noted, either a positive or a negative deviation of a selected level will, of course, trigger the level detection and alarm circuit 4 deenergizing relay 44 and turning on lamp 5 or otherwise actuating a suitable alarm means.

In this manner, a reliable environmental charge sensing device is provided which eliminates the complexity of the prior art double ionization chamber heads as well as the disadvantage of requiring radioactive sources.

The sensing head can of course employ any suitable configuration wherein a pair of electrodes or plates are interconnected and located to define a capacitance. For example, in FIG. 4 a pair of rectangular cup-shaped electrodes 53 and 54 are shown mounted in telescoped, spaced relationship. The electrode 53 is somewhat smaller in size than the electrode 54 to define a predetermined spacing therebetween. The electrodes are connected to an insulator 55 with the electrodes 53 and 54 telescoped over the edges and suitably secured in

any desired manner. The electrode 53 defines the sensing electrode and the electrode 54 defines the ground shield generally as described with respect to the previous embodiment.

A further alternative embodiment is shown in FIG. 5 wherein a pair of generally cylindrical electrodes 56 and 57 are shown with the inner sensing electrodes 56 coaxially mounted within and spaced from the larger outer ground shield electrode 57. Once again the electrodes are interconnected to a suitable insulating support 58 with the electrodes suitably connected into the circuit such as shown in FIG. 2, or any other suitable circuit to provide for sensing of capacitance variations associated with charged conditions in the surrounding environment.

In the embodiment of FIG. 5, the sensing head 1 is modified to include an intrusion sensing antenna or probe 59. The sensing electrode 56 is formed with a threaded coaxial hub 60 in the outer base portion and the outer reference electrode includes a coaxial opening 61 in the outer base portion. The probe 59 is shown as a telescopic rod extending through the opening 61 with the inner end threaded into the hub 60. An insulator 62 of suitable high bulk resistivity material encircles the rod at the opening 61 to insulate the probe from the reference electrode.

The high input impedance of the device circuit permits the electrostatic detection of an intruder in the area of the sensing electrode. Thus, an intruder moving into the area will induce a charge on the electrode probe 59 due to the static charge of a person's body. This, in turn, results in a change of potential on the probe 59 and electrode 56 which is impressed on the gate of the field effect transistor 20. An amplified signal provides the desired triggering generally in accordance with Applicant's previously referred to issued U.S. Pat. No. 3,543,056. Alternatively, the head 1 can be removed and one or more intrusion wires or probes can be connected to the gate of the circuit.

Further, the circuit of FIG. 1 illustrates a capacitance sensing electrode referenced to ground to prevent charge accumulation. Alternatively, the capacitance sensing head can have a referenced interconnection of the capacitance unit with the bias supply, as shown in FIG. 6. Only the input portion of the circuit is shown and corresponding elements are similarly numbered in accordance with the numbers of FIGS. 1 and 5 for simplicity and clarity of explanation. Thus, the lead 7 is connected directly to the gate and to the junction of a resistor 63 and a low leakage Zener diode 64 connected to the bias supply to bias the gate. The capacitor plate 56 is similarly connected to the lead 7. The plate 57 is connected to the negative supply with the diode 64 functioning as the large resistance means connected in parallel with the sensing head to prevent accumulation of charge with time. The field effect transistor 20 is otherwise connected in the circuit as shown in FIG. 1 and the balance of the circuit is similarly as shown in FIG. 1, or any other suitable response circuit is provided to actuate an alarm means. The circuit of FIG. 6 essentially functions in the same manner as that of FIG. 1 and no further description thereof is given.

The present invention thus provides a reliable and relatively inexpensive detection system for determining the ion content in a surrounding gaseous atmosphere and is particularly adapted to determining incipient stages of combustion, air pollution and the like. The in-

vention has been particularly described with detection of air ions for purposes of clearly illustrating preferred constructions and uses, but can be employed in any gaseous environment in which ions are generated. In relatively large areas, a plurality of capacitive sensing units may be distributed through the area and connected to a single input circuit if individual units are not desirable.

Various modes of carrying out the invention are contemplated as being within the scope of the following claims, particularly pointing out and distinctly claiming the subject matter which is regarded as the invention.

I claim:

1. An environmental ion sensing apparatus for detecting a change in the charge in environmental borne elements, comprising an amplifying circuitry including an input means having a high input impedance, a capacitance sensing means including a pair of spaced capacitance electrode means one of which is connected to a reference potential to define a reference electrode and the other of which is directly subjected to the surrounding environment to define a sensing electrode with the charge gradient of the sensing electrode directly related to the environmental charge concentration, means connecting said sensing electrode to the high impedance input means of the amplifying means, and a low leakage semiconductor diode means connected in parallel with said sensing means, said diode means being connected to maintain a high impedance of low noise characteristic across the sensing means and thereby prevent accumulation of charge on the sensing means.

2. The apparatus of claim 1 wherein diode means is a Zener diode.

3. The apparatus of claim 1 wherein the charge sensitive capacitance means includes a reference electrode in the form of an enclosure surrounding the sensing electrode, a large resistance connecting said sensing electrode to the reference electrode to prevent charge accumulation, and a high surface and bulk resistivity insulator mounting said sensing electrode to prevent by-passing of said diode means.

4. The apparatus of claim 1 wherein said reference electrode includes a central opening, said sensing electrode having a mounting opening coaxially aligned with said central opening, a sensing probe secured within said mounting opening and extending outwardly through said central opening to subject the sensing probe to the movement of intruding static charged bodies into the area to provide an intrusion detection response.

5. The apparatus of claim 4 and having a high bulk and surface resistivity insulator between said central opening and said probe.

6. The apparatus of claim 1 wherein the amplifying circuitry includes a field effect transistor having the gate connected to the sensing electrode to define the high input impedance, an operational amplifier having an input connected to the output of the field effect transistor to provide an amplified signal corresponding to the charge gradient on said sensing electrode, a level detection and alarm circuit connected to the output of the operational amplifier and responsive to selected changes of negative and positive voltages from a quiescent operating voltage to indicate the corresponding selected change in the capacitance circuit gradient.

7. The apparatus of claim 6 wherein the level detection and alarm circuit includes a pair of transistors having their inputs connected in common to the output of the operational amplifier and oppositely responding to the changes of negative and positive potential voltages from the quiescent operating voltage and output means connected to both of said transistors and responsive to a selected corresponding change in the conductivity of either one of said pair of transistors.

8. The apparatus of claim 1 wherein the reference electrode is a semispherical dish-shaped aperture plate having a plurality of apertures, a support connected to said plate, said sensing electrode being a solid semispherical dish-shaped plate having a coaxially mounted terminal connected to said sensing electrode and extending rearwardly through said support, and coupled to the terminal insulator to mount the sensing electrode in equicircumferential spaced and insulated relationship to the inner surface of said reference electrode.

9. The apparatus of claim 1 wherein said reference electrode is removably mounted with respect to said sensing electrode whereby said sensing electrode can be removed to directly expose said sensing electrode to the surrounding atmosphere to subject the sensing electrode to the movement of intruding static charged bodies into the area to provide an intrusion detection response.

10. An environmental ion sensing apparatus for detecting a change in the charge in environmental borne elements, comprising an amplifying circuitry including an input means having a high input impedance, a capacitance sensing means including a pair of spaced capacitance electrode means one of which is connected to a reference potential to define a reference electrode and the other of which is directly subjected to the surrounding environment to define a sensing electrode with the charge gradient of the sensing electrode directly related to the environmental charge concentration, means connecting said sensing electrode to the high impedance input means of the amplifying means, a dual field effect transistor connected as a differential amplifier with a first gate connected to the sensing electrode to define a high input impedance and having a second gate, a complementary pair of transistors having an input connected to the output of the dual field effect transistor and an output means connected in said second gate, and operational amplifier means having an input connected to the output means of the pair of transistors to provide an amplified signal corresponding to the charge gradient on said sensing electrode, and a detection circuit connected to the output of the operational amplifier and responsive to selected changes of both a negative voltage and a positive voltage from a quiescent operating voltage to indicate the corresponding selected change in the capacitance charge gradient.

11. The apparatus of claim 10 wherein operational amplifier means includes a pair of cascaded operational amplifiers including a first operational amplifier having one input connected to the output of the pair of transistors, and having a second input, a feedback network including a voltage dividing bias supply connected to said second input and having a high impedance transistor controlling the signal to said second input, said feedback network including a resistive-capacitive branch connecting the output of the second operational amplifier to said high impedance transistor.

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12. The apparatus of claim 11 wherein the high impedance transistor is a field effect transistor connected in series with a resistor to a circuit common potential supply and having a gate, said resistive-capacitive branch includes a timing resistor in series with the gate and the output means of the second operational amplifier and a capacitor connecting the gate to said common potential supply.

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13. The apparatus of claim 12 having a diode means connected across said timing resistor.

14. The apparatus of claim 11 wherein each of said operational amplifiers includes a capacitive feedback means to suppress high frequency above a selected level.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,754,219 Dated August 21, 1973

Inventor(s) CARL F. KLEIN

It is certified that error appears in the above-identified patent
and that said Letters Patent are hereby corrected as shown below:

Col. 9, line 34 After the word "wherein" insert
(Claim 2) ---said---

Signed and sealed this 18th day of December 1973.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

RENE D. TEGTMEYER
Acting Commissioner of Patents