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IONIZATION CHAMBER DETECTION APPARATUS HAVING
A LOW VOLTAGE SOURCE MEANS
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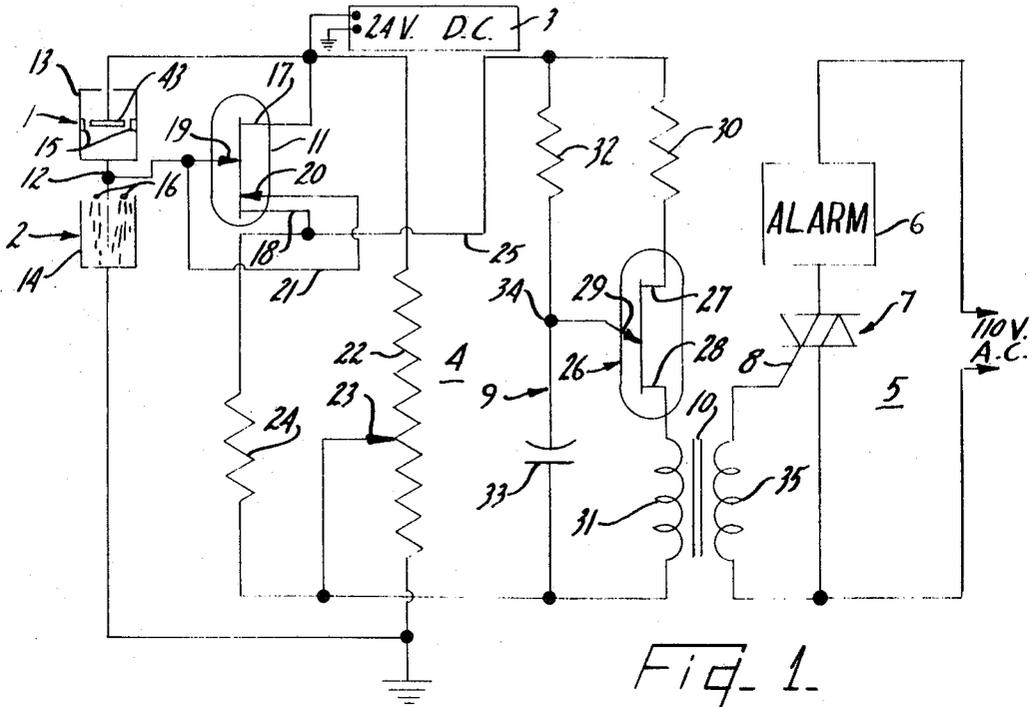


Fig. 1.

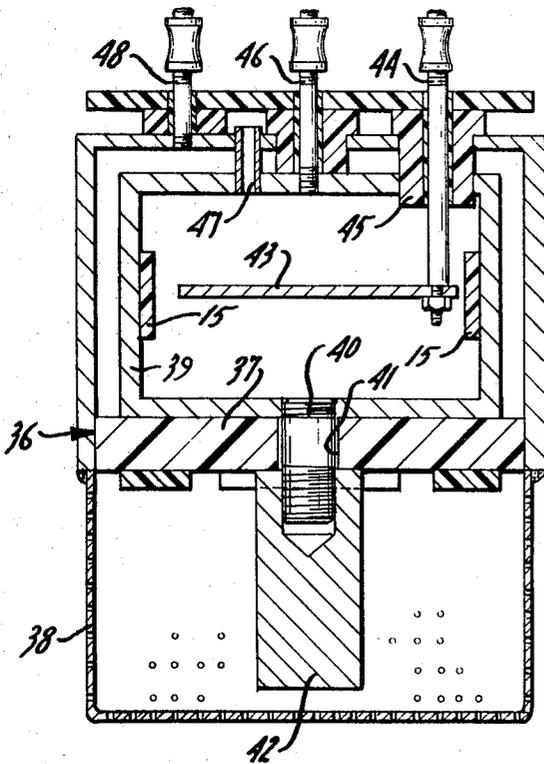


Fig. 2.

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**IONIZATION CHAMBER DETECTION APPARATUS
HAVING A LOW VOLTAGE SOURCE MEANS**

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ABSTRACT OF THE DISCLOSURE

This disclosure relates to a double ionization chamber connected to a D.C. voltage source of the order of twenty-five volts. A common electrode is connected to the input element of a field effect transistor which is connected in a circuit to supply power from the low voltage source to a unijunction transistor oscillator. A pulse transformer connects the oscillator to the gate of a "Triac" which is connected in series with an A.C. power supply and an audible alarm.

This invention relates to an ionization chamber detection apparatus which is responsive to the composition of a gaseous medium and particularly to a low voltage double ionization sensor and a low voltage solid state detection circuit.

The present invention is particularly adapted to the automatic detection of fires and the like by detection changes in the composition of the surrounding air as a result of a combustion process.

Highly satisfactory detection devices have been constructed employing ionization chambers as the sensitive means for detection of combustion products. Basically, an ionization chamber consists of a pair of insulated and properly spaced electrodes forming a chamber through which the environment adjacent the area to be protected passes. A radioactive source ionizes the gases within the chamber and an electric field between the electrodes causes the charged ions to move to the electrodes. The conductivity is a direct function of the chemical and physical composition of the air to which it is exposed. Generally, the prior art systems have suggested the use of a pair of ionization chambers connected in series across a high D.C. (direct current) potential to form a voltage division network such that the voltage divides across the chambers inversely with the conductivity. A change in the detection chambers conductivity thus varies the relative voltage division. The chambers are provided with their own radioactive sources and one of the chambers is open to the surrounding air and forms a detection chamber and the other is only partially opened or completely closed and forms a reference chamber. Only the first chamber will therefore be appreciably affected by the combustion gases generated by the initial combustion process. Generally, such a high voltage ionization chamber device drives a high input vacuum tube such as a cold cathode unit, which also requires relatively high D.C. potentials of the order of several hundred volts for satisfactory and reliable operation. Although such systems do provide satisfactory alarm systems, the high voltage provides a very distinct disadvantage from the standpoint of practical application.

The present invention is particularly directed to a low voltage double ionization chamber device employing a low voltage solid state detection unit such that the ionization chambers and the detection circuit proper are operated from a very low voltage D.C. potential, of the order of tens of volts. The actual alarm circuit may be a conventional power supply line system interconnected

to the detection system or circuit through a suitable isolating transformer or the like.

Thus, in one novel aspect of the present invention, the double ionization chamber operates on a relatively low voltage D.C. source of the order of twenty five volts. Another novel aspect is that a common electrode is connected to the input element of a field effect transistor or similar solid state analog device having a high input impedance. The field effect transistor is connected in a circuit to supply power from the low voltage source to a unijunction solid state device which in turn establishes a series of pulse signals for triggering a solid state switch connected in the alarm circuit. For example, a "Triac" may be connected in series with the secondary of the pulse transformer, and A.C. power supply and an audible alarm. The presence of smoke in the detection chamber will substantially increase the resistance or decrease the conductivity of this chamber. As a result, the voltage division between the two chambers varies and the voltage at the junction of the two chambers varies to forward bias the field effect transistor which conducts and energizes the unijunction oscillator which triggers the alarm circuit. In a highly desirable circuit, bias stabilization is obtained by providing negative feedback; for example, through a source resistor connected between the voltage source and the one side of the field effect transistor. Change in source current provides a corresponding source voltage change applied to the circuit and correspondingly in the circuit between the gate and the source voltage. The polarity of the voltage change across the resistor opposes the initial source change and consequently tends to nullify the effect thereof.

This arrangement and construction of the novel ionization chamber provides a relatively simple and inexpensive construction while providing a very sensitive and reliable means for responding to combustion gases.

The drawing furnished herewith illustrates a preferred construction of the present invention in which the above advantages and features are clearly disclosed.

In the drawing:

FIG. 1 is a schematic circuit diagram of a combustion gas detection system constructed in accordance with the present invention; and

FIG. 2 is a vertical section through a double ionization chamber unit constructed in accordance with the present invention.

Referring to the drawing and particularly to FIG. 1, the illustrated combustion gas detection system includes a pair of ionization chambers 1 and 2 interconnected in series across a low voltage direct current power supply 3. The ionization chambers 1 and 2 are interconnected to control a low voltage triggering or detection circuit 4 which in turn controls an alternating current alarm circuit 5 which may be either of a relatively high or low voltage type. An audible alarm system or the like may advantageously be energized at line voltage to provide a readily heard sound level.

An alarm device 6 is shown connected in series with a Triac 7 to the A.C. power supply lines. The alarm device may be any suitable device such as an audible alarm bell or the like to provide a noticeable signal in the presence of the fire. The Triac 7 is a known solid state switch device which can be triggered into conduction by application of a positive voltage to a gate element 8 and will continue to conduct for the half cycle. The trigger circuit 4 includes a unijunction oscillator 9 connected to the gate element 8 by a coupling transformer 10. A field effect transistor 11 is connected to supply power to the oscillator 9 in accordance with the voltage division across the ionization chambers 1 and 2 and therefore in accordance with the presence of combustion gases.

Thus, in operation, the trigger circuit 4 is normally held in a standby "off" condition. In the presence of combustion gases, the ionization chambers 1 and 2 change their characteristic and provide an input signal to the transistor 11 causing it to conduct and in turn providing a trigger signal to the Triac 7 for firing of the alarm.

More particularly, in the illustrated embodiment of the invention, the ionization chambers are constructed with a common or junction electrode 12 projecting in opposite directions into a pair of spaced cylindrical conducting members 13 and 14, as more fully described with respect to FIG. 2. The conducting member 13 is connected to the positive side of the D.C. power source 3 and the cylindrical conducting member 14 is connected to the opposite side via the illustrated ground connection. This establishes an electric field in the respective chambers with the voltage drop inversely proportional to the conductivity of the chambers. An ionization source 15 such as Polonium 210 is provided centrally of the side wall of the cylinder 13 and directs radiation across the cylinder. A similar ionization source 16 is mounted within the one end of the member 14 to direct radiation axially of the cylinder 14. The radioactive sources 15 and 16, and particularly the alpha particles emitted therefrom, ionize the air. The negative and positive charged ions are attracted by the opposite charges on the central electrode and the outer wall electrode. In the presence of fire, combustion gases will be introduced into the detection chamber 2 and radically effect the movement of the charged ions. The alpha particles from the radiation source attach to the particles of combustion gases. These however are much heavier than the normal air molecules and consequently the mobility is substantially less. As a result, their diffusion coefficient and drift velocity is substantially reduced. Such charged particles remain in the space between the electrodes for a greater period of time and statistically are much more likely to be combined with free electrons and thereby become neutralized before reaching either one of the electrodes, thus resulting in a decrease in current flow through that chamber. The change in current appears as a voltage change at the common electrode 12 as a result of the series connection of the two ionization chambers to the D.C. voltage supply.

In the present invention, this change in voltage is applied to the field effect transistor 11 which is a solid state analog switch having a very high input impedance. As is known, such transistors have a pair of main electrodes or terminals 17 and 18 and a pair of control electrodes or terminals 19 and 20. The control terminals 19 and 20 are interconnected to each other by a suitable jumper lead 21 and to the common conducting electrode 12 and control the conduction between terminals 19 and 20.

The one main terminal 17 is connected directly to the positive side of the D.C. power supply 3. A potentiometer 22 is connected across the power supply 3 and includes a tap 23 connected in series with a feedback resistor 24 to the main terminal 18 of the field effect transistor. The potentiometer 22 is a voltage dividing network and the tap 23 is placed to apply a selected portion of the D.C. power supply voltage across the field effect transistor 11 in series with the feedback resistor 24.

The resistor 24 provides a negative feedback characteristic to maintain highly reliable and accurate operation of the circuit. Thus, the current through the resistor 24 is directly proportional to the voltage of the D.C. source of supply. Any change in the source current will establish a corresponding change in the source voltage which in turn will be accomplished by a change in the gate to source voltage. This change is such as to oppose and neutralize the initial source current change thereby maintaining a stable bias or operating point.

An output lead 25 is connected to the junction of the resistor 24 and the field effect transistor terminal 18 and thus controls the application of power to the unijunction oscillator. The unijunction oscillator 9 includes the con-

ventional unijunction transistor 26 having main electrode or terminals 27 and 28 and a gate terminal 29. A resistor 30 connects the one unijunction terminal 27 to the output lead 25. A primary winding 31 of the coupling transformer 10 is connected in series with the opposite terminal 28 to the opposite side of the load or feedback resistor 24. An R.C. (resistance capacitance) circuit is provided by a resistor 32 in series with a capacitor 33 connected across the resistor 24. The junction 34 of the resistor 32 and capacitor 33 is connected to the gate 29. In the absence of conduction by the field effect transistor 11, the potential across the unijunction oscillator 9 is zero. As soon as the field effect transistor is biased into conduction, the power supply circuit is completed and a charging voltage is applied to the unijunction transistor firing circuit of resistor 32 and capacitor 33. The capacitor 33 charges until the firing level of the unijunction transistor 26 is established at which time the capacitor 33 rapidly discharges through the gate to load terminal firing the unijunction transistor and providing a high pulse signal through the primary winding 31 of the transformer 10.

The transformer 10 includes a secondary winding 35 connected to the gate 8 of a Triac 7.

The double ionization chamber device is preferably formed as a unitized structure such as shown in FIG. 2.

The double ionization chamber device includes an outer metallic housing 36 having an insulating wall 37 secured generally centrally of the housing and defining a pair of chambers to the opposite sides thereof. The housing 36 is a cylindrical member and is perforated to one side of the wall as at 38 and imperforated to the opposite side. An inner metallic housing 39 rests on the wall 37 within the imperforated portion of the outer metallic housing 36 and is radially spaced therefrom. A clamping stud 40 is threaded into an appropriate opening in the wall of inner housing 39 and extends through a central opening 41 in the insulating wall 37. An electrode rod 42 is tapped and threaded onto the stud 40 to clamp the housing 39 and the rod 42 to the insulating wall 37. A reference electrode 43 is mounted within the inner housing 39 extending diametrically of the housing. The reference electrode 43 is secured to and supported on the inner end of a contact stud 44 which projects axially outwardly through the end walls of the housings 39 and 36. An insulating bushing 45 insulates the stud 44 from both housings and supports the stud.

A contact stud 46 is threaded into an appropriate opening in the end wall of the inner housing 39 and projects outwardly through the outer housing 36. An insulating bushing 47 similar to bushing 45 insulates stud 46 from the outer housing 36.

The outer housing 36 is provided with a similar connecting stud 48 threaded into an appropriate opening in the housing. The outer housing portion 38 and the rod-like electrode 42 form the detection chamber and the inner housing 39 and reference electrode 43 form the reference chamber.

The low voltage power source 3 is connected to the terminal studs 44 and 48 to impress the voltage across the chambers in series.

The particle source 15 is shown secured to the side wall of the inner housing 39 in alignment with the reference electrode 43. The alpha particles are thus emitted generally diametrically of the housing 39 and travel substantially at right angles to the field between electrode 43 and the end walls of the housing 39.

The particle sources 16 are shown secured to the insulating wall 37 and the path of the particles is again perpendicular to the electric field between the central rod electrode 42 and the housing portion 38 of the detection chamber.

The electrode spacing in the reference chamber is much less than that established in the detection chamber as a result of the substantially increased diameter of the outer housing.

The relatively low voltage is applied between the two inner and outer housings and thus across the two chambers in series. The reference chamber operates in the saturated region of the voltampere characteristic and consequently provides a constant current source. The larger detection chamber operates however below saturation in the linear region of its voltampere characteristic.

The ionization source means is mounted at the one end of the detection chamber and to the side walls of the reference chamber such that the radioactive source is perpendicular to that of the electric field established between the outer cylinder and the common electrode. As a result, the ions of different charge will be much more quickly removed with respect to each other than they would be if the electric field were parallel to the ion track.

Generally, ionizing sources employed in these devices are alpha particle sources although beta particles or gamma rays might be employed.

The inner housing 39 is a continuous solid metal wall and consequently essentially prevents entrance of combustion gases. However, a vent opening 49 is provided to the exterior and allows equalization of the environments in the reference and detection chambers for normal relatively slow changes in the density of the environmental air.

The outer housing 39 also serves as a shield against stray electrostatic fields by enclosing the chambers and allowing only the reference electrode 43 and the junction electrodes 39 and 42 to penetrate such shield.

In the presence of combustion, the combustion gases will rapidly and readily enter the detection chamber causing a change in the movement of the charges between the electrode 42 and the detection chamber housing wall 38. This increases the voltage drop across the detection chamber and applies an increased forward bias on the field effect transistor 11 which conducts and actuates the alarm circuit as heretofore described. As previously noted, the conduction through the field effect transistor 11 establishes a voltage drop across the series resistor and also applies a corresponding voltage across the unijunction oscillator 9. The unijunction oscillator oscillates at a selected repetition rate to continuously provide firing pulses to the gate 8 of the Triac 7 and thereby conduction through the A.C. alarm circuit 5. The detection circuit as such therefore employs a relatively low voltage direct current in contrast to the prior art devices which generally require very high D.C. voltages for proper and reliable operation.

The present invention thus provides an improved gaseous detection apparatus employing a low voltage direct current solid state detection circuit and a low voltage uniquely designed double ionization chamber sensing element.

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. Apparatus for detecting changes in a gaseous medium, comprising
 - a low voltage power source connecting means for supplying a voltage of the order of 25 volts,
 - a pair of low voltage ionization chambers connected in series to the power source connected means and constructed to operate with a voltage of the order of 25 volts and having a common output element to define a low voltage signal source responsive to the composition of the gaseous medium within said chambers, and
 - a solid state detection circuit connected to the power connection means and including a solid state amplifying means having a high input impedance and input terminal means connected to said common output element and load terminal means connected in

circuit to said power connection means and output connection means to produce an output signal in accordance with the signal at said common output element.

2. The apparatus for detecting changes in a gaseous medium of claim 1, having
 - a low voltage direct current power source connected to the connection means,
 - said pair of ionization chambers includes an outer housing having an insulating central wall, the housing to one side of the wall being imperforated and to the opposite side being perforated, a second housing secured within the imperforated portion of the first housing, a rod-like electrode means secured to the second housing and projecting into the perforated portion of the first housing, a reference electrode located centrally and diametrically of the second housing, said first housing and reference electrode being connected to opposite sides of the power source, and said amplifying means being a field effect transistor means having the pair of input terminal means connected to said second housing and said rod-like electrode and the load terminal means connected in series to said power connection means and the output means.

3. The apparatus of claim 2 having an alternating current indicating circuit including a triggered switch means, and a pulse forming means connected to actuate the triggered switch means, said pulse forming means being connected to the output means of said detection circuit whereby said triggered switch means is actuated in accordance with the signal at said common output element.

4. The apparatus of claim 2 having an alternating current indicating circuit including a bi-directional triggered switch means, and an oscillator connected to actuate the triggered switch means, said oscillator being connected to the output means of said detection circuit to establish a train of trigger pulses in response to conduction of said transistor means, and a coupling transformer connecting said oscillator to said triggered switch means.

5. The apparatus of claim 1 wherein the amplifying means includes a field effect transistor.

6. The apparatus of claim 1 having an alternating current indicating circuit including a triggered switch means, and a pulse forming means connected to actuate the triggered switch means, said pulse forming means being connected to the load terminal means whereby said triggered switch means is actuated in accordance with the signal at said common output element.

7. The apparatus of claim 1 having an alternating current indicating circuit including a solid state triggered switch means, and a pulse forming oscillator connected to actuate the triggered switch means, said oscillator being connected to the load terminal means and establishing a train of pulse signals to said triggered switch means whereby the latter is actuated in accordance with the voltage signal level at said common output element.

8. The apparatus for detecting changes in a gaseous medium of claim 1 wherein said amplifying means is a field effect transistor means and a load terminal means connected in series with said power connection means and the output terminal means.

9. The apparatus for detecting changes in a gaseous medium of claim 1 wherein a direct current power source is connected to said connection means and the ionization chambers have outer cylindrical conducting walls connected to the power source connection means and having a common central conducting rod as the output element.

10. The apparatus of claim 8 wherein the power connection means includes a direct current source of the order of 25 volts D.C.

11. Apparatus responsive to changes in the composition of a gaseous medium, comprising
 - a first conducting housing having an intermediate in-

7

insulating wall of electrically insulating material, said housing being perforated to one side of the wall and imperforated to the opposite side,
 a second conducting housing disposed within the imperforated portion of the first housing and spaced from the conductive walls thereof,
 a rod-like electrode disposed within the perforated portion of the first housing,
 conducting means extending through said insulating wall and connected to the second housing and to the second conducting housing, said rod-like electrode being releasably secured to the conducting means and serving to clamp the second housing and the rod-like electrode to said insulating wall to support the same within the first housing,
 a reference electrode mounted within said second housing,

8

separate terminal means connected to the first housing, to the second housing and to the reference electrode, and
 radioactive sources mounted within the perforated portion of the first housing and within the second housing.

References Cited

UNITED STATES PATENTS

2,963,600	12/1960	Meili et al. -----	313—54 X
3,271,756	9/1966	Crawford et al. ----	250—44 X
3,295,121	12/1966	Meyer -----	250—83.6 X

ARCHIE R. BORCHELT, Primary Examiner

U.S. Cl. X.R.

250—44; 313—54, 93

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,514,603 Dated May 26, 1970

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. 2, line 26, cancel "filed" and substitute therefor
---field---

Col. 2, line 28, cancel "ot" and substitute therefor
---to---

Col. 2, line 48, cancel "lilustrated" and substitute
therefor ---illustrated---

Col. 2, line 66, cancel "occillator" and substitute
therefor ---oscillator---

Col. 3, line 57, cancel "termnial" and substitute
therefor ---terminal---

Col. 3, line 66, cancel "of" and substitute therefor
---or---

Col. 3, line 68, cancel "accomplished" and substitute
therefor ---accompanied---

Col. 5, line 62, cancel "connecting" and substitute
therefor ---connection---

SIGNED AND
SEALED
OCT 13 1970

(SEAL)

Attest:

Edward M. Fletcher, Jr.

Attesting Officer

WILLIAM K. SCHUYLER, JR.
Commissioner of Patents