United States Patent [19]

Primmer

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[45] **Dec. 25, 1973**

[54] **PRODUCTS OF COMBUSTION DETECTOR**

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[73] Assignee: **Development Technology, Inc.**, Bozeman, Mont.

[22] Filed: **Mar. 16, 1972**

[21] Appl. No.: **235,334**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 80,909, Oct. 15, 1970, abandoned.

[52] **U.S. Cl.** .... **340/237 S,** 340/237 R, 340/228 S

[51] **Int. Cl.** **G08b 21/00**

[58] **Field of Search** 340/237

[56] **References Cited**

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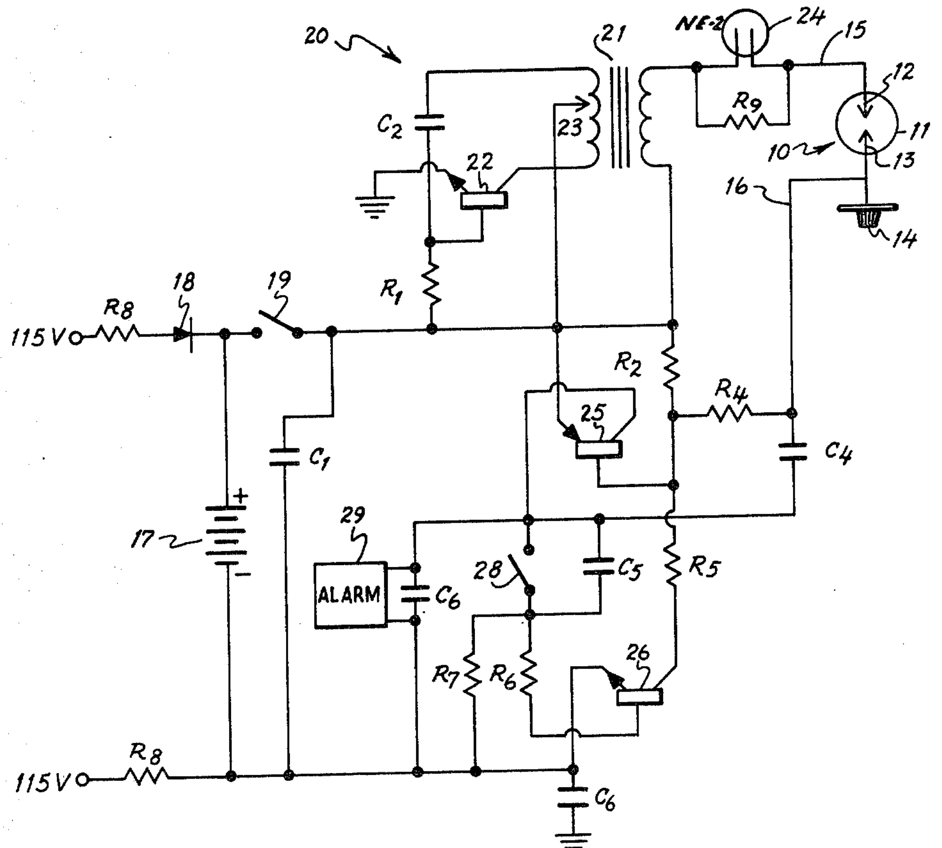
[57] **ABSTRACT**

A products of combustion detector is provided wherein a spark-gap is exposed to the ambient atmosphere and a varying potential is applied thereto of a peak magnitude less than that required to initiate a discharge thereacross. Products of combustion in the ambient atmosphere initiate periodic arcs and a circuit is provided for giving an output signal only when a predetermined number of arcs have occurred within a given period of time.

16 Claims, 8 Drawing Figures



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SHEET 1 OF 2

Fig. 1

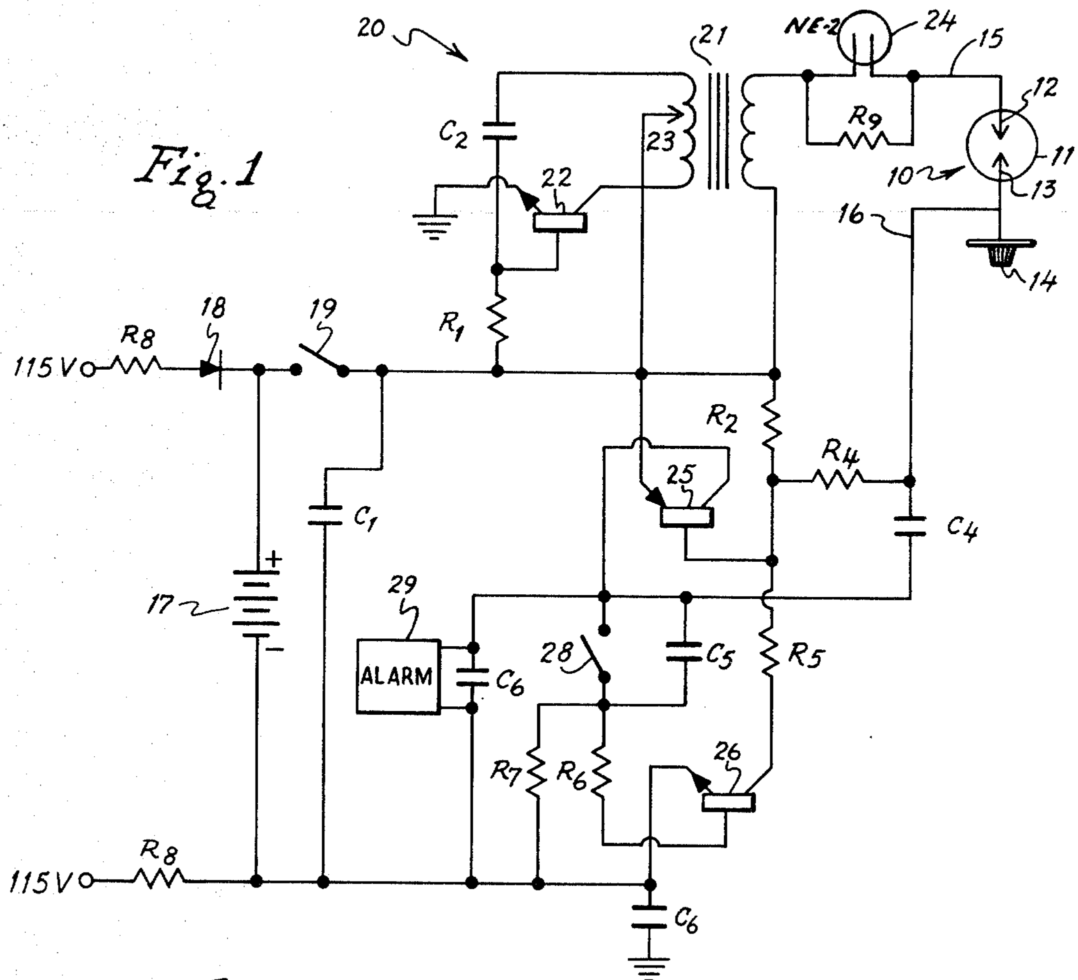

Fig. 2

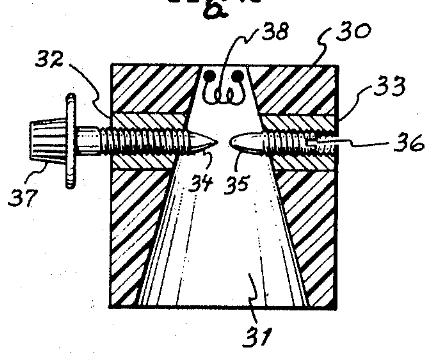

Fig. 3

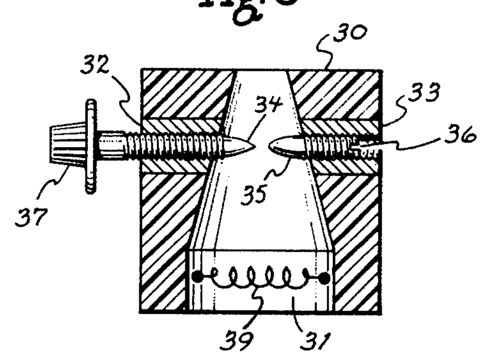

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FIG. 4

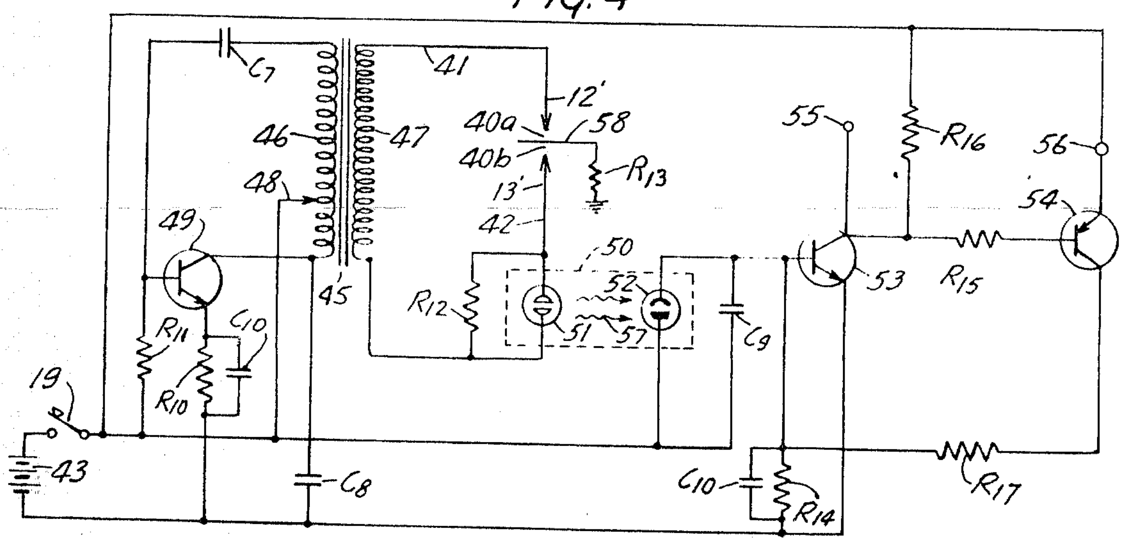


FIG. 5

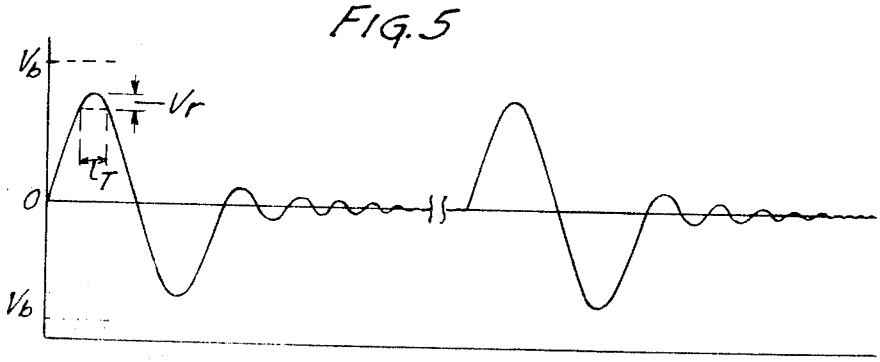


FIG. 6

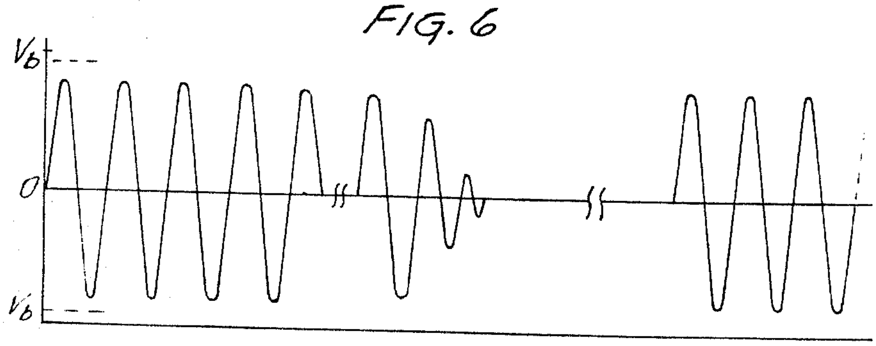


FIG. 7

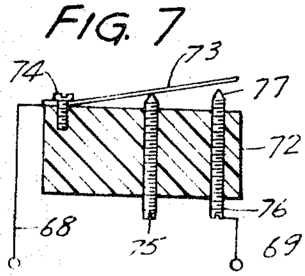
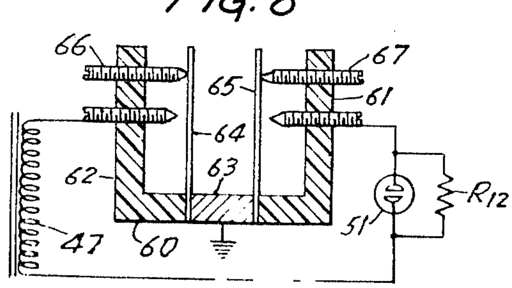


FIG. 8



PRODUCTS OF COMBUSTION DETECTOR

This application is a continuation-in-part of my co-pending application Ser. No. 80,909, filed Oct. 15, 1970, and now abandoned, for PRODUCTS OF COMBUSTION DETECTOR, assigned to same assignee as the present application.

The present invention is directed broadly to a products of combustion detector and is more specifically directed to a products of combustion detector for use as an early warning that undesired combustion is taking place within an environment. In one modification it also will find use as a detector of combustibles in the atmosphere. While the invention will find use in a variety of forms, it is specifically useful as a fire detecting device for protecting homes and other buildings and will be described with particularity for that application. It detects at a very early point in time that undesired combustion is taking place, and, therefore, it provides an alarm at an early stage so that proper steps may be taken to protect both life and property.

The need for and advantages of having such an early warning system are so well known as to require no further comment.

Prior investigators have provided devices operating on a wide variety of principles for indicating that undesired combustion is taking place. These prior art devices include such phenomena as rate of heat rise, ionization detectors utilizing radioactive material, and smoke detectors which optically measure the obscuration produced in the atmosphere by the presence of smoke. Many other types of detectors have been proposed in addition to those mentioned.

Any detector of fire must meet a number of criteria before it will be acceptable to the public. It must be reliable in that it does not give false alarms nor fail to give an alarm when a fire occurs. It also must be compact so that it can be installed without taking up more than a minimum amount of space. A third and equally important factor is that the device must be relatively inexpensive. Unless the cost is kept to a low level, public acceptance will not be obtained. Excessive cost has made many of the more sophisticated devices of the prior art unacceptable. A desirable feature is that the unit be powered by battery to permit installation without need for expensive wiring to supply voltage. In spite of extensive activity by inventors in this field over many years, no generally acceptable devices have resulted. That is, for one reason or another, the prior art devices have failed to find general acceptance.

I have found that a device for detecting the products of combustion, and therefore a fire detector, can be manufactured meeting all of the above requirements. This device in its simplest form is a spark-gap which has applied thereto an electrical potential of a predetermined magnitude sufficient to cause an arc when the products of combustion are within the spark-gap, but which is not sufficient to initiate such an arc in the absence of products of combustion. In order that the device of my invention be of sufficient sensitivity to give an early alarm, it is necessary that the potential applied to the electrodes be of such a magnitude that occasional arcing may take place even in the absence of combustion in the vicinity. Such occasional arcing is believed due to the presence of ions that are formed in the air by means other than combustion. In order to prevent such erratic signaling from giving a false alarm

I provide a varying potential across the electrodes defining the spark-gap with the peak potential being of the predetermined magnitude. I further provide a means in this input potential to the electrodes for preventing the arm from becoming self-sustaining. One such means is a load in the input to the electrodes which will quench any arc formed at each cycle of the varying potential. A transformer design of low load accomplishes the same purpose. The arc will only reoccur in a subsequent cycle if the products of combustion above some predetermined limit are present in the test atmosphere. For detecting that actual products of combustion are present in excess of this predetermined amount, I have provided a circuit means for detecting the existence of an arc, the circuit giving an output signal only after some predetermined number of arcs of a total predetermined intensity has taken place within a specified time limit. Thus the occasional erratic arcing will not give an alarm signal, but rather, an alarm will only be given when products of combustion are present to give a series of arcs within some predetermined period of time. Thus, a detector is provided which gives a signal in the presence of products of combustion, but which does not give false signals due to the occasional erratic arcing that may take place.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic circuit diagram including a first form of detector in accordance with the invention;

FIG. 2 is a cross-sectional view of one form of the detector electrode mounting and housing;

FIG. 3 is a cross-sectional view of a combustible gas detector electrode mounting and housing in accordance with the invention;

FIG. 4 is a schematic circuit diagram of a preferred form of my invention;

FIG. 5 is a graph of electrode potential as a function of time for the embodiment of FIG. 1 utilizing a blocking oscillator for producing the varying potential;

FIG. 6 is a graph of electrode potential as a function of time for the embodiment of FIG. 4;

FIG. 7 is a sectional view of an electrode structure for the spark-gap of the invention utilizing a resilient reed in combination with a pointed electrode; and

FIG. 8 is a cross-sectional view of a preferred from of electrode mounting utilizing a double gap construction.

Referring first to FIG. 1, there is shown in schematic form a circuit diagram and detector in accordance with the invention. The detector element is generally designated **10** and includes a housing member **11**, shown schematically, which is of electrically insulating material. Mounted to member **11** are a pair of electrodes **12** and **13**, which are positioned so as to provide an intervening gap therebetween. Electrode **13** is illustrated schematically as having an adjustment means **14** to permit adjustment of the interelectrode gap between members **12** and **13**. Connected to electrodes **12** and **13**, respectively, are leads **15** and **16**, which serve to apply the necessary electrical bias to electrodes **12** and **13**.

One may power the detector system through ordinary household current, shown as a 115-volt AC source fed through resistors R_8 and diode **18**. This power source is shown as being half-wave rectified to give a direct current of ten volts. It is anticipated that the most common usage of the invention will be with standard household current. However, a standby power source such as battery 17 may be connected in parallel to act as a standby in the event of power failure, or as the sole power source if desired. Other power sources, such as automobile batteries and the like, can be substituted for either of the aforementioned power sources.

When household current is used as the power source, resistors R_8 and diode 18 act to reduce the potential to the desired level, as well as to provide a DC output. A capacitor designated C_1 of relatively large capacity, such as 100 microfarads, is connected across the line to smooth out the power supplied to the balance of the circuit. Also shown is a switch 19 for activating the system.

A blocking oscillator generally designated 20 is provided to give a periodic applied potential to electrodes 12 and 13. The blocking oscillator includes a transformer 21, a transistor 22, a capacitor designated C_2, and a resistor R_1.

The primary of transformer 21 is wound to have 24 total turns, with a tap 23 dividing the primary into sections of 6 and 18 turns each. The secondary of the transformer is desirably wound with 1800 turns.

For the present example, the various circuit elements will have values as follows:

Resistors	Capacitors
R_1 = 100 kohms	C_1 = 100 μf – 15 v
R_2 = 47 kohms	C_2 = 5 μf – 20 v
R_4 = 10 kohms	C_4 = .01 μf – 200 v
R_5 = 10 kohms	C_5 = 10 μf – 15 v
R_6 = 33 kohms	C_6 = 220 pf – 115 v
R_7 = 33 kohms	
R_8 = 22 kohms	
R_9 = 1 megohm	

Capacitor C_2 may have a value of 5 microfarad while resistor R_1 is desirably of about 100 kohms. With these values, the blocking oscillator of FIG. 1 operates on a period of about 110 milliseconds and has a ringing frequency of approximately 7 kilohertz. FIG. 5 illustrates schematically a plot of voltage versus time for a detector utilizing the circuit of FIG. 1. As can be seen an extended time interval exists between peak voltages where only negligible or zero potential is across the electrodes. This "off" state aids in prevention of avalanching by allowing the ionized gas to clear by convection from between the electrodes of the spark-gap between periods of maximum potential across the electrodes. In this example the time interval is provided by the blocking oscillator wave form which sets up the period of 110 milliseconds.

I have found that the shape of the voltage curve is important in achieving the purposes of my invention. As shown in FIG. 5 the voltage rise V_R during a time interval T centered on the peak of the curve should be less than 15 percent of the peak voltage across the electrodes during a time interval T of about 20 microseconds. For a circuit in accordance with FIG. 1 for the values shown in the example above for a 20 microsecond time period T the voltage rise V_R is approximately 150 volts where the peak voltage is about 1200 volts. Desirably, the voltage rise V_R during a time period T should be as small as possible commensurate with the cost of the necessary circuitry. For example, there is greater sensitivity to products of combustion where V_R is less than 100 volts over a time period T of 50 microseconds than is the case where the voltage rise V_R is 150 volts over 20 microseconds. The precise reason for this is not known. However it has been found that where a sawtoothed wave form of voltage is utilized that the detector operates far less reliably than where the wave form permits a relatively long dwell time at a voltage near the peak.

As already noted for the values given in connection with the circuit of FIG. 1 a peak voltage across electrodes 12 and 13 of approximately 1200 volts is achieved. For this level of voltage it is desirable to maintain a gap between the tips of the electrodes of approximately 0.009 inches. A somewhat smaller distance down to approximately 0.0015 inches is operable with correspondingly lower voltages, but the sensitivity at this small gap is so high as to produce an output signal when only minor amounts of combustion products are present, such as those resulting from normal household activities like cooking and smoking. Larger spacings between the electrodes for this form of my invention are likewise possible although the sensitivity declines as the gap is increased.

The preceding example is for illustration purposes only. I have found that the time period between peak voltages across electrodes 12 and 13 in accordance with the circuit of FIG. 1 can be varied over relatively wide ranges from the 110 millisecond period while still attaining substantially the same results.

It should also be appreciated that one may vary the voltage applied across the spark-gap and achieve substantially the same results as in the specific example described above. Compensation for higher or lower voltages is provided by changing the interelectrode spacing of the spark-gap.

Provided in the output circuit of FIG. 1 for transformer 21 is a neon lamp 24 shown in parallel with a large resistor R_9, which may be of a value such as one megohm. When an arc is produced between electrodes 12 and 13, this large resistance acts to quench the arc between cycles and thus prevent the arc from becoming self-sustaining. The neon lamp provides a visual indicator that the device is functioning even when no arcing is taking place. An additional factor aiding the quenching is the low power capacity of the transformer 21. As an arc occurs, the voltage supplied by the transformer drops to approximately one-half due to its low power capacity and this drop further aids in quenching the arc and in preventing formation of a self-sustaining arc due to the recovery time of the transformer. Therefore, unless additional products of combustion are present to bring about a new triggering of the arc, a single arcing will not act to set off an alarm due to its being self-perpetuating. The time period between peak voltage points permits the gases in the arc to rise by convection out of the field between electrodes.

In the form illustrated in FIG. 1, the voltage applied across electrodes 12 and 13 will be AC. An interrupted DC potential is operable in like manner, but I have found that there is less tendency to build up deposits on the electrode tips due to charged particles adhering thereto if an AC potential is used.

It should be apparent that in the nonalarm state, the power dissipated in my system is very low. This permits extended operation using batteries as a source of power without need for frequent changing of batteries.

The sensing portion of the circuit includes two transsistors 25 and 26 which, together with the various resistances and capacitances illustrated in the circuit, act to sense that arcing has occurred and to give an output signal only after a plurality of arcs have occurred within a short period. Several discharges within one second are required in the detector system illustrated in FIG. 1 before the alarm is actuated. Two modes of operation are provided for. When switch **28** is closed the alarm **29**, which may be any of a variety of electrically activated alarms, such as a piezoelectric speaker, begins to sound and when once activated goes into a continuous alarm. If switch **28** is in the open position as shown, then the alarms will be intermittant and its frequency of sounding will depend on the quantity of combustion products entering the gap between electrodes **12** and **13**. That is, an interrupted alarm signal is given.

Should only erratic arcs occur, such as will take place from time to time even in the absence of products of combustion, the charge resulting from each arc is dissipated before it can be added to by further erratic arcs to set off the alarm.

Of course, one may use the signal which turns on alarm **29** to operate external relays or the like rather than to sound alarm **29**.

It is not known with complete certainty what occurs within the spark-gap defined by electrodes **12** and **13**. Tests have demonstrated that water vapor up to 100 percent RH and/or carbon dioxide or carbon monoxide will not bring about arcing under the conditions described above. Thus, it is clear that these most common gases resulting from combustion of organic materials do not activate the alarm. However, when organic material is burning either with an open flame or merely smouldering, the passage of the fumes therefrom through the spark-gap will bring about discharges and set off the alarm. As ions produced in the air by means such as photoionization using high energy UV also set off a discharge, it is believed that the ionized molecules resulting from combustion are the agents in the combustion products that trigger the arc which ultimately sets off the alarm.

Referring now to FIG. **4** there is illustrated a schematic circuit diagram of a preferred form of my invention. The essential functions of the various sections of the circuit are substantially as illustrated with regard to FIG. **1** although improved performance and freedom from false alarms is achieved by the specific form of FIG. **4**. Due to low power in the output of the transformer I utilize a photo isolation arrangement for the detection circuitry.

In FIG. **4**, electrodes **12'** and **13'** define two spark-gaps designated *40a* and *40b*. Lead means **41** and **42** are provided for applying a varying potential to the electrodes **12'** and **13'**. A power source **43** which may be a storage battery having a 10-volt output is provided as the source of power. As in the case of the description with regard to FIG. **1** one may utilize a variety of power sources including alternating current sources such as household 115 volt AC that has been rectified and reduced to the appropriate voltage. An oscillator generally designated **44** is connected to the source of power **43** and is utilized to provide the applied potential for electrodes **12'** and **13'**. The oscillator includes a transformer generally designated **45** having a primary **46** and a secondary **47**. The primary **46** is divided by tap **48** into two segments; one of five turns and the other of 20 turns. The secondary is desirably of about 3600 turns. The primary **46** is desirably wound with No. 36 wire while the secondary is desirably No. 40 wire. The fineness of the wire gauge for the transformer and in particular for for the secondary of the transformer aids in limiting the total power output of the transformer which aids in quenching any arc occuring in spark-gaps *40a* and *40b*. Peak voltage is about 1800 volts.

The remainder of the oscillator consists of a 2N3053 transistor **49** and a capacitor C_7. The emitter of transistor **49** is connected to an RC pad consisting of resistor R_{10} and a capacitor C_{10} and then to ground. The base of transistor **49** is joined to the positive of power source **43** via resistor R_{11} and is also connected to one side of capacitor C_7.

The secondary of transformer **45** is connected via leads **41** and **42** to electrodes **12'** and **13'** respectively. A leaf electrode **58** connected to ground via resistor R_{11} defines with electrodes **12'** and **13'** spark-gaps *40a* and *40b* respectively. Joined in series with spark-gaps *40a* and *40b* by means of lead **42** is a photoisolator schematically illustrated by a dotted line and identified **50**. The photoisolator **50** includes a neon lamp **51** and a photodetector **52**. Such an assembly is available as an integral unit from Sigma Relay Division of Sigma Industries, Inc., of Braintree, Mass., under their designation 301TI-120AI. A resistor R_{12} is in parallel with neon lamp **51**.

One side of photoconductive element **52** is connected to the power source while the other side is connected to the base of a 2N3053 transistor **53** and via resistor R_{14} to ground. A capacitor C_9 is placed in parallel to photocell **52**. A capacitor C_{10} is placed in parallel to resistor R_{14}. The emitter of transistor **53** is connected to ground while the collector is in series with a resistor R_{15} which in turn connects to the base of a 2N4126 transistor **54**. The collector of transistor **53** is also connected via resistor R_{16} to the positive side of power source **43**. Transistor **54** has its emitter connected to power source **43** and its collector joined via resistor R_{17} to the base of transistor **53**. A pair of jacks **55** and **56** are provided for the output of the isolator portion of the circuit and may be joined to a relay for operating an alarm.

The values of the various capacitors and resistors in the circuit of FIG. **4** are as follows for the operation which will be described below:

C_7 = 10 microfarad	R_{10} = 27 ohms
C_8 = 100 microfarad	R_{11} = 47 kohms
C_9 = 0.1 microfarad	R_{12} = 220 kohms
C_{10} = 10 microfarad	R_{13} = 4.7 megohms
	R_{14} = 47 kohms
	R_{15} = 37 kohms
	R_{16} = 37 kohms
	R_{17} = 10 kohms

One form of the spark-gaps defined by **12'**, **13'** and **58** is illustrated in FIG. **8**. This construction will now be described.

Referring to FIG. **8** there is shown in side cross-sectional view a two-gap sensor which includes an electrically insulating base **60** of a material such as plastic which has two ear portions **61** and **62** projecting upwardly therefrom. Emdedded within the base **60** is a metal member **63** of a material such as copper which has attached thereto as by welding reed members **64** and **65** of a spring material such as beryllium copper. Reed member **65** is biased toward arm **61** and reed **64** is biased toward arm **62**. Metal member **63** is advantageously grounded as shown. Electrodes **12'** and **13'** extend through the respective arm members. The gap between electrode **12'** and reed **64** is adjustable by advancing or retarding screw **66** while screw **67** provides a similar purpose for electrode **13'**.

Operation of the circuit of FIG. 4 will now be described. Upon closing switch 19 a continuous wave output is produced by transformer 45 for about 10 milliseconds and is then off for about 100 milliseconds to produce a voltage versus time curve as illustrated in FIG. 6. As in the case of the curves of FIG. 5 a burst of energy by way of the peak potentials is followed by an "off" period when only minor voltage or none at all is impressed across the electrodes. The maximum potential across spark-gap 40*a* and 40*b* will be approximately 1800 volts and will alternately charge electrodes 12′ and 13′ during the on period so as to tend to prevent the accumulation of deposits of material on the electrodes due to electrostatic collecting. The frequency of the output of the transformer 45 using the circuit elements as described above will be approximately 2.5 kilohertz. Using a spark-gap between electrodes 12′ and 58 and 13′ and 58 of approximately 0.015 inches is sufficient so that arcing will not normally occur in ambient air. Arcing across both gaps will only take place when products of combustion are present in a significant quantity. The wave form as illustrated in FIG. 6 will have a value for T of about 80 microseconds with a total voltage rise V_R during this time internal of about 150 volts. It will be noted that the breakdown voltage of air V_b is not attained for the individual spark-gap intervals given. This time period is such that greater sensitivity of detection of products of combustion is achieved. Under conditions where products of combustion are not present arcing will ordinarily not occur across either of gaps 40*a* or 40*b*. Lamp 51 will have a flickering light of a low intensity showing that the unit is on. However, the light intensity is not sufficient to make photocell 52 conductive. Should an erratic arc occur across either gap 40*a* or 40*b* (it is extremely unlikely that it will occur across both gaps simultaneously) the arc will not increase the brightness of lamp 51. As shown electrode 58 is grounded via resistor R_{11} and erratic discharges are bled off without buildup. Resistor R_{11} is not mandatory to this form of my invention although it does improve performance. As the power of an individual arc is extremely low dissipation of the charge of an arc is relatively rapid. Electrode 58 can be a floating or non-grounded electrode.

Should products of combustion come into the region 40*a* and 40*b* between electrodes 12′ and 58 and 13′ and 58 discharge will occur across 12′ and 13′ due to the lowering of the breakdown voltage V_b below the peak of the potential being applied across the electrodes. When such a condition is achieved the spark occurs and brightly lights neon lamp 51 to produce an increased photo output indicated by arrows 57. However, due to the small power capacity of transformer 45 the arc will not reoccur at each cycle as illustrated in FIG. 6, but rather, the arc cannot reoccur until transformer 45 has had an opportunity to rebuild the peak potential. During this time interval convection will tend to carry away the results of the first discharge so that a second discharge will only take place if additional and new products of combustion are present within the spark-gap. Each light pulse produced by neon lamp 51 makes photocell 52 temporarily conductive and turns on transistor 53 for a period of time corresponding to the time and intensity of arc. An output is thus produced by transistor 53 which when of sufficient duration turns on transistor 54. The output of transistor 54 regeneratively feeds back to 53 although a portion thereof is stored by capacitor C_{10}. Should a series of arcs and corresponding outputs occur within a short time period capacitor C_{10} will be saturated and transistor 53 will be held on. Jacks 55 and 56 provide an output indicative of this condition and can be used to activate an alarm relay. By varying the capacity of C_{10} one can adjust the sensitivity level needed to produce an alarm state.

It should be understood that gaps 40*a* and 40*b* ordinarily will have the same spacing. However, it is possible to operate the unit when these gaps are of different value. For the example preceding a gap of 0.015 inches is appropriate for both 40*a* and 40*b*. However, the detector functions satisfactorily at other gap spacings such as 0.015 inches for one gap and 0.030 inches for the other. As in the case of the description with regard to FIG. 1 variation can be made of both gap and voltages.

Turning now to FIG. 2, there is illustrated in cross-sectional view one form of a spark-gap assembly in accordance with my invention. This assembly includes an electrically insulating body 30, which may be of a variety of materials including ceramics and plastics. I have found that Lucite (polymethylmethacrylate) has a number of advantages for use in this portion of the detector. Body 30 is formed to have a frusto-conical interior section 31 with openings to the atmosphere at the top and bottom thereof. As can be seen from the figure, the uppermost opening is considerably narrower than the lower opening. This type of a construction aids in providing a chimney effect for increasing the flow of gas from the ambient surroundings through the detector portion. Such a flow of gas is, of course, desirable to increase the speed of response of the detector to the presence of combustion products. The electrodes and spark gap in all cases must be exposed to the atmosphere in a manner which will insure that the sensor will be exposed by normal motion of the room air to any unusual level of products of combustion in the atmosphere. Extending through the wall portions of the body 30, and in axial alignment, are two openings 32 and 33, which are desirably threaded. In the form shown in FIG. 2, these openings have inserts of a conductive material, such as a metal sleeve, which provides a means for maintaining electrical contact with the electrode members. Not shown are the leads providing electrical connection to the sleeves in openings 32 and 33.

Threadably extending through openings 32 and 33 are electrode members 34 and 35. Electrode member 35 is shown as having a slot 36 at the rearward portion thereof, which can be utilized for advancing or retreating member 35 within slot 33. The forward tip of electrode 35 is shown as being of a rounded or ball-shaped configuration. Electrode 34 is similarly passed through opening 32 and has on its external end an adjustment means such as knob 37. Various means can be provided to give an indication of the interelectrode spacing between electrodes 34 and 35, such as a scale on the face of knob 37. For many uses, it will be desirable to have the interelectrodes spacing set by the factory or by the service man installing the device. In this instance, the interelectrode spacing would be adjustable through use of special tools and would be fixed in place by some means such as a set screw. In such an instance, the graduated knob 37 would not be utilized.

Electrode 34 has been shown as having a sharply pointed tip. I have found that a variety of electrode configurations can be used. However, the most stable and reproducable devices have been those wherein at least one of the tips defining the spark-gap is rounded or has a generally pointed configuration. It is desirable to have configurations that will tend to maintain a relatively uniform set of conditions under which arcing will occur. Thus, if the electrodes are of nonpointed or rounded shape, there is a greater tendency for the arc to wander. It is also desirable, although not required, to form the electrodes 34 and 35 of materials which will not become corroded in service. The electrode can be formed of any of the conventional base metals and plated with a metal which is relatively free from corrosion. I have found that brass plated with gold or nickel is particularly suitable for this purpose.

Also illustrated in FIG. 2 is a resistance coil 38. The resistance coil is shown in a schematic illustration as being positioned at the uppermost portion of the frustoconical cavity 31. Not shown are the lead means which supply power to this resistor. The function of the resistor 38 is to provide a heat source to warm the air and provide positive flow of gas through the chamber 31. Resistor 38 also acts to prevent condensation by maintaining the electrode tips slightly above ambient temperature. The preferred position for such a heat means is above the interelectrode gap. However, I have found that substantially identical results occur whether the resistance heater is above or below the electrodes. When the heater is below the electrodes, the rise in temperature of the gas, as noted above, reduces any tendency for condensation to occur on the electrodes under exposure to extremely high humidity.

Of course, a variety of constructions can be utilized for the sensor portion of the system. The electrodes can be spaced in a completely open environment, but because of the relatively high potential across the electrodes it is desirable to provide some type of shielding. This can be accomplished by means of an open lattice grid surrounding the electrodes.

It should be recognized that the alternate potential which is applied to the electrodes forming the spark-gap has an additional advantage. Because the electrodes are alternately charged positively and negatively, the tendency to build up deposits of charged particles on the surface of the electrodes is substantially reduced, if not eliminated. Such deposits of dust and the like can be deleterious if such deposits become severe. An additional factor which tends to prevent such an occurrence is the occasional or random arcing brought about by stray ions in the air. This occasional arcing acts to clean the electrode surfaces.

Referring now to FIG. 7 there is illustrated in side cross-sectional view a further form of spark-gap or sensor portion of my invention. In this form a block of an electrically insulating material such as plastic has had attached thereto at one end thereof a reed member 73 by suitable means such as screw 74. Reed 73 is advantageously formed of a resilient material such as beryllium copper that has been plated with a material such as nickel of either the electrolytic or electroless type. Such a coating of nickel is also advantageous for the electrodes of the unit of FIG. 8. The reed 73 may be of about 3/16 inch in width and approximately one inch in length. It is formed so that it is resiliently biased toward the surface of block 72. At an intermediate position along block 72 there is provided a screw member 75 which passes threadably through block 72 to abut at its tip on reed 73. By advancing or retarding screw 75 reed 73 is moved outwardly from or toward block 72. At the opposite end of block 72 from screw 74 there is provided a second screw member 76 which is threadably passed through block 72 so that a point 77 on the forward end is in close relationship to reed 73 and defined therebetween a spark-gap. Lead means 68 and 69 connect respectively to reed 73 and screw 76 and are used for applying the potential across these two members. Due to the positioning of screw 75 relatively small turns on this screw will be magnified in the amount of spacing provided between tip 77 and reed 73. Greater stability is thus attainable in adjusting the interelectrode gap for the spark-gap by this type of an arrangement over having the screws advance in a manner as illustrated in FIGS. 2 and 3. A similar construction is illustrated in the form shown in FIG. 8. Lead 69 may advantageously be connected electrically to screw 66 in a manner illustrated in FIGS. 2 and 3 so that the problem of rotation of the lead will not exist.

Turning to FIG. 3, there is shown a modified form of the device in accordance with my invention. In this form of the device, like parts are given the same numerical designation as in FIG. 2. In the lower portion of the chamber 31, there is positioned a means such as wire 39 for converting gaseous hydrocarbons that enter chamber 31 into a combusted form. This can be accomplished by maintaining wire 39 at a temperature high enough to bring about ignition of the hydrocarbons, or it can be accomplished by a combination of temperature and the use of a catalytic surface such as platinum on the wire to bring about a catalytic combustion of such hydrocarbons. The lead means supplying power to wire 39 are not shown. The gas containing the hydrocarbons will be carried through chamber 31 both by normal convection and by the chimney effect provided by the wire 39. The combustion of hydrocarbons upon passing over wire 39 will produce combustion products, which will in turn bring about arcing across electrodes 34 and 35. The detector portion of the balance of the system then will provide a signal that combustion products are present. Thus, one has a detector which can serve a dual purpose of providing both an indication that combustion products may be present from the fire in the area, or one which can provide an alert that an excessive quantity of hydrocarbon gases are present in the environment. Other applications of the detector in accordance with my invention will be apparent to those skilled in the art.

I claim:

1. A detector for determining when products of combustion from an organic substance in the air exceed a predetermined limit comprising:

a. first and second electrodes electrically insulated from one another and defining a gap therebetween, said electrodes being exposed to the environment to be sensed;

b. first electrical circuit means connected to said electrodes for applying a varying electrical potential of fixed period across said electrodes of a peak magnitude less than that required to initiate an arc across said gap under normal ambient conditions and of sufficient peak magnitude to initiate an arc when said products of combustion are present above a predetermined limit in said gap, said period being of sufficient interval to allow said products of combustion to rise by convection out of said gap, said first circuit means including means to prevent the arc from becoming self-sustaining; and

c. second electrical circuit means said second circuit means cooperatively responding to a plurality of electric discharges across said gap within a predetermined period of time and providing an output signal only upon such plurality of discharges occurring within said period of time.

2. A products of combustion detector in accordance with claim **1** wherein the electrical potential means provides an AC potential across said electrodes.

3. A products of combustion detector in accordance with claim **1** wherein the peak magnitude of the electrical potential is about 1200 volts and the gap between said electrodes is about 0.009 inches.

4. A products of combustion detector in accordance with claim **1** wherein said electrical potential means includes a blocking oscillator.

5. A products of combustion detector in accordance with claim **4** wherein the blocking oscillator period is about 110 milliseconds.

6. A products of combustion detector in accordance with claim **1** wherein a body of electrically insulating material defines a chamber with openings at the upper and lower end thereof and said electrodes are mounted to said body within said chamber.

7. A products of combustion detector in accordance with claim **6** wherein a heater means is provided within said chamber to maintain said chamber at a temperature above ambient.

8. A products of combustion detector in accordance with claim **6** wherein at least one of the electrodes is threadably mounted within said chamber so that the interelectrode spacing can be readily adjusted.

9. A system for detecting the presence of hydrocarbons and products of combustion in an atmosphere comprising:

a. a housing defining a chamber with openings at remote ends thereof;

b. first and second electrodes mounted to said housing and electrically insulated from one another and defining a gap therebetween;

c. first electrical circuit means connected to said electrodes for applying a varying electrical potential across said electrodes of a peak magnitude less than that required to initiate an arc across said gap under normal ambient conditions and of sufficient peak magnitude to initiate an arc when products of combustion are present above a predetermined limit in said gap, said period being of sufficient interval to allow said products of combustion to rise by convection out of said gap, said means including arc suppressing means to prevent the arc from becoming self-sustaining;

d. second electrical circuit means, said second circuit means cooperatively responding to a plurality of electric discharges across said gap within a predetermined period of time and providing an output signal only upon such plurality of discharges occuring within said period of time;

e. means for causing a flow of air through said chamber; and,

f. means for combusting hydrocarbon gases entrained in said air positioned upstream of said electrodes.

10. A system in accordance with claim **9** wherein said means for combusting is a wire of high resistivity and means are connected thereto for applying electrical power to thereby heat said wire to a temperature sufficient to cause combustion of said hydrocarbons.

11. A system in accordance with claim **10** wherein at least the surface of said wire is a metal which catalytically aids combustion of hydrocarbon gases.

12. A detector in accordance with claim **1** wherein a third electrode is interposed between said first and second electrodes to define with said electrodes first and second portions of said gap.

13. The detector in accordance with claim **12** wherein said third electrode is joined via a resistor to ground.

14. A detector in accordance with claim **1** wherein said first electrical circuit means includes an emitter which emits light upon a discharge across said gap and said second electrical circuit means includes a photoelectric detector cooperatively positioned to receive light from said emitter.

15. A detector in accordance with claim **12** wherein adjustment means are provided for individually varying the spacing between said first electrode and said third electrode and said second electrode and said third electrode.

16. A detector in accordance with claim **1** wherein the varying electrical potential is at the peak magnitude for about 10 milliseconds and has a period of about 110 milliseconds.

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